Later Palaeogeography of Queensland.

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Text Figures 1-4.

I. INTRODUCTION.

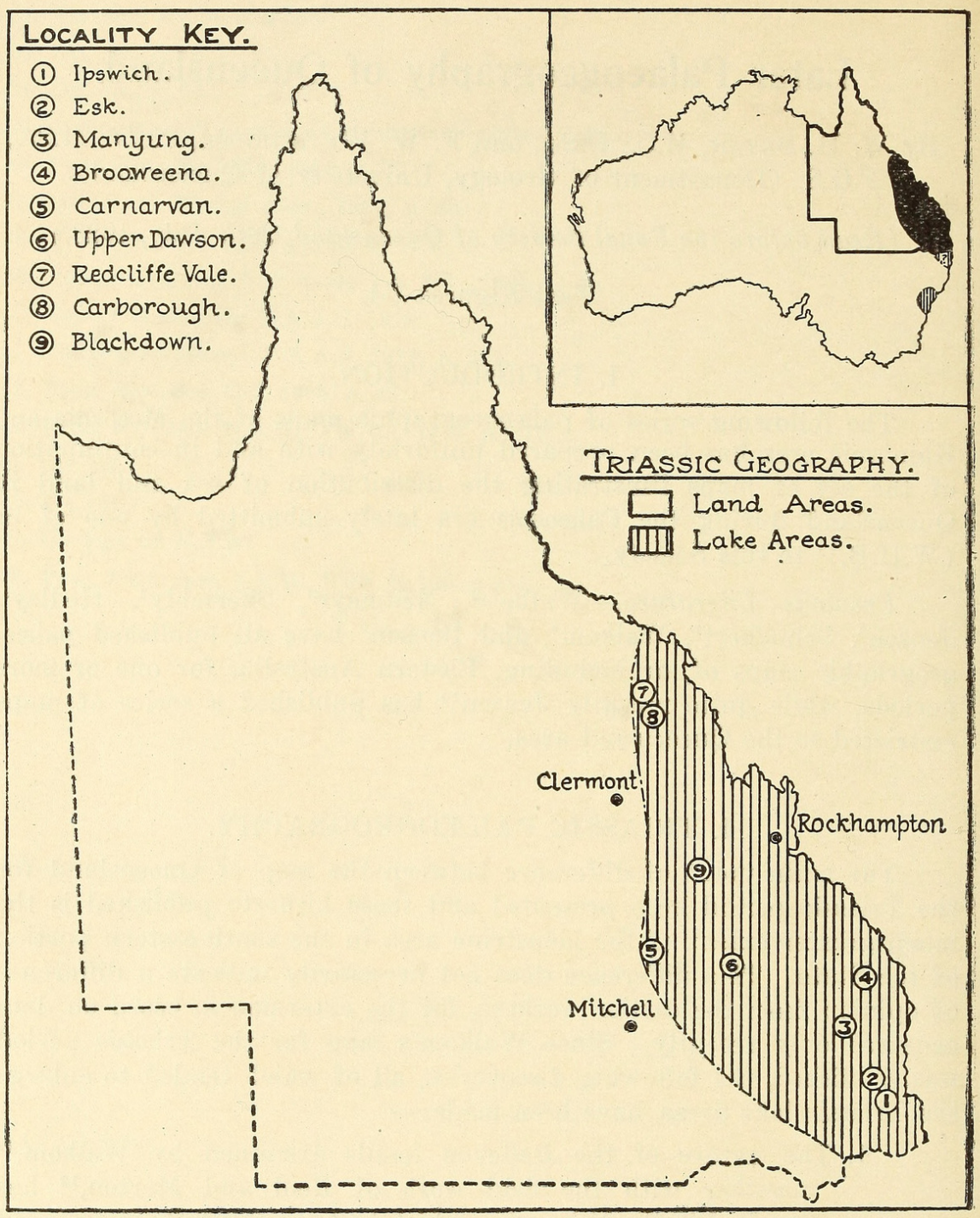
The following series of palæogeographic maps of the Mesozoic and Kainozoic eras has been prepared uniformly with and in continuation of the set of maps illustrating the distribution of sea and land in Queensland during the Palæozoic era lately submitted by one of us (W.H.B.)[1] to this Society.

