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A CONTRIBUTION TO THE PERMIAN - UPPER CARBONIFEROUS PROBLEM AND AN ANALYSIS OF THE FAUNA OF THE UPPER PALAEOZOIC (PERMIAN) OF NORTH-WEST BASIN, WESTERN AUSTRALIA.

By

H. G. RAGGATT, M.Sc.,
Geological Survey of New South Wales,

and

H. O. FLETCHER,
Australian Museum, Sydney.

INTRODUCTION.

IN a recent paper by Raggatt (1) a brief discussion of the fauna of the Upper Palaeozoic of North-West Basin, Western Australia, was given. In attempting to analyse the revised faunal lists more critically, it became necessary to examine the range of certain of the species in Eastern Australia, India, and adjacent regions. We were thus led to examine the arguments which have been put forward in determining the boundary between the Permian and Carboniferous Systems in those regions. We found that our conclusions had a bearing on the age of the Lower Gondwana rocks of South Africa and South America; hence some discussion on these beds is given. Incidentally, also we make reference to the Upper Palaeozoic glaciation. Thus, this paper may be considered as a contribution to the discussion inaugurated by Schuchert (2) and continued by David and Sussmilch (3).

The order of arrangement of this paper is that which was found necessary to achieve the object of determining the age of the Upper Palaeozoic beds of the North-West Basin. The New South Wales "Permo-Carboniferous" section and the criteria which have been put forward to determine the limits of the Permian and Carboniferous Systems in Australia are discussed first. Next, the bearing of this evidence on the age of the beds in India and Kashmir which contain Australian species is stated. Brief reference is then made to the Upper Palaeozoic succession in South Africa and South America. Finally, an analysis is made of the Western Australian fauna, mainly in terms of the range of species in India and Eastern Australia.

New South Wales.

The sequence of rocks in the Lower Hunter district of New South Wales which are commonly referred to as "Permo-Carboniferous", is as follows:

Series.	Stage.	Thickness in Feet.	
Upper Coal.	Newcastle.	400–1,500	Shales, sandstone, conglomerate, cherts, and coal seams. Fossil plants, *Phyllotheca*, *Vertebraria*, *Cladophlebis*, *Glossopteris*, *Gangamopteris*.
	Tomago.	500–3,000	Mainly shale, with thin beds of sandstone and coal seams. Same fossil plants as Newcastle Stage.
Upper Marine.	Mulbring.	1,000–2,000	Shale with calcareous concretion horizons. Glacial erratics near base. Marine fauna limited to about 30 genera, of which commonest are *Stenopora*, *Chaenomya*, *Warthia*, *Martiniopsis*, *Conularia*.
	Muree.	200–400	Sandstone, argillaceous and calcareous in places. Shales in middle part. Glacial erratics common. Fauna closely similar to Branxton Stage.
	Branxton.	2,000	Alternation of shales with beds like those of Muree Stage. Well marked *Fenestella* shale beds 1,550 feet above Greta Coal Measures. Glacial erratics common. Fauna includes several species of *Spirifer*, *Stenopora*, *Dielasma*, *Deltopecten* *Martiniopsis*, and *Productus*.
Lower or Greta Coal.		100–300	Fine conglomerate, sandstone, shale with thick coal seams. Fossil plants, *Glossopteris*. *Gangamopteris*, *Noeggerathiopsis*, *Odontopteris*, and *Sphenopteris*.
Lower Marine.		4,800	Shales and sandstones with flows of basalt. Lochinvar glacial shales at base, 200 feet thick. Marine fossils include *Eurydesma*, *Conularia*, *Keeneia*, *Warthia*, *Martiniopsis*, *Aviculopecten*.

The stratigraphic column given above is that now recognized by the Geological Survey of New South Wales. Its only important difference from that given by David and Sussmilch (3, page 485) is in omitting the Dempsey Beds,[1] which have been proved by L. J. Jones to be a facies of the Tomago Coal Measures and not a separate stage.

The position of the glacial beds which occur throughout the sequence is given by David and Sussmilch (3, p. 485). These need not be redescribed, but some comments on the higher glacials are given. David and Sussmilch list two separate horizons in the upper part of the Upper Marine Series, one in the Branxton Stage and one in the Muree. This does not give quite a true picture of the higher glacials, since erratics occur almost continuously from about 200 feet above the Greta Coal Measures to about 50 feet above the Muree. The Muree can be distinguished from beds of similar lithology in the Branxton Stage only by the fact that it is overlain by a considerable thickness of shales.

Over most of the Sydney Basin the Upper Coal Measures pass upwards without angular unconformity into the overlying Lower Triassic Narrabeen Series, but unconformity exists between the Permian and Triassic on the Lochinvar dome in the Lower Hunter Valley. The basal glacial shales of the "Permo-Carboniferous"

[1] No doubt due to typographical error, unfortunately misspelled Kempsey in their paper. Kempsey is another locality in New South Wales where Upper Palaeozoic rocks occur.

rest upon the underlying Kuttung Series (Carboniferous) without angular unconformity. Even where the Lower Marine Series is represented by volcanic rocks or is entirely absent, the contact between the Permo-Carboniferous and Kuttung is still angularly conformable, thus showing there was no orogeny in the interval between the deposition of the Kuttung Series and the Greta Coal Measures.

Although there is no angular unconformity between the Kuttung and Lower Marine, the change from the one to the other clearly marks an important time break. The Kuttung Series is characterized by the *Rhacopteris* flora and the Permo-Carboniferous by the *Glossopteris* flora.[2] In discussing this, Walkom (9, p. 163) writes: "The *Glossopteris* flora in New South Wales is separated from the earlier flora of the Kuttung Series by an absolute break, not one of the species known from the Kuttung Series occurring in association with the *Glossopteris* flora."

The glacial deposits of the "Permo-Carboniferous" are all closely similar to each other, but differ from those of the Kuttung. They differ not only in environment and lithology, but the materials of which they are composed were derived from different sources. This point was stressed by Browne and Dun (4, pp. 198–206) in 1924. They put it forward as a good reason for placing the break between the Carboniferous and the Permo-Carboniferous at the base of the Lochinvar glacials. David and Sussmilch (3, p. 498) also stress the significance of this change in the glacials, and we discuss it again later in this paper.

The Kuttung is a freshwater series generally considered to be Middle Carboniferous[3] in age, but in the absence of marine strata this can scarcely be said to be proved. There is evidence (briefly referred to later in this paper) that some members of the Carboniferous flora of the Northern Hemisphere lingered on into the Permian in the Southern Hemisphere. Hence it is not impossible that the upper part of the Kuttung may be Upper Carboniferous. However, we do not consider this point vitally important. It has been suggested that if the Kuttung is Middle Carboniferous we must look for the Upper Carboniferous in the Lower Marine Series, but the break between the Kuttung and the succeeding Lochinvar shales is sufficient to account for the absence of the Upper Carboniferous. Those who put forward this argument have to face the facts (which we next discuss) that the fauna of the Lochinvar shales not only has practically no links with the Lower Carboniferous Marine Series (the Burindi), which underlies the Kuttung, but is closely allied with the Permian; in other words, that an Upper Carboniferous fauna has practically no survivals from the Lower Carboniferous, but continues almost unchanged into the Permian.

It is agreed by most contributors to this discussion that the beds from the base of the Greta upwards are Permian, and there is probably no one who would on the evidence now available seriously suggest that the base of the Permian should be placed higher than this. David and Sussmilch (3, pp. 497-499) place the base of the Permian tentatively at the base of a prominent *Eurydesma cordatum* horizon, 1,800 feet below the base of the Greta Coal Measures.

In support of this they rely on certain palaeontological criteria and on the following evidence. At Allandale the *Eurydesma* beds include a conglomerate which contains a number of andesite pebbles. There seems little doubt that these

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[2] The first appearance of this flora is about 2,000 feet above base of Lochinvar glacials.

[3] Walkom (3, p. 624) refers the Kuttung to the Lower Carboniferous, but the context indicates that he refers to a twofold division of the Carboniferous.

pebbles were derived from a Kuttung land mass now represented by the Blair Duguid inlier. These authors earlier stated that there exists a marked unconformity between the Allandale conglomerate and the Kuttung at Pokolbin. In the Cranky Corner Basin there is a condensed sequence of Lower Marine beds with no evidence of any break or even of conglomerate at the *Eurydesma* horizon.

We consider that the evidence shows epeirogenic movement only, and not orogeny as has been suggested, and that the Pokolbin section represents an overlapping contact which has been tilted in later orogenies.

Since, then, the Lower Marine Series requires discussion, a section thereof, measured in the type area (5) and (3) is given:

Detailed Section of Lower Marine Series.

Stage.	Thickness in Feet.	Lithology.	Fossil Horizon.
Farley.	800–1,000	Sandy shales and mudstones.	9
	200	Mainly sandstones; Ravensfield sandstone at base.	8
Allandale.	560	Calcareous mudstone with thin beds of limestone. A few large granite erratics at top. Fossils about 130 feet above base. (=Pokolbin Ostracod horizon.)	7
	250	Allandale conglomerate with abundant *Eurydesma cordatum* overlain by Harpers Hill sandstone.	6
Lochinvar.	1,300	Shales and mudstones with a few erratics. Fossils abundant at top.	5
		Lowest horizon for *Gangamopteris* in Hunter Valley about half-way up in these beds.	4
	20	Limestone.	3
	310	Calcareous shale.	
	635	Amygdaloidal basalt.	
	345	Sandstone with indeterminable plant remains and marine fossils.	2
	150–250	Reddish-brown shales with glacial erratics. *Eurydesma hobartense* near the top.	1

The Lochinvar Stage would thus be put in the Upper Carboniferous by David and Sussmilch. We may therefore compare the fauna of this stage with that of the higher beds.

From horizon 2, Mr. W. S. Dun (4) recognized *Spirifer* aff. *tasmaniensis*?, *Dielasma* sp. indet., *Platychisma* sp., *Conularia* sp. (Dun thought this was not *Conularia levigata* Morris, but Fletcher is now satisfied that it should be referred to that species).

From 3, Dun identified the following fossils: *Fenestella internata*, *Fenestella fossula*, *Seminula* sp. nov., *Martiniopsis subradiata*, *Spirifer* aff. *tasmaniensis*, *Deltopecten limaeformis*, *Aviculopecten englehardti*, *Aviculopecten tenuicollis*, *Aviculopecten mitchelli*, *Chaenomya* sp., *Conocardium* sp. nov., *Orthoceras* sp.

From 4, Walkom records *Ptychomphalina trifilata*, *Ptychomphalina nuda*, and *Gangamopteris*, and from 5 the following (5):

Tribrachiocrinus sp.	*Aviculopecten* sp. nov.
Fenestella (?) *internata*.	,, *sprenti*.
,, (?) *fossula*.	,, *tenuicollis*.
Stenopora tasmaniensis.	,, *englehardti*.