Previous Literature.—Wallace[2], Neumayr[3], Skertchly[4], Hedley[5], Jensen[6], Schuchert[7], Walkom[8], and Benson[9] have all published palæogeographic maps of, or including, Eastern Australia, for one or more periods, while quite recently Jensen[10] has published a series of maps restricted to the Queensland area.

II. TRIASSIC PALÆOGEOGRAPHY.

The main point of difference between the map of Queensland for the Triassic period here presented and those hitherto published is the much greater extent of the lacustrine area in the south-eastern portion of the State. This difference does not necessarily indicate a difference of opinion from the earlier workers, for the extension is based on data acquired only recently. Since Walkom's map for the Triassic period was published, the following discoveries, all of which tended to enlarge the Triassic lake areas, have been made:—

1. The nature of the Bellevue fossils examined by Walkom,[11] together with the field work of Reid and Morton,[12] has resulted in the Esk series, which had previously been assigned tentatively by Walkom to the Walloon (Jurassic) series, being correlated with the Ipswich (Triassic) series.
2. The work of Bryan and Massey[13] has shown that the so-called "Tiaro series," formerly regarded as the equivalent of the Walloon series, was in reality made up of three conformable series, the lowest of which could be correlated satisfactorily with the Ipswich series.
3. The discovery by Jensen[14] of an extensive series of deposits equivalent to the Ipswich series to the north of Roma.
4. The correlation of certain areas of massive sandstone, which occur overlying the Bowen River coalfield and its southerly prolongation, with the Bundamba series, by Reid.[15]



Text-figure 1.

Although the barren Bundamba series has not yielded sufficient fossils for the precise determination of its age, the authors have followed Walkom[16] in treating it with the underlying Ipswich series rather than with the overlying Walloon series. Thus, while the numbers 1 to 5 in the accompanying map represent localities in which the Ipswich series (or one of its equivalents) is found, localities 6 to 9 represent massive sandstones of Bundamba type. The authors are indebted to officers of the Geological Survey of Queensland for information as to the position and extent of these sandstones.

Although the Triassic lacustrine area, as now mapped, shows a very great enlargement in comparison with the maps of earlier workers, the authors feel that this extension is conservative; for the works of Ball and of Jensen in the Cape York Peninsula suggest that a considerable portion of this area may also have been covered by Triassic lakes.

An interesting feature about the map is that a natural prolongation of the Triassic lake southerly from Queensland would just enclose the area of New South Wales covered by members of the Clarence series. There has been some controversy[17] as to whether the Ipswich and Bundamba series are represented in the Clarence series, and the present map certainly suggests (though it does not prove) that the Clarence area was covered by a lake in Triassic times.

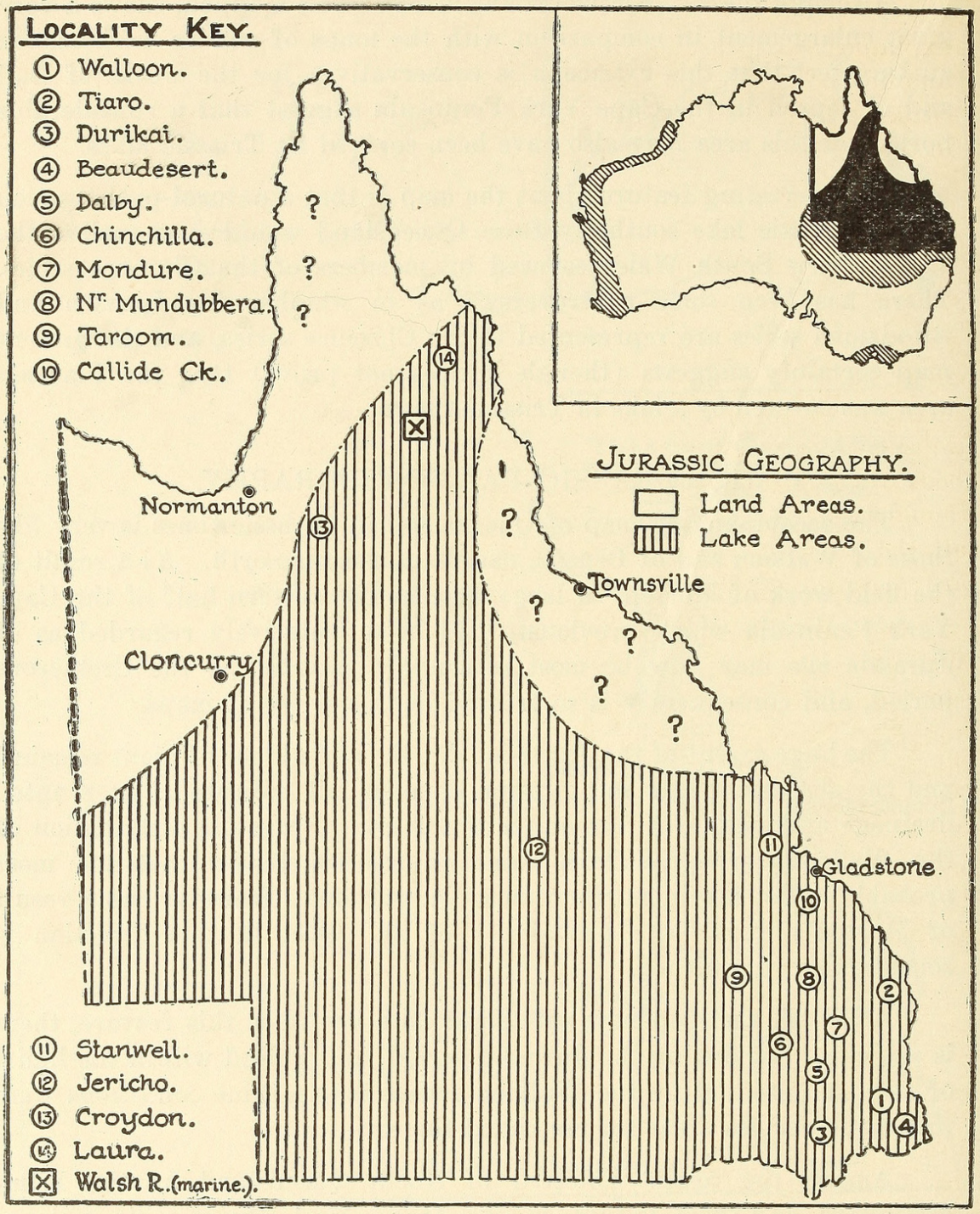
III. JURASSIC PALÆOGEOGRAPHY.

The accompanying map of Queensland in Jurassic times is very like those of Walkom and of Benson, except in the far north. As a result of the field work of Morton[18] a large area in the western half of the Cape York Peninsula which previously had been tentatively regarded as of Jurassic age may now be most reasonably assigned to the Cretaceous period, and consequently is so treated in this series of maps.

The huge extent of the Jurassic lake, the abundance of plant remains, and the absence of salt and gypsum deposits, all indicate uninterrupted drainage and suggest a free outlet to the sea. From the distribution of the Walloon series, Walkom came to the conclusion that the most probable outlet lay in northernmost Queensland. However, as a result of Morton's work[19] the probability of an outlet in this direction is considerably diminished.

Although the map now submitted does not show this feature, there is evidence that during the Jurassic period, and indeed within the limits of time represented by the Walloon series, true marine conditions were present in certain areas for restricted times.

Among the fossils collected in North Queensland by the Hann expedition and now lodged in the Queensland Museum, is a large *Coroniceras* (*C.* aff. *bucklandi* J. Sowerby sp.) recorded from the Walsh River, which flows completely across the Mesozoic outcrops. This would indicate localised marine conditions in the Lower Lias (Coroniceratan stage). Such a phase may have been purely transient, as in Western Australia, where the marine beds of the Jurassic represent merely the *sauzei* and *Emileia* zones of the Bajocian.[20] Similar localised phases of the marine Jurassic (Bajocian and Bathonian) were characteristic also of New Guinea. Consequently one may expect to find, in the future, marine beds of limited thickness interbedded in the Walloons at other localities in Eastern Queensland (see later reference to the Cretaceous Morven bed).



Text-figure 2.