Spirifer duodecimcostata.
„ *tasmaniensis.*
„ *vespertilio.*
„ *stokesi.*
„ *avicula.*
Martiniopsis subradiata.
var. *morrisii.*
cf. *morrisii.*
Productus cora var. *farleyensis.*
Strophalosia jukesi.
Chonetes sp.
Edmondia (?) *nobilissima.*
Merismopteria sp. nov.
Deltopecten subquinquelineatus.
„ *farleyensis.*
Myonia sp.
Pleurophorus.
Notomya (?).
Pachydomus.
Chaenomya.
Ptychomphalina trifilata.
Mourlonia rotundatum.
Platyschisma.
Keeneia (juv.).
Conularia levigata.
Plant stems.

On examining the list of fossils from horizons 1, 2, 3, 4, and 5 (i.e., from Lochinvar Stage), we find that of the forms recorded the only ones which are not found on horizons 6, 7, 8, and 9 are: *Tribrachiocrinus* sp., *Spirifer avicula*, *Strophalosia jukesi*, *Mourlonia rotundatum*, *Conocardium* sp. nov., *Seminula* sp. nov., *Ptychomphalina nuda*, *Dielasma* sp. indet. All of these except *Ptychomphalina nuda* and possibly *Seminula* sp. nov., are found in the still higher Upper Marine beds.

In fact, of the whole of the Lochinvar fauna as listed herein, only the following species are not known in the Upper Marine Series: *Productus cora* var. *farleyensis*, *Chonetes* sp., *Ptychomphalina nuda* and possibly *Seminula* sp. nov.

Discussing horizons 2 and 3, Dun (4, p. 204) stated: "A departure from a normal Permo-Carboniferous facies is afforded by the specimen probably referable to *Seminula*. A possible relationship to the Burindi (Lower Carboniferous) fauna is evidenced by this latter and by the *Spirifer*, which may be regarded as a distinctly transitional type." The identification of *Seminula* has since been questioned by Walkom (6, p. 625), and Miss Prendergast (7, p. 27) shows that *Seminula* is not uncommon in Permian beds.

It will be noted that *Eurydesma hobartense* is the lowest fossil recorded. Raggatt has long suspected that the criteria used for separating *Eurydesma cordatum* from *Eurydesma hobartense* were unreliable. It is to be noted that Etheridge (8, p. 75), in describing *Eurydesma hobartense*, stated: "The separation of this shell from *E. cordatum* is merely a question of degree—the general structure is the same, but all the parts are on a less massive scale." Both species occur in great numbers, and must have lived under similar conditions in the undisputed Permian beds of Maria Island, Tasmania. Morris and Dana recorded the genus from Upper Marine beds in the Illawarra District, while Frech recorded it from Kiama, also a locality in the Illawarra District (Upper Marine). Etheridge and Dun considered these localities to be probably due to errors in labelling, and were of the opinion that *Eurydesma* was a characteristic Lower Marine form. Since then specimens of both *Eurydesma hobartense* and *E. cordatum* have been collected from the Upper Marine at Ulladulla in the South Coast District of New South Wales.

The Pectinoid fauna of the Lower Marine and Upper Marine Series have many species common to both horizons. The facies of these shells are very similar, whereas in the Burindi an altogether different type of shell is found, smaller in size and with delicate ornamentation. Etheridge and Dun (9, p. 1) state: "The Aviculopectinidae of the Carboniferous System of New South Wales are rare, having been found in only a few localities. They are small, and are closely allied to European and American forms. On the other hand, one of the most striking features of the fauna of the Permo-Carboniferous Marine beds of New South Wales, and, in fact, of Eastern Australia, is the variety and large size of the Pectinoid shells, one very noticeable fact being the apparent isolation of types displayed by these genera."

John Mitchell, in 1924 (10, pp. 468–474), described eleven new species of *Aviculopecten* from newly discovered Carboniferous beds on the shores of Myall Lakes, New South Wales. The species are totally dissimilar to the Permian *Aviculopecten* fauna, and for close general comparisons Mitchell had to resort to European Carboniferous species.

Cowper Reed (11, pp. 72–73) states: ". . . . it has not been possible in Kashmir to distinguish between beds corresponding respectively to the Lower and Upper Marine beds of New South Wales." As geological work proceeds in New South Wales the differences between these faunas is seen to be less and less marked. The genus *Eurydesma* is an instance of this; another is *Aviculopecten mitchelli*, which was formerly thought to be a Lower Marine species, but has since been found in the Upper Marine at Ulladulla and Branxton. It is not possible at present to make a direct comparison of the faunas. Much information has been collected over the past decade by the Geological Survey of New South Wales during coal-field surveys, but most of this work is unpublished.

In 1929 Raggatt referred some fossils from the Muswellbrook District (Middle Hunter Valley) to the late W. S. Dun for identification. Dun supplied the following list of determinations:

Productus cf. *P. bellistriata*.
Spirifer cf. *acuta*.
„ *stokesi*.
„ *avicula*.
„ *tasmaniensis*.
Martiniopsis subradiata.
Dielasma sacculus (inflate var.).
„ sp. nov.
Conocardium sp. nov.
Pleurophorus sp. nov.
Eurydesma hobartense (?).
Platyschisma oculum.
Mourlonia subcancellata var.
Keeneia sp. nov.
Ptychomphalina sp.

At the time these fossils were collected their stratigraphical position was unknown. Dun commented that if they had come from the Lower Hunter he would have had no hesitation in referring them to the Lower Marine. But in subsequent field-work the Greta Seam was found eighty feet below the fossils, which therefore are in the Upper Marine. If Dun, with his intimate knowledge of these faunas, could not place a suite of fifteen species definitely in one series or the other, one is entitled to conclude that the faunal differences must be slight. The Upper Marine fauna is more diverse than that of the Lower, but the number of species restricted to the Lower Marine must be very few.

Thus it seems clear that a separation of the Lower Marine Series into Upper Carboniferous and Lower Permian has little palaeontological evidence to support it. As we have already stated, those who advocate such a division are in effect suggesting that an Upper Carboniferous fauna has practically no links with the Lower Carboniferous, but has strong affinities with the Permian.

OTHER EASTERN AUSTRALIAN SECTIONS.

In support of their tentative conclusion that the base of the Permian should be placed at the base of the *Eurydesma* beds of Allandale, and of the thesis that the *Glossopteris* flora ranges down to the Carboniferous, David and Sussmilch (3, pp. 502–514) discuss other Upper Palaeozoic sections in Australia. Those of Eastern Australia are briefly referred to here. These authors rely mainly on the presence of *Monilopora nicholsoni*, *Cladochonus tenuicollis*, and *Taeniothaerus subquadratus* as establishing a Carboniferous age. Bryan (12, pp. 71–74) has since shown the unreliability of *Monilopora nicholsoni* as an Upper Carboniferous zone fossil, and more evidence showing that this species ranges well up into the Permian has become available since Bryan's paper was published.

The value of *Monilopora nicholsoni* as an Upper Carboniferous zone fossil has also been discredited by the new evidence available from Western Australia. In each of the three marine Permian basins of Western Australia, *Monilopora nicholsoni* is rcorded from one horizon only. In the Irwin River Basin it is recorded from the Fossil Cliff beds, which are about 1,000 feet above the Ammonoid beds now known to be Permian (64). In the North-West Basin, *Monilopora nicholsoni* occurs in the Callytharra beds with a diverse Permian fauna which includes *Aulosteges*, a genus whose importance as indicating a Permian age is stressed by David. In the Kimberley Basin, *Monilopora nicholsoni* occurs no less than 2,000 feet above limestones containing Permian Ammonoids (13).

Voisey has recently given some particulars concerning the Drake Series (northern New South Wales (14, pp. 155–168), the age of which, as shown by his research, is Lower Permian. Of thirty-four forms listed by him (p. 164), twenty-seven are found in the Upper Marine Series of the Hunter Valley. *Eurydesma* has not been found here, but *Monilopora nicholsoni*, *Cladochonus tenuicollis* and *Taeniothaerus subquadratus* are all present, the corals being found in abundance at the top of the Series.

Voisey has also described the Macleay Series of the Kempsey District (North Coast District of New South Wales) (15, pp. 189–197). He considers that this series can be correlated with the Drake Series and the Lower Marine Series of the Hunter Valley. The Permian age of the Macleay Series is also beyond doubt; of twenty-two definitely determined species in Voisey's lists, twenty-one are found in the Upper Marine Series of the Hunter Valley. *Eurydesma cordatum* occurs here in abundance. *Monilopora nicholsoni* and *Cladochonus tenuicollis* also occur above, below, and in the same beds as *Eurydesma cordatum*, *Monilopora nicholsoni* being "most abundant" in a limestone above *Eurydesma cordatum*.

Taeniothaerus subquadratus occurs in the Lower Marine Series in the Hunter Valley (16, p. 301) and the Lower Bowen of Queensland, and ranges well up in the Western Australian section.

It is believed that specimens referred to *Monilopora nicholsoni* constitute several species and possibly more than one genus (12). When these have been described, it is possible that the range of one or the other of these species may be found to have value in correlation.

David and Sussmilch (3, pp. 502–503) also discuss the Springsure (Queensland) section of the "Permo-Carboniferous". This section was measured by J. H.

Reid (63, pp. 92–98, and 18, p. 57), and its implications are sufficiently important to warrant quoting it again:

	Thickness in Feet.
Upper Coal Measures	5,000
Middle Bowen Marine shell beds with glacial horizons	900
Lower Bowen Serecold Sandstone with *Conularia* sp. and *Gangamopteris* cf. *cyclopteroides* Feist.	950
Dilly Stage. Marine glacials and freshwater beds with *Eurydesma cordatum*, *Eurydesma* sp. nov. *Plerophyllum gregoriana* abundant. Fairly diverse marine fauna (see below)	375
Catherine Sandstone	500
Coral Stage (Marine) *Monilopora nicholsoni* and *Trachypora wilkinsoni* abundant. *Martiniopsis subradiata, Warthia micromphalus*	500
Aldebaran Sandstone with " Rare fragments of *Glossopteris* "	2,500
Gypseous (Marine) Stage. This stage and upper part of next below have *Martiniopsis subradiata* (small form), *Deltopecten comptus, Productus brachythaerus*	350
Staircase Sandstone	950
	11,900

David and Sussmilch place the base of the Permian at about the base of the Catherine Sandstone, stating that the beds with *Monilopora nicholsoni* and *Trachypora wilkinsoni* mark the top of the Upper Carboniferous.

Reid gives reasons for regarding the Dilly Stage as Lower Permian, and, of the seventeen species he lists (18, p. 58) as being of "more than ordinary interest from the stage", thirteen are known from the Upper Marine and three from the Lower Marine of New South Wales.

He also says (p. 58): "The Lower Bowen section below the Dilly Stage is not well known, and it would be unsafe yet to dogmatize as to the downward range of some of the characteristic species of that stage, the base of which has not been definitely identified."

Frank Reeves, in an unpublished report to Oil Search Ltd., states: "The lowest known formation in the region is the Staircase Sandstone, which may underlie the Dilly by a few hundred feet. Reid places the Catherine Sandstone, Coral Stage, and Aldebaran Sandstone below the Dilly. We find these overlie the Dilly and are respectively the Consuelo Sandstone, Ingelara Stage, and the Serecold Sandstone. It is probable that Reid's Gypseous Stage is the lower part of the Dilly."

K. Washington Gray and I. C. H. Croll confirm Reeve's interpretation of the Springsure section, with perhaps one slight modification. All the foraminifera noted by Irene Crespin in their specimens from the Gypseous Stage are found in higher beds and are also recorded from the Upper Marine Series of New South Wales, but some specimens from low in the Dilly Stage contain foraminifera which were not noted from the Gypseous Stage or higher beds, and three of which are recorded from the Lower Marine Series of New South Wales. It is unlikely, therefore, that the Gypseous beds would represent only the lower part of the Dilly. Gray and Croll regard the "Gypseous beds" as a facies variant of the Dilly, and equate the sandstone which overlies them ("Aldebaran" Sandstone of Reid) with the Serecold Sandstone. (From unpublished report kindly made available by Dr. K. Washington Gray.)

The revised section of the Lower Bowen as worked out independently by F. Reeves and by K. Washington Gray and I. C. H. Croll is:

Descending Sequence.	Thickness in Feet.
Catherine or Consuelo Sandstone	275–500
Coral or Ingelara Stage	425–500
Serecold or Aldebaran Sandstone	1,700–3,000
Dilly or Gypseous Stage	350–625
Staircase Sandstone	950
	5,575[1]

[1] Maximum.

This section shows that the beds containing *Monilopora nicholsoni* in abundance occur above those with *Eurydesma.* This interpretation tends to be supported by the fact that Reid himself records *Monilopora nicholsoni* "in post-Dilly beds of the Springsure dome" (18, p. 64). It will be noted that the relative positions of the main horizons of *Eurydesma* and *Monilopora* in this section are the same as at Kempsey, and the reverse of what they were originally thought to be.

The Springsure evidence is entirely opposed to the interpretation placed upon it by David and Sussmilch that *Glossopteris* descends "probably into rocks of Upper Carboniferous age". A further point of interest is that *Productus brachythaerus,* stressed by these authors as a Permian species (3, p. 499), occurs at Springsure below *Eurydesma,* with *Deltopecten comptus* and *Martiniopsis subradiata.*

Similarly, there is no proof that the *Glossopteris* beds of the Rockhampton District are Upper Carboniferous. These occur in the Dinner Creek Series of the Lower Bowen. There is nothing in the published lists of the Lower Bowen fauna to suggest that it is any different from the New South Wales Permian (of this paper).

J. H. Reid, after a critical discussion of the Gympie Series, concluded (17, p. 60) that: "The Middle Gympie beds of the Gympie Goldfield are entirely older than the recognized Lower Bowen of the Great Syncline, the Dinner Creek *Glossopteris* beds and the Lower Marine of the Hunter River (New South Wales) . . . ."

Reid correlated the Neerkol beds with the Gympie, and this, no doubt, considerably influenced him in coming to the conclusion quoted above. As he himself pointed out, however, these beds contain only four species in common, and their relationship to the Lower Bowen is different. Reid states (17, p. 69): "Yet the present difficulty obtrudes itself of where to draw a division line between Gympie and Lower Bowen marine beds owing to their apparent general conformability, should a sequence be found." Concerning the relationship between the Neerkol and the Dinner Creek beds (Lower Bowen), he writes (17, p. 39): "The heavy boulder conglomerates form the base of the Dinner Creek Series, and, as they have been derived partly from the whitish grits of the Neerkol Series, a considerable break in sedimentation is evinced."

It has been suggested by F. W. Whitehouse (14, p. 163), that the Neerkol fauna is also represented at Mt. Barney in Queensland, and he and Voisey (14,

p. 163) consider that the Neerkol can be correlated with the Emu Creek Series of the Drake Area in New South Wales. If we accept these views we must conclude that the Neerkol is certainly older than the Drake Series, that is, than the Lower Marine Series of the Hunter Valley (New South Wales). This Neerkol fauna is as yet too poorly described to permit a detailed analysis, but it certainly contains Carboniferous species which are not found in higher beds, and is probably of Upper Carboniferous age.

We conclude that the Neerkol beds, therefore, are older than the Gympie, and that in discussing the age of the Gympie Series we should consider only the list of fossils from Gympie itself. This list comprises forty-eight species, of which thirty-four are found in the Lower Bowen or higher beds. Of the remainder, *Spirifer dubia* is found in the Callytharra Stage (Middle (?) Permian) of North-West Basin, Western Australia. *Leptaena analoga* is found in the Rockhampton Series of Queensland (Lower (?) Carboniferous) and the Burindi (Lower Carboniferous) of New South Wales, but is also recorded from the Callytharra Stage and the Agglomeratic Slate of Kashmir (Lower Permian). *Polypora* (?) *smithii* is a Neerkol species. The rest (eleven species) are local species, a number of the determinations being tentative.

It is considered that the "Middle Gympie" is of Permian age; that it probably is, as Reid contends, pre-Bowen, or, say, pre-Dilly Stage, but that it is not pre-Lower Marine (of New South Wales). In other words, that it can be correlated approximately with the Lochinvar Stage of the Hunter Valley. David (65) also came to this conclusion.

Gangamopteris is recorded from the Gympie Series (19, p. 38) from an horizon which may be fairly safely put down as coming from somewhere about the middle of the Gympie Succession. This horizon probably corresponds approximately to that of the lowest record for *Gangamopteris* in New South Wales.

India and Neighbouring Lands.

According to Fox (20, p. 9), the Lower Gondwana sequence in the Salt Range, Punjab, is:

Productus limestone (Upper, Middle, Lower).
Speckled Sandstone.
Glacial boulder bed (Blaini tillite).

The Productus limestone is the equivalent of the Damuda of India and the lower beds of the Talchir glacial series. The divisions of the Productus limestone are commonly regarded as being, respectively, Upper, Middle, and Lower Permian. The Ammonites from the Upper Productus limestone show that it is late Permian, and an examination of the Fusulinids leaves little doubt that the Lower Productus limestone is Permian (see Dunbar, 21, pp. 405–413).

Early in this discussion, Thomas (22, pp. 946–948) stated that he considered that the base of the Permian should be drawn above *Schwagerina*. Cowper Reed (23, pp. 36–37 and footnote) refers a fauna from Tibet with *Schwagerina* to the Upper Carboniferous, but remarks that *Schwagerina princeps* is believed to range up into the Permian. The tenor of recent papers (24 and references therein) indicates a general tendency to place the base of the Permian in Europe, Asia, and America at the base of the *Schwagerina-Uddenites* zone, that is, to include most, if not all, of the Uralian in the Permian.

Unfortunately, neither of these zone fossils occurs in the countries we are discussing, but the zone Fusulinids of the higher Permian occur in India. Because of the absence of *Schwagerina*, *Schuchert* (25, p. 547), also Dunbar (21) incline to the view that the Lower Productus limestone is in the upper part of the Lower Permian or somewhere in the Middle Permian. At least it is agreed that the Productus limestone is Permian.

The geologists of India have usually regarded the Speckled Sandstone and Talchir Series as Upper Carboniferous. It is to be noted, however, that beds formerly regarded as Upper Talchir (Karharbari Stage) are now included in the Lower Barakara (i.e., Permian), leaving only about 1,000 feet of Lower Gondwana strata classified as Upper Carboniferous (see Fox, 20, p. iv).

So far as can be judged from a study of the literature, the conclusion that the Speckled Sandstone, Lower Talchirs, and their correlates in Kashmir and neighbouring regions are Upper Carboniferous, is based mainly on a comparison of the faunas with that of the so-called "Carboniferous" of New South Wales.

Much of Thomas's argument (22, pp. 946–7) depends on the fact that the overlying strata are Lower Permian and on the Upper Carboniferous age of the *Eurydesma-Conularia* fauna. In view of the facts already presented in this paper, we are of opinion that this view is no longer tenable.

As long ago as 1893 Oldham (26, p. 121) wrote that the Speckled Sandstone contained "thirteen out of twenty-two species which are identical with forms found in the marine Carboniferous beds of New South Wales, showing not only contemporaneity, but free communication between the two areas".

This statement is based on Waagen's (27, pp. 144–147, 153–155) list of fossils from the Speckled Sandstone, which is as follows:

Lowest Horizon:

Hyolithes orientalis Waag.
" sp. indet.
Cardiomorpha indica Waag.

Middle Horizon:

A *Pleurotomaria nuda* Dana.
Bucania warthi Waag.
A *Conularia laevigata* Morris.
A " *tenuistriata* McCoy.
" *warthi* Waagen.
A *Sanguinolites* cf. *mitchelli* De Kon.
A " *tenisoni* De Kon.
Nucula sp. indet.
Pseudomonotis subradialis Waag.
A *Aviculopecten* cf. *limaeformis* Morris.
A *Spirifer vespertilio* Sow.
A " *darwini* Morris.
A *Chonetes cracowensis* Eth.
Discina sp. indet.
Discinisca warthi Waag.
Serpulites undulatus Waag.
" *warthi* Waag.
" *tuba* Waag.

Highest Horizon:

A *Eurydesma globosum* Dana.
A „ *ellipticum* Dana.
A „ *cordatum* Morris.
A *Maeonia gracilis* Dana.

The thirteen species considered by Waagen to be identical with species occurring in Australia are marked A in the above list. The range of these species in Australia as now known is:

Pleurotomaria nuda Dana	Lower Marine, Hunter Valley, New South Wales.
Conularia laevigata Morris	Lower and Upper Marine Series.
„ *tenuistriata* McCoy	„ „ „ „ „
Sanguinolites cf. *mitchelli* De Kon.	Upper Marine Series.
„ *tenisoni* De Kon. ..	Burindi Series, New South Wales.
Aviculopecten limaeformis Morris	Lower and Upper Marine Series.
Spirifer vespertilio Sow.	Lower (?) and Upper Marine Series.
„ *darwini* Morris	Upper Marine Series.
Chonetes cracowensis Eth.	Rockhampton Series, Gympie Series and Lower Bowen Series, Queensland.
Eurydesma globosum Dana	Upper Marine Series.
„ *ellipticum* Dana	Lower Marine Series.
„ *cordatum* Morris	Lower and Upper Marine Series.
Maeonia gracilis Dana	Upper Marine Series.