In the several papers dealing with the Jurassic palæogeography of Queensland, mention is often made of a supposed deep inlet which Neumayr named the "Queensland Gulf."[21] Walkom[22] has pointed out that the only positive evidence in favour of the existence of this gulf is "the presence of an impoverished fauna of Foraminifera and Ostracoda in the upper beds of the Wianamatta stage in New South Wales." In spite of its name there is no fossil evidence forthcoming from Queensland itself confirming Neumayr's supposition. Notwithstanding the absence of direct evidence in its favour, the presence of such an inlet in Jurassic times would supply a plausible link, both spatially and temporally, between the great and persistent Tasman geosyncline of Palæozoic times and the present important Thompson trough.

A temporary marine phase in the Walsh River area might well be explained by an epicontinental transgression from such a gulf, or from another possible arm of the sea, extending through the present Torres Strait, which, in the Bathonian, gave an offshoot to the north, resulting in the deposition of marine beds in the Fly and Strickland Rivers region.

Again, if there were an outlet of the Walloon lake to the sea in the north-easterly direction, as suggested on the accompanying map, a marine phase in the Walsh River area may be explained by a fluctuation in this connecting arm.

The Walloon series of Southern Queensland is characterised in many areas by a calcareous phase, which Jensen[23] suggests is typical of the lower portion of the series.[24] Abundant cone-in-cone structure is developed in these beds; and, from the extreme rarity of this feature in beds other than of marine origin in other parts of the world, it may be thought that this also is evidence of localised marine conditions. However, all the available evidence at the moment tends to the idea that these are lacustrine limestones.

Deposition within the lake or series of lakes which gave rise to the Walloon series may not have been continuous or have represented the same time interval in various regions. In the Walsh River area, according to what information is available, there does not seem to be a great thickness of Walloon beds beneath the Roma series (Cretaceous). Consequently, considering the evidence of the *Coroniceras*, it may be that the lower Cretaceous shales in this area rest directly upon Lower Lias beds or beds of a little later date. Should this be so, discontinuous deposition is not necessarily indicated, for overlap, or pene-contemporaneous erosion, may have been involved.

IV. CRETACEOUS PALÆOGEOGRAPHY.

The Cretaceous in Australia was a period of alternating marine and non-marine conditions. The large central depression, occupied in the Jurassic by the Walloon lake, persisted, and, as mentioned later, it is most probable that the lacustrine conditions of the Walloon continued within the Neocomian.

The earliest marine stage known in the Australian Cretaceous is that of the Morven bed, which represents the Simbirskitan stage of the Hauterivian. This determination, made by Whitehouse[25] on the evidence of a *Simbirskites*, has since been supported by the same author's record[26] of fossils from the succeeding marine horizon at the same locality (Victoria Downs, Morven) and by the field work of L. C. Ball.[27] This may have been but a transient marine condition similar to the Lower Lias of the Walsh River, for at present it is known only from the one locality.

Two main transgressions of the sea took place over the area. The earlier and, apparently, the more extensive of these began in the Lower Bedoulian (lowest Aptian), as shown by the work of one of us