In addition, it may be noted that another species, *Conularia warthi* Waagen, occurs over a range from about 1,500 feet below the top of the Lyons Series to the Byro Stage in Western Australia.

Thus, of fourteen species eleven are known from the Permian of Eastern Australia (nine of them ranging high in the system), and one from the Permian of Western Australia. *Chonetes cracowensis* Eth. ranges from Lower Carboniferous to Lower Permian, and one only, *Sanguinolites tenisoni* De Kon., is Carboniferous.

In a recent publication Cowper Reed (28) gives some further comments on a fauna from strata "approximately contemporaneous" with the *Eurydesma* beds described by Waagen. The fauna comprises thirty species, thirteen of which, according to him, are "identical, allied, or comparable" with Australian species. These species with their range in New South Wales are:

Fenestella fossula Lonsd.	Upper Marine Series.
Dielasma amygdala (Dana)	Upper Marine Series.
Pterinea lata De Kon.	(see footnote[4])
Tellinomya darwinii De Kon.	Lower Marine Series (High).
Cardiomorpha pusilla (McCoy) (= *Astartila pusilla*)	Upper Marine Series.
Meaonia gracilis Dana (= *Cleobis gracilis*)	Upper Marine Series.
Astartila ovalis (McCoy) (= *A. intrepida* Dana)	Upper Marine Series.
Pachydomus danai De Kon.	Upper Marine Series.

[4] Cowper Reed compares this shell with *Pterinea lata* De Kon., rather than with *Merismopteria macroptera* (Morris). The specimen is an imperfect anterior portion, and it is difficult to determine exact characters. His figures (pl. v, figs. 6, a, b) place the shell in the genus *Merismopteria*, common in the Upper Marine Series. *Pterinea lata* De Kon. is a Burindi (Lower Carboniferous) form.

Eurydesma cordatum Morr.	Lower and Upper Marine Series.
„ *cordatum* var. *sacculum* Dana	Lower Marine Series.
„ *hobartense* Johns.	Lower and Upper Marine Series.
„ *ellipticum* Dana	Lower Marine Series.
„ *globosum* Dana	Upper Marine Series.

It will be noted that the fauna had a dominantly Permian aspect.

How strongly the age determinations of faunas in Southern Asia are based upon comparison with Australian (particularly Eastern Australian) faunas may be seen from Cowper Reed's recent discussion of fossils from Kashmir, which he concludes are Upper Carboniferous.

He writes: "In the Kashmir fauna . . . . we can recognize the presence of the following Australian species or varieties of them":

A *Protoretepora ampla* Lonsd.
A *Spiriferina duodecimcostata* (McCoy).
A *Spirifer* (*Brachythyris*) *darwini* (Morris).
W.A. „ (*Neospirifer*) *hardmani* Foord var.
W.A. „ („) *fasciger* Keys. var. *australis.*
A *Maeonia gracilis* Dana var.
A *Astartila transversa* Dana.
A *Eurydesma cordatum* Morr. vars.
A *Astartila ovalis* (McCoy).
A *Warthia micromphala* (Morris).

The forms marked "A" in the above list are found in the Upper Marine Series of New South Wales and are by no means uncommon forms. The remaining two marked "W.A." are found in the Callytharra and Wooramel Stages of the Western Australian Upper Palaeozoic sequence. Thus they are all found in the Permian of Australia. Further, according to Cowper Reed (11, p. 73): "Of other Kashmir species, which through poorness of the specimens and their imperfect preservation, or as a result of the inadequate description of the Australian types, cannot be positively identified with Australian forms, there are the following":

A *Stenopora* cf. *gracilis* Dana.
A „ cf. *crinita* Lonsd.
A *Fenestella* cf. *fossula* Lonsd.
A „ cf. *internata* Lonsd.
A *Strophalosia* cf. *clarkei* Eth.
A *Spirifer* (*Fusella*) cf. *avicula* Sow.
A *Martiniopsis* sp. (cf. *M. subradiata* Sow).
Orthis (*Rhipidomella*) sp. (cf. *O.* (*Rh.*) *australis* McCoy).
A *Sanguinolites* cf. *carinatus* (Morr.).
Parallelodon cf. *interrupta* De Kon.
A *Aviculopecten* cf. *mitchelli* Eth. & Dun.
A *Eurydesma* cf. *globosum* Dana.
A *Astartila* cf. *corpulenta* Dana.
L.M. *Pleurotomaria* cf. *nuda* Dana.

To these we may add:

A *Strophalosia* cf. *gerardi* (King).
A *Spiriferina* cf. *stokesi* De Kon.
A *Aviculopecten* (*Deltopecten*) cf. *subquinquelineatus* McCoy.

L.M. *Pachydomus* ? cf. *sacculus* McCoy.
Leptaena analoga (Phill.).
Spirifer hardmani Foord.

Nearly all the above species (those marked "A") have been collected from the Upper Marine Series; two, *Pleurotomaria* cf. *nuda* Dana, *Pachydomus* ? cf. *sacculus* McCoy, from the Lower Marine Series.

One species, *Orthis* (*Rhipidomella*) *australis* is a Burindi (Lower Carboniferous) form. *Leptaena analoga*, another Burindi form, is recorded from the Rockhampton Series and Gympie in Queensland, and the Callytharra Stage of North-West Basin, Western Australia. *Spirifer hardmani* ranges from the Lyons Series to the Wooramel Stage in Western Australia. That is, of the thirty forms listed, twenty-six are found in the Permian of Eastern Australia, and of the remainder all except one range up into the Permian in Western Australia.

In a later work Cowper Reed (28, p. 3) considers that differences between the faunas of the Agglomeratic Slate and the Talchir Series may probably be attributed to physical environment rather than to age. He is, however, inclined to place the Kashmir fauna slightly higher than the Salt Range, mainly because "the genus *Eurydesma* marks two distinct stratigraphical horizons in Australia and is represented on them by different species. . ." As we have seen, it is no longer possible to maintain that *Eurydesma cordatum* and *Eurydesma hobartense* mark two distinct stratigraphical horizons in Australia.

Summarizing, we may say that close correlation between the Upper Palaeozoic sequences of Southern Asia and Eastern Australia is possible; namely, glacials followed by the *Eurydesma* fauna, passing up into beds containing *Gangamopteris-Glossopteris* and an admittedly Permian marine fauna. Also that the faunas of the Speckled Sandstone Series and the Agglomeratic Slate of Kashmir, like that of the Lower Marine Series of New South Wales, have close affinities with the Permian Upper Marine and few with the Carboniferous. In regard to the last statement we may quote Cowper Reed, who writes (11, p. 77): ". . . but we must admit that the fauna of the calcareous facies of the Upper Carboniferous of Europe and Asia shows very few features in common with that of the Salt Range, Kashmir, and Australia."

We therefore conclude that the Speckled Sandstone Series, the Agglomeratic Slate and the Lower Marine Series of New South Wales are Lower Permian.

South Africa.

A sequence closely similar to that of India and New South Wales is found in South Africa. The Dwyka Series has glacials at or near the base (in some places resting on a glaciated surface) which pass upwards into shales, which have yielded *Eurydesma globosum*, *Conularia* sp., *Orthoceras* sp., and *Productus* (see Cowper Reed (11, p. 72) and Du Toit (29, p. 215)). These beds are overlain by the Ecca Series, characterized by the *Glossopteris* flora and regarded as Lower Permian (Du Toit, 29, p. 280).

Correlates of these beds in the Congo Basin have recently been described by Veatch (30, pp. 78–114).

The South African succession differs from that of Southern Asia and New South Wales in that *Gangamopteris* appears right at the base of the tillite and below *Eurydesma*. In New South Wales and Asia the order of appearance of these fossils, as we have seen, is reversed.

Du Toit (29) considers that all the beds below the Ecca Series are Upper Carboniferous. Veatch (30, p. 96) regards the correlate of the Upper Dwyka on the Congo with *Glossopteris* sp. and *Cyclodendron leslii* as Permian, but considers the Dwyka tillite itself to be Upper Carboniferous. If Veatch concedes that beds with these two fossil plants are Permian, it is difficult to see why he should not also regard the Dwyka as Permian. Similarly, Du Toit stresses the fact that the presence of *Lepidodendron australe* (29, p. 280) in the Dwyka supports an Upper Carboniferous age for it, but also says "the collective evidence points to the Ecca Series as being not younger than Lower Permian, the flora actually including such typically Carboniferous genera as *Lepidodendron*, *Bothrodendron* and *Sigillaria*". (See Du Toit, 31, p. 245, for complete list of fossil plants.)

If the Ecca with such fossil plants is Permian, it is difficult to see why the Dwyka, which besides *Lepidodendron* has *Phyllotheca*, *Gangamopteris*, and *Dadoxylon* (?), should not also be regarded as Permian. We may note that Walkom (61, p. 164) suggests that the identification of *Lepidodendron australe* might be reviewed, and Du Toit's statement (31, p. 245) that the specimen identified was a fragment.

We have endeavoured to show that all the evidence available in Australia points to the fact that *Gangamopteris* and *Glossopteris* made their first appearance in the Permian. This flora is unanimously accepted in India as Permian. This is clear from the general tenor of recent reports. See Fox (20, p. iv), Gee (32, p. 27), Reed, Cotter and Lahiri (33, p. 443).

Diener (34, p. 111) and Middlemiss (35, p. 6) agree that beds containing *Gangamopteris* must be referred to the Permian, a view which is strongly supported by Licharew (36, p. 131) in his recent discussion of the fauna of the Kolyma region in Russia.

In view of all this evidence it seems curious that Du Toit and others should stress the presence of the lingering remnants of the *Rhacopteris* flora rather than the appearance of the newer *Glossopteris* flora. We are thus led to reaffirm Walkom's statement of 1929 (32, p. 165): "It is not to be expected that the pre-existing flora would have been completely exterminated before the initiation of the *Glossopteris* flora, and therefore the presence of a few species of the earlier flora associated with the *Glossopteris* flora should not be given undue weight in the determination of the age of the beds in which they occur. The first marked appearance of a flora (or fauna) is much more important in determination of age than the presence of the last lingering representatives of an earlier one."

Dr. Wade's work in the Kimberley Basin of Western Australia shows that *Lepidodendron* and *Bothrodendron* both occur above the Nura-Nura limestone, the age of which is undoubtedly Permian. (Verbal information, and 13.)

Other local evidence upon which Du Toit relies is the fossil fish and crustacea. Du Toit's list (29, p. 215) of forms from the Dwyka Series is:

Fishes: *Palaeoniscus capensis*, *Acrolepis lotzi*, *Namaichthys schroederi*, *Rhadinichthys* (?), *Elonichthys* (?).

Crustacea: *Pygocephalus* sp., *Anthrapalaemon* sp.

The original description of these is not available to us, but there seems to be some anomalies in this evidence, to judge from the statement of Dighton Thomas (22, p. 947), who writes that the occurrence of *Palaeoniscus*, *Anthrapalaemon* and *Pygocephalus* "does not invalidate" an Upper Carboniferous age for the Dwyka.

In considering the genera of the fossil fish from the Dwyka Series it is to be noted that three of them, *Palaeoniscus*, *Acrolepis*, and *Elonichthys*, are also found in the Permian and even extend into the Triassic. *Namaichthys* is *apparently* a local genus, while *Rhadinichthys*, the occurrence of which in the Dwyka Series is doubtful, is the only true Carboniferous form.

Veatch does not rely on this evidence, but on Haughton's study of the Reptilia. Haughton (62, pp. 252–262) does not adduce direct evidence bearing on the absolute age of the Dwyka glacials; his conclusion that the Reptilia (chiefly *Mesosaurus*) indicate an Upper Carboniferous age is based on a theoretical consideration as to rate of development and migration and cannot be allowed undue weight in the determination of absolute age. In fact, it would appear that his conclusions cannot stand in view of the recently published information from South America (discussed later).

Apart from the local evidence, both Du Toit and Veatch rely to a considerable degree on evidence from New South Wales. Their viewpoints, however, are quite different. Du Toit relies on a correlation of the Dwyka Series with the Lower Marine Series. We agree that the invertebrate fauna, though comprising only four genera, suggests a correlation of the Dwyka Series with the Lower Marine Series of New South Wales, and the Speckled Sandstone Series of India, the age of which, for reasons already given, we regard as Lower Permian. The *Eurydesma* (*globosum*) is recorded from the Upper Marine (Permian) of New South Wales. Veatch (30, p. 155) regards the Lower Marine Series as Permian, and develops his argument thus:

"Beds containing glacial boulders are found in Australia at several horizons in the Lower Marine Series and Upper Marine Series, both of Permian age, but these deposits, in contradistinction to the continental glaciation shown by the great succession of tillites, outwash gravels and varve shales of the Carboniferous ice sheets . . . . show only iceberg transported materials from glaciers, presumably a considerable distance to the south. . . . In view of this condition in Australia, it seems improbable that the continental ice sheets survived much farther north, in Africa, beyond the Upper Carboniferous."

Veatch rightly stresses the change in type of glacial deposits. Browne and Dun (4, pp. 200–202) earlier stressed the same fact and, in addition, showed that not only was the environment different, but that the lithology of the pebbles and boulders was also different, indicating derivation from a different source. The older tillites have granite, aplite and quartz porphyries, the younger, diorites, gabbros, porphyrites and andesites, so that it cannot be argued, as it possibly might have been, if the reverse had been true, that the change was due to the stripping of a granite bathylith. Veatch, however, and so also Schuchert (25, p. 546), overlook the fact that a great number of the erratics in the Branxton and Muree beds are quartzites with Devonian fossils which can be matched at the outcrop 100 miles S.W. from the Hunter Valley. As this area is approached the quartzite boulders in the marine deposits are so numerous, i.e., in tillites at Dunedoo, Marangaroo, and Little Hartley, that we must conclude there was land ice there well into the Permian and certainly long after the appearance of the *Eurydesma* fauna.

Hence Veatch cannot conclude either that the glaciation is entirely pre-*Eurydesma* or pre-Permian.

South America.

The evidence to be gleaned from the Upper Palaeozoic succession of South America is similar to that of South Africa.

In the Parana basin the lower part of the Gondwana sequence is classified as follows (37, p. 1728):

Lower Estrada Nova	Shale and grey sandstone.
Iraty	Shale and bituminous limestone.
Tubarao Series	Sandstones and grey shale.
Itarare	Tillites and glacial sediments.

The Itarare glacials have not yielded many fossils. Cowper Reed assigned the fauna to the Carboniferous (38, pp. 494–496), but Oppenheim (37, p. 1738) thinks it should be regarded as Permian. The Tubarao Series contains a flora which, according to Oppenheim (p. 1741), David White considered to be Permian. The lower beds contain: *Gangamopteris cyclopteroides*, *Gangamopteris obovata*, *Glossopteris browniana*, *Cordaites hislopi*, *Phyllotheca griesbachi*, *Lepidopholios aricinius*, *Sigillaria bradrii*, *Lepidodendron pedroanum*, *Pecopteris* spp. Several species of *Glossopteris* are found in the higher Tubarao beds.

Here, as in South Africa, representatives of the *Rhacopteris* flora occur with those of the *Glossopteris* flora, an association which has already been considered in our discussion of the South African sequence.

Mesosaurus tenuidens is found in the Iraty shales. These beds are about 300 feet thick and pass upwards through the Lower Estrada Nova (about 200 feet thick) into Triassic sediments. In view of this and the considerable thickness of beds below the Iraty characterized by the *Glossopteris* flora, it would seem almost impossible to maintain an age older than Permian for *Mesosaurus*.

North-West Basin, Western Australia.

The term North-West Basin is used to describe a part of North Western Australia lying west of the 116th east meridian and north of 27° south latitude. It includes most of the country drained by the Lyndon, Minilya, and Wooramel Rivers, and the lower course of the Gascoyne.

A detailed account of the stratigraphy of this region was given by Raggatt in a recent paper (1). An abridged account appeared shortly afterwards in the Bulletin of the American Association of Petroleum Geologists (39).

A summary of the stratigraphy of the Upper Palaeozoic and some brief notes thereon are now given:

SUMMARY OF UPPER PALAEOZOIC STRATIGRAPHY (DESCENDING SEQUENCE).

Series.	Stage.	Thickness in Feet.	
Gascoyne.	Wandagee.	1,250–1,450	Mainly shale with thin-bedded friable sandstone and sandy limestone.
	Kennedy.	400–700	Almost wholly sandstone, including dense blocky ferruginous, well bedded white micaceous and fine grained yellowish-brown types. Ferruginous marine fossil casts and concretions found in some places.
	Byro. Disconformity ?	2,300	Mainly marine argillaceous sandstone and sandy shales in upper half; thin bedded marine sandstones and sandy to carbonaceous shales in lower half (mainly marine but freshwater in part). Small glacial erratics in lower 300 feet.
	Wooramel.	130–280	Sandstone with some thin quartz pebble bands. Sparse marine fauna.
	Callytharra. Disconformity ?	85–400	Flaggy limestone and calcareous shaly mudstone. Rich marine fauna.
Lyons.		2,150–2,400	Upper 300 feet mainly shales with sandstones and fossiliferous limestones; remainder fine grained sandstone, glacial boulder beds and some shales. Glacial erratics up to 12 feet in length. Marine fossils in lower part 1,300 to 1,600 feet below top of series.

The total thickness of the Upper Palaeozoic on the Gascoyne River is about 6,750 feet, and on the Lyndon River 7,350 feet. The Upper Palaeozoic is overlain unconformably by the Cretaceous and rests unconformably on the Pre-Cambrian.

The Lyons Series is distinguished from the rest of the sequence by being dominantly glacial. The lowest fossils known in the section are those found by Raggatt near Windalia Outcamp on the Lyndon River in 1935. These and the fossils at higher horizons prove that the upper half of the Lyons was deposited in a marine environment, and there is nothing in the lithology of the lower beds to suggest that the conditions under which they accumulated were different.

The Callytharra limestone is also a most distinctive stratigraphical unit, and, were it not for the Winnemia section (1, pp. 147–149), which suggests repetition of Callytharra conditions in early Byro time, the Callytharra might have been constituted a separate series.

Rudd (verbal statement) thinks that Raggatt is in error in assigning the highest beds exposed on the Minilya River to a stratigraphical position above the Kennedy. He considers that these beds are high in the Byro, and Miss Crespin states that the evidence of the micro-fauna is not opposed to this conclusion. If Rudd's contention is correct, proof of the existence of the Wandagee Stage rests upon bore information. This is scarcely open to any other interpretation. As we are mainly concerned in this paper with the age of the Gascoyne Series as a whole, the point is not important at the moment.

PALAEONTOLOGY.

The following fossil lists include those in the earlier paper (1), revised and enlarged. An attempt has also been made to include as much of other previously published information as possible. The lists, as now given, include a number of determinations of fossils from the Wooramel District. Oil Search Ltd. kindly made available a map of this area by E. A. Rudd and T. W. H. Dee. By reference to this map it has been possible to assign many of the fossils in the published lists to stratigraphical units.

Chapman and Miss Crespin have been the most important contributors to the list of fossil determinations, but some have also been made by Fletcher and Miss Prendergast. Fletcher's descriptions will appear shortly in these RECORDS. Since the publication of Raggatt's paper (1), Miss Crespin has had an opportunity of examining type specimens in Perth, and she and Fletcher have checked most of the original determinations. The authority for the determination is given in the next section of the paper.

As we do not refer specifically to the Foraminifera and Ostracoda in our discussion, they are omitted from the present lists.

List of Fossils in Series and Stages.

Lyons Series.

(*a*) About 1,600 feet below top of Series.

Fenestella propinqua De Kon.
Crinoid ossicles cf. *Platycrinus*.
Conularia warthi Waagen.

(*b*) About 1,300 feet below top of Series.

Plerophyllum australe Hinde.
Chonetes pratti Davidson.
(?) *Orthis* (*Rhipidomella*) *australis* McCoy.
Productus sp. nov.

(*c*) Upper part of Series.

Aviculopecten tenuicollis Dana.
Reticularia lineata Martin.
Evactinopora dendroidea Hudleston.
Amplexus pustulosus Hudleston.
Plerophyllum australe Hinde.
Spirifer fasciger var. *australis* Davidson.
„ *hardmani* Foord.
„ *byroensis* Glauert.
Cleiothyris macleayana Eth.
Linoproductus tenuistriatus var. *foordi* Eth.
Productus semireticulatus Martin.
„ *undatus* Defrance.
Spiriferella australasica Eth.

Gascoyne Series.

Callytharra Stage.