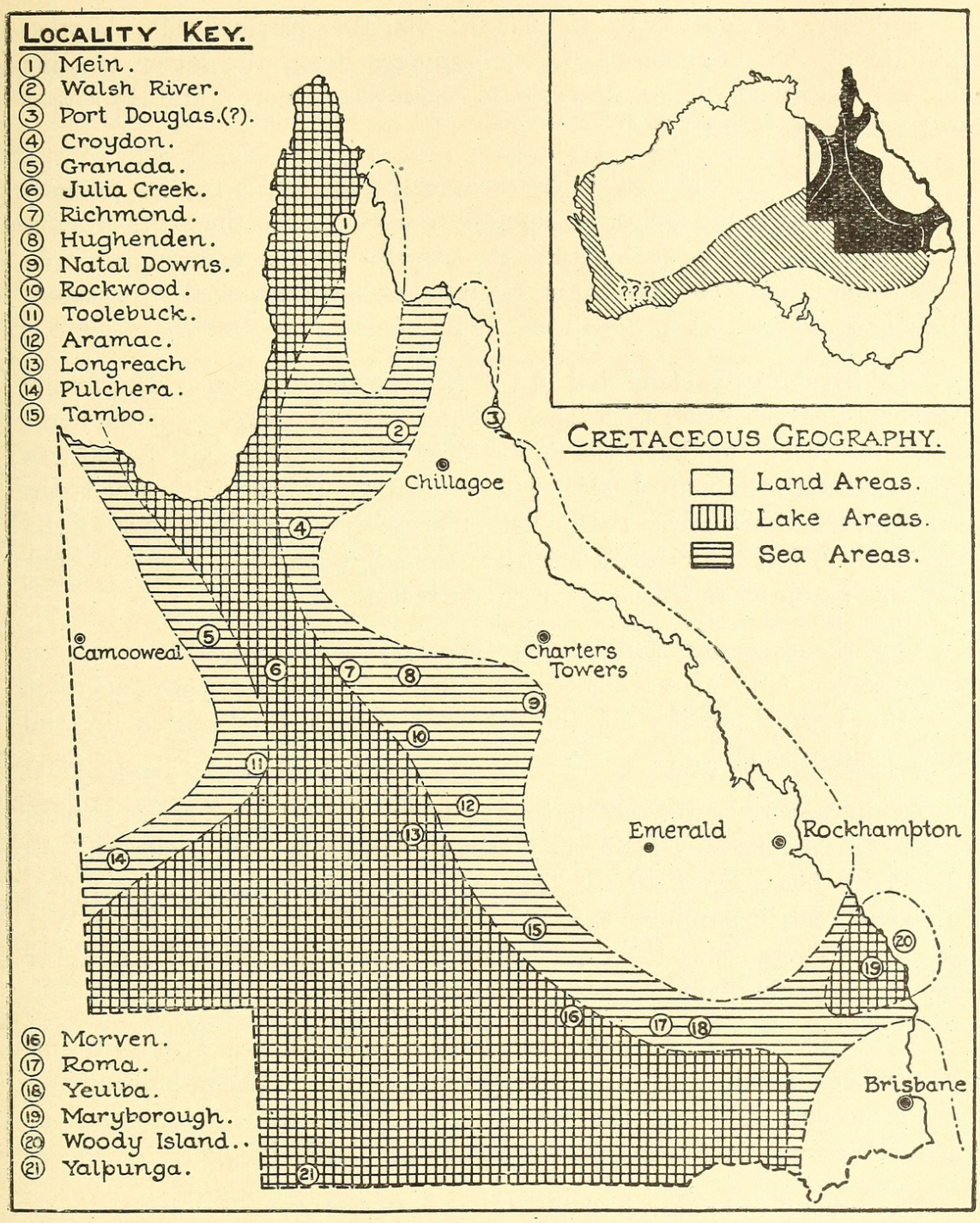
(F.W.W.)[28] on the cephalopods. This transgression, which gave rise to the beds of the Roma series, was caused, apparently, by the flooding of the Walloon lake by the sea. Consequently it is probable that the upper time limit of the Walloon series should be drawn at the top of the Neocomian (Barremian). The abundant individuals of genera suggesting a brackish condition (*Cyrenopsis*, etc.) in the basal beds of the Roma series lends support to the idea that the sea invaded a lake rather than the basin from which the lake waters had previously withdrawn.

The outcrop of the "Rolling Downs formation," as marked on the Queensland geological maps, gives the areal distribution of the Roma series, except in the north-west, where (*v. inf.*) the Tambo series completely overlaps on to beds of Pre-Cretaceous age. It may be noted that those areas on the margin of the basin (Croydon and White Cliffs), which have been mapped as "Desert Sandstone," represent the base of the Roma series. The evidence for this is to be published very shortly by one of us (F.W.W.).

Following the close of the Roma series at the top of the Aptian (Upper Gargasian), there was a non-sequence due to a regression of the sea from the whole area. The succeeding beds, forming the Tambo series, represent the Upper Albian. No Lower or Middle Albian fossils are known in the area, and there is no evidence from the bore records to suggest that any deposition took place in the time interval separating the two series. It may be that in the centre of the Great Artesian Basin, where bores are very few, beds of limited horizontal distribution deposited in this interim may be present (at a considerable depth); but, in the absence of evidence to the contrary, we may reasonably assume that the regression of the sea from the area was complete at the end of the Roma series.