Clisiophyllum talboti Hosking.
Plerophyllum australe Hinde.
„ *sulcatum* Hinde.
„ *gregoriana* De Kon.
Amplexus pustulosus Hudleston.
Evactinopora dendroidea Hudles.
„ *crucialis* Hudles.
Dybowskiella sp.
Glyptopora sp.
Coscinum australe Bretnall.
Trachypora sp.
Pachypora sp.
Monilopora nicholsoni Eth.
Fenestella spinulifera Moore.
„ *pectinis* Moore.
„ *horologia* Bret.
„ *affluensa* Bret.
„ *fossula* Lonsd.
Rhombopora tenuis Hinde.
„ *multigranulata* Bret.
„ *mammillata* Bret.
Acanthocladia sp.
Aetomocladia ambrosioides Bret.
Streblotrypa etheridgei Bret.
„ *marmionensis* Eth.
Pinnatopora trilineata var. *texana* Moore.
Protoretepora ampla Lonsd.
Sulcoretepora meridianus Eth.
Polypora cf. *biarmica* Keyser.
Philocrinus sp.
Rhipidocrinus sp.
Platycrinus sp.
Cf. *Cyathocrinus*.
Cf. *Hexacrinus*.
Spiriferella australasica Eth.
Cleiothyris macleayana Eth.
„ „ var. *baracoodensis* Eth.
Chonetes pratti Davidson.
Strophalosia sp. nov.
Seminula randsii.
„ *callytharrensis* Hosking.
Seminula globulina Phillips.
Derbyia cf. *bennetti*.
Reticularia lineata Martin.
Schellwienella sp.
Productus semireticulatus Martin.
„ *punctatus* Phillips.
„ *undatus* Defrance.
„ cf. *spiralis* Waagen.
„ cf. *indicus* Waagen.
Linoproductus cancriniformis Tschern.
„ *tenuistriatus* var. *foordi* Eth.
Spirifer hardmani Foord.
„ *rostalinus* var. *auritus* Hosking.
„ *fasciger* var. *australis* Foord.
„ *dubia* Eth.
Spiriferina cf. *duodecimcostata* (McCoy).
„ *cristata* Schloth.
„ *cristata* var. *decipiens* Hosking.
„ *papilionata* Hosking.
Spirifer cf. *convolutus* Phill.
Syringothyris exsuperans De Kon.
Martiniopsis sp.
Taeniothaerus subquadratus (Morris).
Aulosteges baracoodensis Eth.
„ *spinosus* Hosking.
Composita subtilita Hall.
Streptorhynchus plicatilis Hosking.
Nuculana sp.
Deltopecten subquinquelineatus (McCoy).
Dielasma hastata Sowerby.
„ *nobilis* Eth.
Leptaena analoga Phill.
Pustula senticosa Hosking.
„ *micracantha* Hosking.
Aviculopecten sprenti Johnston.
„ *tenuicollis* Dana.
Bellerephon costatus Sowerby var.
Pleurotomaria sp.
Conularia warthi Waagen.
Spirorbis ambiguus Fleming.

Wooramel Stage.

Protoretepora ampla Lonsdale.
Fenestella horologia Bret.
„ *fossula* Lonsdale.
Aetomacladia ambrosioides Bret.
Rhombopora multigranulata Bret.
Streblotrypa marmionensis Eth.

Strophalosia clarkei Eth.
Productus undatus Defrance.
„ *brachythaerus* Sow.
„ *semireticulatus* Mart.
Taeniothaerus subquadratus (Morris).
Cleiothyris macleayana Eth.
Dielasma trigonaspis Hosking.
Spirifer rostalinus var. *auritus* Hosking.
Spirifer hardmani Foord.
„ *convolutus* Phill.
„ *fasciger* var. *australis* Foord.
Cardiomorpha blatchfordi Hosking.
Palaearca cf. *costellata* McCoy.
Deltopecten subquinquelineatus (McCoy).
Aviculopecten sprenti Johnston.
„ *tenuicollis* Dana.

Byro Stage.

Plerophyllum australe Hinde.
Fenestella horologia Bret.
Polypora cf. *gigantea* W. & Pich.
Philocrinus sp.
Tribrachiocrinus sp.
Chonetes pratti Davidson.
„ *cracowensis* Eth.
Dielasma trigonaspis Hosking.
„ *cymbaeformis* Morris.
Strophalosia clarkei Eth.
„ sp. nov.
Productus semireticulatus Martin.
Aulosteges ingens Hosking.
Linoproductus tenuistriatus var. *foordi* Eth.
Linoproductus cancriniformis Tschern.
Taeniothaerus subquadratus Morris.
Cleiothyris macleayana Eth.
Orthotetes crenistria Phill.
Spirifer byroensis Glauert.
„ *convolutus* Phill.
„ *rostalinus* var. *auritus* Hosking.
„ *fasciger* var. *australis* Foord.
„ *marcoui* Waagen.
Deltopecten subquinquelineatus (McCoy).
Aviculopecten tenuicollis Dana.
Sanguinolites sp.
Cardiomorpha blatchfordi Hosk.
Stutchburia sp.
Myalina sp.
Bellerephon (*Warthia*) sp.
Ptychomphalina maitlandi Eth.
Conularia warthi Waagen.
Palaechlya gigas Eth. (?).

Kennedy Stage.

Chonetes pratti Davidson.
Strophalosia clarkei Eth.
Spirifer fasciger var. *australis* Foord.
Spirifer byroensis Glauert.
Aviculopecten tenuicollis Dana.
Cardiomorpha blatchfordi Hosking.

Wandagee Stage.

Stenopora sp.
Chonetes pratti Davidson.
Spirifer rostalinus var. *crassus* Hosking.
„ *marcoui* Waagen.
„ *byroensis* Glauert.
„ *fasciger* var. *australis* Foord.
Spirifer convolutus Phill.
Aulosteges ingens Hosking.
„ *baracoodensis* Eth.
Strophalosia sp. nov.
Taeniothaerus subquadratus (Morris).

List of Fossils, with Local and Foreign Ranges.

The following is a list of the fossil fauna so far recorded from the Upper Palaeozoic beds of North-West Basin. The stratigraphical distribution of each species in this sequence is given and reference made to the authors who have recorded the species. Any species which have come under notice as being found in the Upper Palaeozoic of the Irwin River and Kimberley Districts (both in Western Australia) are indicated, though this reference does not pretend to be complete.

The range of the species found in Eurasiatic and Eastern Australian areas is given, the principal beds referred to being:

Lower and Upper Marine Series, New South Wales	Permian.
Macleay and Drake Series, New South Wales ..	Permian.
Burindi Series, New South Wales	Lower Carboniferous.
Bowen Series, Queensland	Permian.
Gympie Series, Queensland	Lower Permian.
Rockhampton Series, Queensland	Lower (?) Carboniferous.
Productus limestone, Salt Range, India	Middle and Upper Permian.
Speckled Sandstone, Salt Range, India.......	Lower Permian.
Agglomeratic Slate, Kashmir	Lower Permian.

These beds have all been discussed in the preceding pages.

Coelenterata.

1. *Clisiophyllum talboti* Hosking ..	Restricted to Callytharra Stage (40).
2. *Amplexus pustulosus* Hudleston ..	Lyons to Callytharra Stage (41), (42), (43).
3. *Plerophyllum australe* Hinde	Lyons, Callytharra and Byro Stage (44), (40), (42), (45). Kimberley District (46). Irwin River District (42).
4. „ *sulcatum* Hinde ...	Callytharra Stage (44). Irwin River District (42).
5. „ *gregoriana* De Kon.	Callytharra Stage (44). Upper Marine Series. Burindi (?). Gympie to Middle Bowen Series.
6. *Evactinopora dendroidea* (Hudl.)	Lyons and Callytharra Stage (45), (44), (41).
7. „ *crucialis* (Hudl.) ..	Callytharra Stage (41).. Kimberley District (46).
8. *Dybowskiella* sp.	Callytharra and basal Byro Beds (44). This genus occurs in the Middle and Upper Divisions of the Productus Limestone.
9. *Monilopora nicholsoni* Eth.	Callytharra Stage (44). Kimberley District (46). Gympie and Lower Bowen Series. Macleay and Drake Series.

Echinodermata.

10. *Philocrinus* sp.	Callytharra and Byro Stage (44). Upper Marine Series. Middle Productus Limestone. Permian of Timor.
11. *Rhipidocrinus* sp.	Callytharra Stage (44).
12. *Platycrinus* sp.	Cf. *Platycrinus* from Lyons Stage. Callytharra Stage (44). Burindi. Lower Bowen (*Platycrinus* ? *nux* Eth.). Permian of Timor.

13. *Tribrachiocrinus* sp.	Byro Stage (44). Upper Marine Series. Lower and Middle Bowen Series. Macleay Series.
14. Cf. *Cyathocrinus*	Callytharra Stage (44), (41). Genus occurs in Permian of Timor.
15. Cf. *Hexacrinus*	Callytharra Stage (44).
16. *Poteriocrinus* sp.	Callytharra Stage (41). Permian of Timor.
Annelida.	
17. *Spirorbis ambiguus* Fleming	Callytharra Stage (43).
Bryozoa.	
18. *Fenestella propinqua* De Kon. ...	Lyons Stage (43). Macleay Series. Burindi. Upper Marine Series.
19. „ *horologia* Bretnall ...	Callytharra, Wooramel and Byro Stage (40), (47), (48).
20. „ *pectinis* Moore	Callytharra Stage (44).
21. „ *spinulifera* Moore	Callytharra Stage (44).
22. „ *affluensa* Bretnall ...	Callytharra Stage (47), (40).
23. „ *fossula* Lonsdale	Calytharra and Wooramel Stage (40). Upper Marine Series. Gympie to Middle Bowen Series. Agglomeratic Slate, Kashmir. Burindi.
24. „ *modesta* Ulrich	Callytharra Stage (44).
25 *Stenopora tasmaniensis* Lonsd. ...	Callytharra Stage (44). Lower and Upper Marine Series. Genus occurs in Gympie to Upper Bowen Series.
26. *Protoretepora ampla* Lonsdale ..	Callytharra to Wooramel Stage (44), (45). Lower and Upper Marine Series. Drake and Macleay Series. Gympie to Middle Bowen Series. Agglomeratic Slate, Kashmir.
27. *Polypora* cf. *biarmica* Keyser	Callytharra Stage (45). Upper Marine Series. Upper Productus Limestone.
28. „ cf. *gigantea* W. & P. ..	Restricted to Byro Stage (45). Middle Productus Limestone.
29. *Pinnatopora trilineata* var. *texana* Moore	Callytharra Stage (44).
30. *Glyptopora* sp.	Callytharra Stage (44).
31. *Sulcoretepora meridianus* Eth. ..	Callytharra Stage (47), (40).
32. *Coscinum* (?) *australe* Bret.	Callytharra Stage (44), (47). (?) *Coscinum* from Wooramel Stage (40).

33. *Rhombopora tenuis* Hinde	Callytharra Stage (47), (44), (42).
34. „ *multigranulata* Bret.	Callytharra to Wooramel Stage (44), (40), (47).
35. „ *mammillata* Bret. ..	Callytharra Stage (40), (47).
36. *Aetomacladia ambrosioides* Bret.	Callytharra to Wooramel Stage (47), (44), (40)).
37. *Streblotrypa marmionensis* Eth. ..	Callytharra to Wooramel Stage (47), (44), (40).
38. „ *etheridgei* Bret.	Callytharra Stage (47)), (44).
39. *Acanthocladia* sp.	Callytharra Stage (44). Genus ranges from Burindi to Middle Productus Limestone.
40. *Lyropora* (?) *erksoides* Eth.	Callytharra Stage (47).
41. *Trachypora* sp.	Callytharra Stage (44). Upper Marine Series. Gympie and Lower Bowen (genus). Macleay Series and Drake Series.
42. Cf. *Pachypora*	Callytharra Stage (44). Gympie Series (genus). Permian of Japan (genus).

Brachiopoda.

43. *Leptaena analoga* (Phill.)	Callytharra Stage (44). Burindi. Rockhampton and Gympie Series. Agglomeratic Slate, Kashmir.
44. *Dielasma hastata* Sowerby	Callytharra Stage (44). Burindi to Upper Marine Series. Lower and Middle Bowen Series.
45. „ *cymbaeformis* Morr. ...	Byro Stage (40). Lower and Middle Bowen Series. Upper Marine Series.
46. „ *trigonopsis* Hosking ...	Wooramel to Byro Stage (49).
47. *Schellwienella* sp.	Callytharra Stage (44). Agglomeratic Slate, Kashmir.
48. *Orthotetes crenistria* (Phill.)	Byro Stage (43). Kimberley District (46). Irwin River District (50). Burindi. Genus only from Gympie, Lower and Middle Bowen Series.
49. *Chonetes pratti* Davidson	Lyons Series, Byro, Kennedy and Wandagee Stages (51), (44), (45), (40), (43), (48), (52), Kimberley District (46).
50. „ *cracowensis* Eth.	Byro Stage (44). Rockhampton to Lower Bowen. Speckled Sandstone.

51. *Strophalosia clarkei* Eth.	Wooramel to Wandagee Stage (45), (44), (48). Burindi (?). Upper Marine Series. Agglomeratic Slate, Kashmir. Gympie (?), Lower and Middle Bowen Series. Lower and Middle Productus Limestone.
52. „ sp. nov.	Byro Stage (45). Kimberley District (53).
53. *Aulosteges baracoodensis* Eth. ...	Callytharra, Byro and Wandagee Stage (54), (43), (48). Kimberley District.
54. „ *spinosus* Hosking	Callytharra Stage (54).
55. „ *ingens* Hosking	Byro and Wandagee Stages (45), (40).
56. *Taeniothaerus subquadratus* (Morris)	Callytharra to Byro Stage (44), (40), (55). Irwin River District (56). Kimberley District (57). Lower and Middle Bowen Series. Lower and Upper Marine (Tasmania). Lower Marine Series (N.S.W.).
57. *Productus semireticulatus* (Martin)	Lyons Series to Byro Stage (44), (40), (45), (48). Kimberley District (57). Burindi and Gympie Series. Lower Productus Limestone. Permian of Timor. Muscovian to Artinskian.
58. *Productus* sp. nov.	Lyons Series (45).
59. „ *punctatus* Phill.	Callytharra Stage (44). Burindi. Upper Carboniferous to Artinskian of Europe.
60. „ *undatus* Defrance	Lyons to Wooramel Stage (44), (40). Irwin River District (56), (50), (58). Burindi. Gympie Series (?).
61. „ cf. *indicus* Waagen ...	Callytharra Stage (45). Middle and Upper Productus Limestone.
62. „ cf. *spiralis* Waagen ...	Callytharra Stage (45). Lower Productus Limestone.
63. „ *brachythaerus* Sow. ...	Wooramel Stage only (44). Kimberley District (57). Gympie, Lower, Middle and Upper Bowen Series. Lower and Upper Marine Series.

64. *Linoproductus tenuistriatus* de Vern. var. *foordi* Eth.	Lyons Series, Callytharra and Byro Stage (44), (45), (40), (48). Kimberley District (57).
65. *Linoproductus cancriniformis* Tschern.	Callytharra and Byro Stage (55). Kimberley District. Artinskian.
66. (?) *Orthis* (*Rhipidomella*) *australis* (McCoy)	Lyons Stage only. Identification of imperfect single specimen (45). Known from Burindi and a shell with close affinities recorded from Agglomeratic Slate, Kashmir.
67. *Spiriferella australasica* Eth.	Lyons to Callytharra Stage (55), (44), (40). Irwin River District (56). Kimberley District (46).
68. *Spiriferina* cf. *duodecimcostata* (McCoy)	Callytharra Stage (44). The typical species is found in Burindi to Upper Marine. Gympie to Upper Bowen Series. Agglomeratic Slate, Kashmir.
69. *Spirifer fasciger* Keys. var. *australis* Foord	Lyons to Wandagee Stage (45), (52), (50), (43), (44), (40), (55). Agglomeratic Slate, Kashmir. Lower, Middle and Upper Productus Limestone. Permian of Timor. Kolyma area, Russia (Permian).
70. *Spirifer hardmani* Foord	Lyons to Wooramel Stage (45), (50), (40), (44), (43). Kimberley District (57). Agglomeratic Slate, Kashmir.
71. „ *byroensis* Glauert	Lyons, Callytharra, Byro, Kennedy and Wandagee Stage (44), (40), (52), (48), (46). Kimberley District (46). Lower Bowen (?).
72. „ *dubia* Eth.	Callytharra Stage (44). Gympie Series.
73. „ *convolutus* (Phill.)	Wooramel, Byro and Wandagee Stage (52), (44). Middle Bowen Series.
74. „ *rostalinus* var. *auritus* Hosking	Callytharra to Byro Stage (40).

75.	*Spirifer marcoui* Waagen	Byro and Wandagee Stage (46), (45). Kimberley District (?) (57). Upper Speckled Sandstone. Lower and Middle Productus Limestone beds.
76.	„ *rostalinus* var. *crassus* Hosk.	Wandagee Stage (40).
77.	*Spiriferina cristata* Schloth. var. *decipiens* Hosking	Wooramel Stage (49).
78.	*Spiriferina cristata* Schloth.	Wooramel and Byro Stage (49), (48). Lower and Upper Productus Limestone.
79.	*Reticularia lineata* Martin	Lyons, Callytharra and genus recorded from basal Byro Stage (44), (55), (45), (40), (43). Irwin River District (50), (58). Burindi. Lower Productus Limestone. Permian of Timor. Moscovian to Artinskian. Fusulina limestone of Kinsyozan, Akasaka-Mati, Japan (Lower Permian).
80.	*Cleiothyris macleayana* Eth.	Lyons to Byro Stage (44), (48), (43), (40), (50). Kimberley District.
81.	„ *macleayana* Eth. var. *baracoodensis* Eth.	Callytharra Stage (43).
82.	*Derbyia* cf. *bennetti*	Callytharra Stage (44).
83.	*Syringothyris exsuperans* De Kon.	Callytharra Stage (44), (45), (50). Burindi. Genus recorded from Macleay Series. An allied species recorded from Agglomeratic Slate of Kashmir.
84.	*Seminula randsii*	Callytharra Stage (44).
85.	„ *globulina* Phillips	Callytharra Stage (55). Upper Productus Limestone.
86.	„ *callytharrensis* Hosk. ..	Wooramel Stage (49).
87.	*Martiniopsis* sp.	Callytharra Stage (44). Lower and Upper Marine Series. Gympie to Middle Bowen Series. Agglomeratic Slate, Kashmir (*M.* cf. *subradiata*). Lower and Upper Productus Limestone.
88.	*Composita subtilata* (Hall)	Callytharra Stage (55). Irwin River District (58). Kimberley District (55). Burindi.
89.	*Pustula senticosa* Hosking	Calytharra Stage (49), (48).
90.	„ *micracantha* Hosking ...	Callytharra Stage (49).

91. *Streptorhynchus plicatilis* Hosking	Callytharra Stage (59).
92. *Spiriferina papilionata* Hosking	Callytharra Stage (49).
Pelecypoda.	
93. *Palaearca* cf. *costellata* McCoy ...	Wooramel Stage (44). Burindi. Neerkol Series.
94. *Parallelodon* sp.	Callytharra Stage (40). Genus occurs in Rockhampton Series. „ „ „ Burindi Series. Agglomeratic Slate, Kashmir.
95. *Sanguinolites* sp.	Byro Stage (44). Burindi. Lower and Upper Marine Series. Gympie Series. Agglomeratic Slate, Kashmir.
96. *Nuculana* sp.	Callytharra Stage (44). Gympie to Lower Bowen Series. Agglomeratic Slate, Kashmir. (This form, *N.* (*Leda*) *thompsoni*, thought to be identical with form from Lower and Upper Marine Series. Kimberley District. Upper Productus Limestone.
97. *Cardiomorpha blatchfordi* Hosking	Wooramel to Kennedy Stage (40), (44).
98. *Aviculopecten tenuicollis* Dana ..	Lyons to Kennedy Stage (45), (44), (43). Kimberley District (53). Lower and Upper Marine Series. Lower and Middle Bowen Series.
99. „ *sprenti* Johnst. ...	Wooramel and Byro Stage (44), (52). Irwin River District (58). Lower and Upper Marine Series. Gympie and Middle Bowen Series.
100. *Deltopecten subquinquelineatus* (McCoy)	Wooramel and Byro Stage (40), (44), (48), (52). Irwin River District (56). Kimberley District (57). Lower and Upper Marine Series. Gympie, Lower and Middle Bowen Series. (?) Agglomeratic Slate, Kashmir.
101. *Deltopecten illawarensis* Morris ..	Wooramel Stage (49). Lower and Upper Marine Series. Lower Bowen Series.
102. *Stutchburia* sp.	Byro Stage (49). Irwin River District (58). Lower and Upper Marine Series. Lower and Middle Bowen Series.

Gastropoda.	
103. *Ptychomphalina maitlandi* Eth. ..	Callytharra and Byro Stage (44), (40).
104. *Pleurotomaria* sp.	Callytharra Stage (48).
	Lower and Upper Marine Series.
	Burindi.
	Gympie to Middle Bowen Series.
	Middle and Upper Productus Limestone beds.
	Agglomeratic Slate, Kashmir.
105. *Bellerephon (Warthia) costatus* Sowerb. var.	The genus has been recorded from Callytharra and Byro Stages (46).
	Irwin River District (58).
	Lower and Upper Marine Series.
	Lower to Upper Bowen Series.
	Upper Productus Limestone.
	Agglomeratic Slate, Kashmir.
Pteropoda.	
106. *Conularia warthi* Waagen	Lyons to Byro Stage (45), (40), (49), (52).
	Speckled Sandstone.
Cephalopoda.	
107. *Orthoceras* cf. *martinianum* De Kon.	Callytharra Stage (44).
	Burindi.

FAUNISTIC RESULTS AND CONCLUSIONS.[5]

The fauna of the Upper Palaeozoic beds of North-West Basin shows an intermingling of Eastern Australian and Productus Limestone forms with local species.

There are 107 species in the foregoing list. Two of these—14 and 42— have no importance in this discussion. Forty-four are local species, but these include three species of *Aulosteges*, a genus restricted to the Permian.