With the incoming of the Tambo sea there were, naturally, conditions of overlap. At all the recorded fossiliferous localities of the western margin of the basin, from the latitude of Oodnadatta (South Australia) northwards, only the Tambo series is represented. It is apparent, therefore, that in this area the overlap of the Tambo series over the Roma series on to older beds was complete. On the eastern and southern margins of the basin, overlap of the Tambo series on to earlier portions of the Roma series has happened at various localities, the evidence for which will be published at a later date by one of us (F.W.W.).

The outlets of this central sea may now be considered. Of the three previous palæogeographic maps of the region published locally,[29] [30] [31] all agree in having an outlet to the north. Walkom and Benson, further, indicate an outlet to the south-west via the Eucla basin. This is not shown on Jensen's map. Jensen and Benson treat the Maryborough marine beds as an extension from the main basin, but no outlet to the sea is suggested in this region. On Walkom's map the Maryborough beds are treated as a separate arm of the sea, not connected directly with the central basin.



Text-figure 3.

In the present map the obvious outlet to the north is upheld. That there was an east-west gulf in the region of the present Arafura Sea during the Jurassic appears certain. Such a sea was present during the Cretaceous, accounting for the transient deposition of Upper Albian beds (slightly later in age than the Tambo series) at Point Charles, and of the Lower Cenomanian (*baylei* zone) beds of Melville Island. It may be mentioned that beds with Cenomanian fossils (to be described shortly by one of us) very similar to those of Melville Island, occur at the Strickland River in New Guinea. It seems, therefore, that the northern extension of the basin is connected with this gulf.

Further, an outlet to the south, via the Eucla basin, is also maintained. The Cretaceous fossils reported from the latter locality include *Fissilunula* (?) *sp.*, *Maccoyella corbiensis* (Moore), and *Aucellina hughendenensis* (Eth.).[32]

This list, if the identifications are correct, includes species of both the Roma and Tambo series, and points to an outlet to the south during both periods. It is probable that the connecting strata from the area between the Eucla and the main basins have been removed by erosion, following uplift.

A third outlet is suggested in the Maryborough region. The fossils of this area agree so well with those of the Lower Roma series of the main basin that there can be little doubt that the Maryborough basin was continuous with the main basin. The percentage of brackish water types in this area is much lower than of other areas (e.g., White Cliffs) of the same horizon[33] (Lower Roma series). Consequently it is assumed that there was an outlet to the ocean in this direction.

That the sea connection between the Maryborough and Western area was, however, only of a transitory nature is indicated by the fact that only the lowest portion of the Roma series is represented in the Maryborough beds.

Again, it may be noticed that a specimen of the Tambo series species *Myloceras Ammonoides* (Eth. fil.) is recorded from Port Douglas. As Etheridge[34] has suggested, the locality may be incorrectly given; but, if it be correct, it supports the suggestion held by one of us (F.W.W.) that in the Cretaceous, the *essential* outline of Australia did not differ very considerably from its present form.

At the close of the period of the Tambo series the sea withdrew, and no later beds definitely of marine origin are known in Queensland during the Cretaceous, although they existed in other States (Santonian at Gingin, Western Australia; Cenomanian at Melville Island).

The Post-Tambo series beds in the Great Artesian Basin were included by Dunstan[35] as the Winton series, the name "Desert Sandstone" being restricted to deposits originating secondarily from beds ranging from Jurassic to Tertiary. Ward and Jack,[36] however, recognise two stages above the "Rolling Downs." The lower of these, the "lignitic series" of these authors, would correspond with the Winton series of Dunstan, and is of lacustrine origin. This would indicate that the depression occupied by the Tambo sea remained when marine conditions ceased, and became the site of an extensive lake or series of lakes.

Ward and Jack retain the name "Desert Sandstone" for a succeeding series, which, according to them, contains marine fossils. One of us (F.W.W.) has examined the marine cretaceous fossils now in the various

Australian museums, but has seen no forms which would indicate an horizon higher than the Tambo series.

Further, such localities as Croydon and Maryborough (in Queensland), White Cliffs (New South Wales), and Stuart Range (South Australia), which, from their lithology, have been recorded as localities for the marine stage of the "Desert Sandstone," all yield faunas typical of the lower portion of the Roma series. It seems to us therefore that the so-called marine stage of the "Desert Sandstone" is nothing other than superficially altered sediments of the Roma or Tambo series; and that, if a distinct series is to be recognised overlying the Winton series, it also is most probably of lacustrine origin.

That portion of such lacustrine series should be shown on the Tertiary map is very probable; but in the absence of definite evidence to the contrary these sediments are treated in this essay as Cretaceous. It should be mentioned that the highest fossils obtained in the very deep Patchewarra bore were at 4,500 ft.; and these, examined by one of us (F.W.W.), were typical Tambo series forms (*Labeceras trifidum* Whitehouse, *Hamites* sp.). This indicates a minimum thickness of about 4,000 ft. for these Post-Tambo beds.

From Plutoville, in Cape York Peninsula, Mr. Morton[37] recently obtained fossil plants from beds apparently underlying the Roma series. These plants were determined by Dr. Walkom as of lower Cretaceous age. This would agree with the idea advanced earlier in this paper that the top of the Walloon series transgresses into the Cretaceous. No Jurassic fossils are known in this area, which rather suggests that the Walloon lake extended northwards rather late in its history.

The stratigraphical position of the known Marine Cretaceous deposits of Australia may be tabulated thus:*

Senonian	Danian Maestrictian Campanian Santonian Coniacian	Gingin Chalk (W.A.).
	Turonian	
	Cenomanian	Melville Island bed.
	Albian ..	Tambo series; Point Charles Bed; Cardabia bed (W.A.); Eucla beds (*pars.*).
	Aptian ..	Roma series and Maryborough beds; ? Eucla beds (*pars.*).
Neocomian	Barremian Hauterivian Valanginian Infra-Valanginian.	Morven bed.

* This table is based on the work of one of us (F.W.W.), much of which is still unpublished.

V. TERTIARY PALÆOGEOGRAPHY.

Although very little work has been done in Queensland with the object of obtaining a full knowledge of the extent and nature of the Tertiary deposits of the State,* incidental references to strata of this age are to be found in many of the publications of the Geological Survey of Queensland. Such references are so comparatively numerous as to suggest that the Tertiary deposits of the State are much more widespread than is generally supposed.

As little is yet known of the extent of the Tertiary deposits, the area of each has been represented conventionally by a circle in the accompanying map. Of the occurrences shown, one is based upon information hitherto unpublished—namely, the finding of a fossil flower of modern aspect at Goodger, near Kilkivan.

Although each locality upon the map is represented as an isolated lake, further work may well prove that some of these areas were once connected. It would not be reasonable, however, to expect very much progress in this direction, for the areal discontinuity of the deposits is not the only obstacle to be overcome. Proof of contemporaneity of any two deposits may be much more difficult, and without such proof it would be positively dangerous to assume that they were deposited simultaneously, for there is no reason whatever for regarding all the Tertiary deposits of Queensland as representative of the one horizon. On the contrary, they probably are the result of several distinct periods of deposition. The importance of this aspect needs to be emphasised, as there exists in Queensland the tendency to under-estimate the length of the Kainozoic era—to regard it, indeed, as merely a period, and a short one at that. Hence it would serve no useful purpose to draw *one* map of Queensland for the whole Kainozoic era, as many important geographical changes quite probably took place within the era itself. However, the nature and distribution of our Tertiary deposits provide us with suggestions which, while they are regarded merely as such, are not without some value.

The fact that all are lacustrine suggests that the whole of Queensland was a land area during the Tertiary, while the restriction of the Tertiary deposits to the neighbourhood of the present coast seems to indicate shore lines not far from the present one. The latter suggestion is supported by the fact that several of the occurrences contain fossil ostracods, which are indicative of estuarine or brackish water conditions.