Of the remainder, 26 are identical with species described from the Permian of New South Wales. Actually 24 of these are found in the Upper Marine Series, only two—9 and 103—being restricted to the Lower Marine or an equivalent series. Eighteen species are known from the Productus Limestone, and, of these, six are found also in the Permian of New South Wales. Three species are recorded —106, 50, 75—which occur in the Speckled Sandstone, one of which—75—is also a Productus Limestone species, and one—50—a Rockhampton to Lower Bowen species. In addition to those already mentioned, seven species—12, 16, 65, 71 (?), 73, 72—have been recorded from the Permian of Timor, Europe or Queensland. Two forms—47, 70—are common only to Western Australia and the Agglomeratic Slate of Kashmir, and an additional three—43, 66, 95—common to Western Australia, Agglomeratic Slate and Burindi Series of New South Wales. That is, of 61 species common to both the North-West Basin and other regions, 51 occur in beds the Permian age of which has been indicated in this paper. The great majority, in fact, occur in beds whose Permian age has been accepted for many years.

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[5] Numbers quoted in this section of the paper refer to the foregoing list.

The nine species not so far considered are:

20. *Fenestella pectinis* Moore.
21. ,, *spinulifera* Moore.
29. *Pinnatopora trilineata* var. *texana* Moore.
48. *Orthotetes crenistria* (Phill.)
60. *Productus undatus* Defrance.
83. *Syringothyris exsuperans* De Kon.
88. *Composita subtilata* (Hall).
93. *Palaearca* cf. *costellata* McCoy.
107. *Orthoceras* cf. *martinianum* De Kon.

The three American species—20, 21, 29—are recorded from the Upper Graham formation of North Central Texas, originally placed in the Pennsylvanian, but now, we understand, considered to be Lower Permian.

The remaining six are all Australian species and, with the possible exception of 60, are restricted to the Carboniferous in Eastern Australia. Two of these —48 and 60—range high in the Western Australian sequence, and it is worthy of note that these two, together with 88, have been recorded from other parts of Western Australia. Five of the six species are restricted to the Callytharra Stage.

Evidence bearing on the age of the North-West sequence is provided by correlation with the Irwin River and Kimberley areas. Some discussion of a suggested correlation with the Irwin River sequence has been given by Raggatt (1). One of the correlations discussed in that paper was that of the Callytharra with the Fossil Cliff beds. In preparing the present paper it has been noted that the beds contain many species in common. Miss Crespin agrees that the correlation is supported by a study of the Foraminifera (written note).

From shales about 500 feet above the glacials (equivalents of Lyons Series) in the Irwin River, ammonites have been collected which have been determined by A. K. Miller (60) as *Metalegoceras jacksoni*, a genus not known outside the Permian in Europe. This horizon is 1,000 feet below the Fossil Cliff beds.

One of the most important Upper Palaeozoic sequences in Australia is that of the Kimberley region, but until the results of Dr. Wade's recent researches have been published it would be unwise to attempt much discussion about this interesting region. It will be noted, however, that sixteen species in our lists are reported from the Kimberley area. It seems likely that the Callytharra fauna is represented in beds at Mt. Marmion. Ammonites lately collected by Dr. Wade from the top of the glacial series in the Kimberley succession have recently been described by A. K. Miller (13) as *Thallassoceras wadei* and *Metalegoceras clarkei*. He states: ". . . . it is concluded that the beds from which these cephalopods came are Middle Permian in age and are to be correlated in a general way with the *Metalegoceras jacksoni* beds of the Irwin River coalfield (Western Australia), the Bitauni beds of Timor, the Artinsk sandstone of the Urals and the Leonard formation of western Texas."

Whilst, therefore, it is concluded from the faunal analysis and the general evidence afforded by correlation that the whole of the Upper Palaeozoic succession of the North-West Basin is undoubtedly Permian, it is difficult to see where the dividing lines between Lower, Middle, and Upper Permian should be placed.

In the Lyons Series three species have been recorded from 1,600 feet below the top of the Series. *Fenestella propinqua*, which is apparently restricted to these beds in Western Australia, has been recorded from the Permian (Upper Marine and Macleay Series) of New South Wales. Ossicles of a crinoid doubtfully determined as *Platycrinus* have no value for stratigraphic correlation. The genus is found, however, in the Callytharra Stage and has been recorded from the Permian beds of Timor. *Conularia warthi* ranges into the Byro Stage. This species has been described from the Speckled Sandstones of the Salt Range, a series discussed in this paper and concluded to be Lower Permian.

From the middle horizon in the series, four forms have been collected. A new species of *Productus*, which is abundant here, does not appear to range any higher. *Plerophyllum australe* is also particularly abundant, but, like another fossil of this horizon, *Chonetes pratti*, it ranges well up in the sequence. It will be noticed that this is true of a great number of species in the North-West Basin. The fourth fossil is one referred to (?) *Orthis* (*Rhipidomella*) *australis*. This determination is doubtful, being based on a single badly preserved specimen.

Of the thirteen species so far recorded from the upper part of the Lyons Series, not one is restricted in range. Eight are local species, but included among them is *Evactinopora dendroidea*. In the Salt Range this genus is found only in the Middle and Upper Productus Limestone. Of the remainder, *Aviculopecten tenuicollis* occurs in the Lower and Upper Marine Series in New South Wales and the Lower and Middle Bowen in Queensland. Two particularly interesting species (*Reticularia lineata* and *Productus semireticulatus*), occur here. These are cosmopolitan species with about the same range, namely, Carboniferous to Artinskian. With them is *Spirifer hardmani*, also recorded from the Agglomeratic Slate of Kashmir. All these are found at higher horizons in the local sequence. The Carboniferous species, *Productus undatus*, previously referred to, occurs here, and ranges up to the Wooramel Sandstone.

In the Callytharra Stage are found several of the Carboniferous species—60, 83, 88—referred to above, along with a typically Permian assemblage, including *Deltopecten*, *Aulosteges*, *Nuculana*, *Strophalosia*, *Dybowskiella*, *Martiniopsis*, *Philocrinus*, *Protoretepora*, all the species discussed in the previous paragraph, and many others. The much discussed *Monilopora nicholsoni* and a common associate of this fossil, *Taeniothaerus subquadratus*, are also present, but, whereas the former is restricted to the Callytharra, the latter ranges up into the Byro. *Trachypora* sp. is a form in which the genus is common in the Upper Marine, *Trachypora wilkinsoni* being one of the most characteristic corals of that series. *Seminula globulina* has been recorded from the Upper Productus Limestone beds.

The presence of three Carboniferous species and of *Parallelodon*, *Schellwienella*, and *Leptaena analoga* in the Callytharra Stage suggests that it is low in the Permian.

Although there are perhaps 4,000 feet of strata above the Callytharra, the fauna does not show much variation.

The following species make their first appearance in the Wooramel Sandstone:

51. *Strophalosia clarkei.*
63. *Productus brachythaerus.*
74. *Spirifer convolutus.*
100. *Aviculopecten sprenti.*
101. *Deltopecten subquinquelineatus.*
102. ,, *illawarensis.*

All except two—63, 102—are found in higher beds. These are all characteristically Permian forms, but all except one have a long range in Eastern Australia. The exception—74—is a Middle Bowen form.

Among species which first appear in the Byro those of special interest are: *Tribrachiocrinus* which occurs with abundant *Deltopecten subquinquelineatus*, *Dielasma cymbaeformis*, *Spirifer marcoui*, *Chonetes cracowensis* (Lower Permian in Queensland and India), *Orthotetes crenistria* (Burindi). *Spirifer marcoui* is found in Lower and Middle Productus beds, Middle Permian of India.

It is interesting to note also that *Spirifer fasciger* var. *australis* ranges from the top of the Lyons Series to the Wandagee beds. A closely allied, if not identical, species from the Salt Range extends from the Lower to the Upper Productus Limestones.

Mention may be made of the fossil shark *Helicoprion* (?). Great stress has been laid upon the importance of this fossil (2 and 3), but the facts about it unfortunately are that it was not found *in situ*, and that it is practically impossible to identify it beyond doubt. Judging by the lithology of the matrix and the fact that the specimen was picked up somewhere on the Arthur River, Raggatt would hazard the guess that it came from the Byro Stage. If so, it is Permian; but in view of the uncertainty attaching to the specimen no useful conclusions can be drawn from it.

From this analysis and from the evidence provided by correlations, we conclude that the greater part of the Lyons Series, including all the marked glacial boulder beds, is Lower Permian in age. As we have seen, the correlates of the upper part of the Lyons Series in the Irwin and Kimberley Districts contain ammonites considered to be Middle Permian. The upper shaly part of the Lyons Series, the Callytharra and Wooramel Stages, and the basal Byro beds of the Winnemia sequence (1, pp. 147–9), are all closely related palaeontologically, and should perhaps be grouped together in the Middle Permian. The remainder of the sequence is then Upper Permian.

Tentatively we suggest the following scheme of sub-division:

Upper Permian: Wandagee, Kennedy and Byro Stages, except basal part.

Middle Permian: Basal part of Byro Stage, Wooramel Stage, Callytharra Stage, upper 300 feet of Lyons Series.

Lower Permian: Lower part of Lyons Series, including all important glacial beds.

Finally, some points of general interest may be mentioned.

The extended range of many of the species in the Permian of the North-West Basin has been remarked earlier. This is a feature common to the Permian of New South Wales, and has been emphasized by Reid (17, p. 47) in his discussion of the Queensland Upper Palaeozoic.

Small glacial erratics occur in the lower part of the Byro Stage in beds which are correlated with the "Upper Marine" of the Irwin River (1, p. 153). David (3) has suggested the correlation of the Irwin River coal measures with the Greta of New South Wales. This seems likely to be sustained, as does correlation of the Lyons with the Lochinvar glacials. The higher glacials would thus accord quite well with those of the Branxton-Mulbring beds of New South Wales.

Correlation with the Irwin River also provides valuable information on the appearance of the *Glossopteris* flora in Western Australia. With the exception of *Dadoxylon* (?) from an horizon high in the Byro, no determinable plant fossils have been found in the North-West Basin. However, from the Irwin River coal measures, which are considered to be the equivalents of the basal Byro beds, the following plants have been identified (3, p. 509): *Gangamopteris*, three species of *Glossopteris*, *Noeggerathiopsis*, *Bothrodendron*, *Sphenopteris lobifolia*.

In the palaeozoic fauna of the North-West Basin we clearly have many representatives of the typical cold-water (*Eurydesma-Conularia*) Permian fauna, though *Eurydesma* itself, curiously enough, has not been found there so far. The similarity in the faunas of the Kashmir, Indian, and Australian sequences is so striking that contemporaneity and free communication between these regions may be assumed. We appear to be justified in concluding that beds characterized by the *Eurydesma-conularia* fauna and the *Gangamopteris-Glossopteris* flora should be assigned to the Permian.

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