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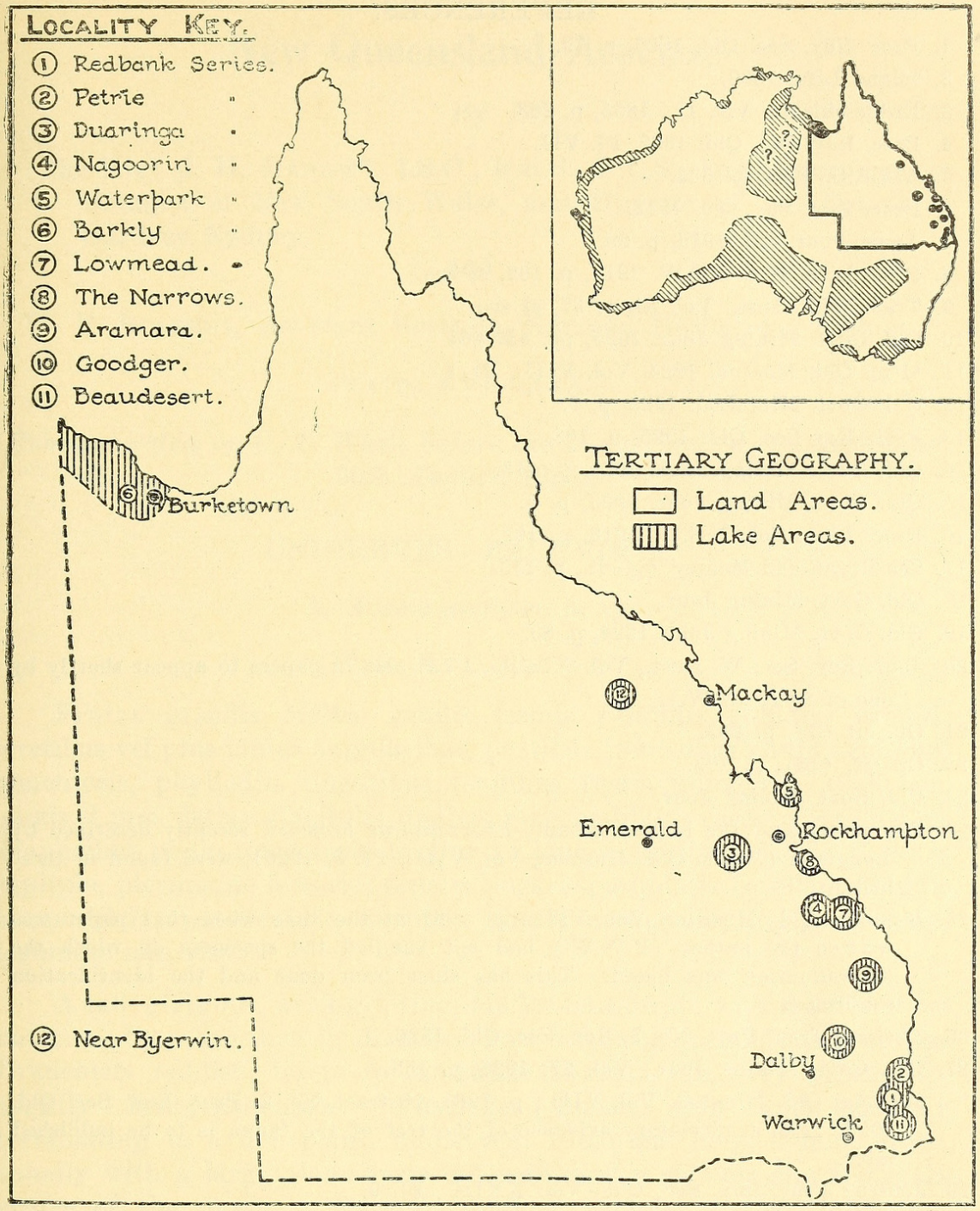
* A notable exception is the valuable paper by Mr. O. A. Jones, B.Sc., entitled "The Tertiary Deposits of the Moreton District," which was recently read before this Society.



Text-figure 4.

The great differences in the lithological nature, fossil content, and tectonic history of the Tertiary deposits of the island of New Caledonia, when compared with those of Queensland, point to their structural independence during Kainozoic times, and suggest that the Queensland coastlines lay far to the west of New Caledonia, a suggestion which is in harmony with the tentative conclusions arrived at above.

That the landmass of Northern Queensland was connected with that of New Guinea during Kainozoic times there can be little doubt, but whether such connection was continuous throughout the era cannot at present be decided, nor can the exact date of its final partition.

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