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The Geological History of Queensland
A Stratigraphical Outline

BY

W. H. BRYAN, M.C., D.Sc., and O. A. JONES, M.Sc.

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PREFACE.

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Our principal purpose in writing this outline of the Geological History of Queensland was to provide a short text to meet the needs of the students of geology within the University of Queensland, but we have kept in mind also the teachers and students of geology in the secondary schools. It is hoped too that it may be of use to others interested in the geological history of the State who have not the time or the necessity to make a more complete study from the original sources.

The scope of the work is wide in space, embracing as it does, the whole area of the State of Queensland—some 670,000 square miles—and wider in time, ranging as it does over a thousand million years. To encompass these dimensions within a mere 100 pages has proved a difficult task. Geographical generalisations for such a large area inevitably tend to oversimplify what are in fact complex patterns of distribution. Further, as in any other short, simple outline of a long and complicated history, conciseness and simplicity could be achieved only at the expense of completeness and accuracy in detail.

The method adopted in these circumstances was to collect and examine all the available data and then present them in summarised form. This involved a certain amount of selection, but every effort was made to ensure that the facts as presented represent a well-balanced summary of the whole. It must be admitted however that the south-eastern part of the State, which is of particular interest to students at Brisbane, and about which more information is available, has received some added emphasis. With regard to the interpretation of the facts, the position was more difficult. Rival schemes of correlation are so numerous, and hypothetical restorations of gaps in the evidence so varied, that we felt compelled deliberately to select those explanations which in our judgment appeared most nearly adequate; where other things were equal we selected the simplest. We have, too, used question marks rather sparingly, in spite of the fact that the geological record of the State is crowded with unanswered queries. This arbitrary procedure was necessary if we were to avoid the welter of argument and controversy which characterises Queensland stratigraphical studies, and which we thought would be out of place in an outline such as this. Inevitably, as a result of the methods we were forced to adopt, the story as we have told it is incomplete and over simplified.*

The material used in the preparation of this Outline has come from many and varied sources, and it is our wish that all these should be acknowledged in their proper places, However, the references would have been so numerous and the interruptions to the continuity of the text so frequent, that we decided to record our sources of information as bibliographic lists. Selected and incomplete as these are they may serve to indicate the degree of our indebtedness to other workers. It will be seen that they include many of the valuable publications of the Geological Survey of Queensland and other original papers from diverse sources. But the lists do not indicate the help we have received from discussions with the officers of the Geological

* For further information on the many intricate stratigraphical problems of the State, the reader is referred to the papers cited in the bibliography at the end of this work and to our "Revised Glossary of Queensland Stratigraphy."

Survey and our own colleagues for which we are most grateful. More particularly, and at the risk of appearing to make invidious distinctions, we wish especially to acknowledge the help we have received from one book, one map and one individual. The book is "The Geology and Palaeontology of Queensland and New Guinea" by Jack and Etheridge. Although published over fifty years ago this magnificent work remains a mine of information and a source of inspiration to those interested in the geology of the State. The map is the "New Geological Map of the Commonwealth of Australia" prepared by Sir T. W. Edgeworth David and published (together with a volume of "Explanatory Notes") in 1932. That part of the map which includes this State is by far the best geological map of Queensland in existence and as such was of the greatest help. The individual is our colleague Dr. (Major) F. W. Whitehouse, who, when his duties as an officer in the Australian Army permitted, gave us freely of his extraordinarily wide and intimate knowledge of the geology of Queensland.

In addition to the information derived directly from our numerous sources, and particularly from those just mentioned, we have introduced where we thought advisable or necessary certain new information and certain new interpretations hitherto unpublished, for which we personally must accept responsibility.

In addition to dealing with the more strictly stratigraphical aspects of the geological history of Queensland in some detail, an endeavour has also been made to outline briefly the more important earth movements and the igneous activity during each period and to give a synopsis of the deposits of economic importance.

Accompanying the text will be found a series of maps. A note of warning is necessary with regard to these, which have been prepared for two purposes. In the first place they show with some precision the localities from which fossils have been obtained and on which the ages and facies of the several series have been determined. Secondly, they give in broad outline a picture of the general distribution of the sediments of the different periods. They should not be regarded either as geological or palaeogeographical maps. They differ from the former in that they include more than the actual outcrops, and from the latter in that they show less than the actual extent of the seas and lakes.

In addition to the purposes which moved us to write this work and which are set out at the beginning of the preface, is the hope that by bringing together the available information in this compact form we may encourage others to take part in unravelling the tangled skein of Queensland Stratigraphy.

W. H. BRYAN.

O. A. JONES.

March, 1945.

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THE GROWTH OF QUEENSLAND.

INTRODUCTORY.

The State of Queensland does not constitute a complete natural unit. Geographically it is but part of the Australian continent—geologically it is a smaller part of the much greater Australasian mass. This fact should continually be borne in mind when reading the following generalisations which concern, but are not necessarily restricted to, the geological evolution of our State. On the other hand Queensland is so large and geologically so varied, that it is difficult to present a clear picture of some phases of its geological history in general terms. In particular, during most of the periods of the Palaeozoic era, the interior of the State presents a series of events quite different from those of the coastal regions. It is convenient therefore to consider each of these parts of the State separately for those periods. It must not be thought, however, that these differences indicate independence of the two regions concerned. The differences are rather those of complementary parts than of independent units. This is seen when, with the approach of Mesozoic times the stories of the two regions merge and we are able to cover the whole State with one set of generalisations.

The geological history that will be presented in the succeeding chapters has been based essentially on stratigraphical sequences, determined where possible on fossil evidence, and where this is not available by other, usually less satisfactory, methods. But although stratigraphy rightly forms the core of geological history it has associated with it other closely related aspects, the chief of which are concerned with the ever-changing geography, the varying climate, the sequence of earth-movements, and the many manifestations of igneous activity.

These last especially, are closely interwoven with the stratigraphical story. Indeed the igneous sequences can as yet be determined only by reference to the strata with which they are associated. Thus our knowledge of the ages of our igneous rocks can, at present, be no better than that of the strata with which they are interbedded or into which they are intruded. This position may be improved, or even reversed in the future when, as a result of the study of their radioactive minerals, the igneous rocks, may not only be assigned to their relative positions in the geological record, but be given absolute ages in terms of years. When this comes about, the igneous rocks may be used not only to supplement the orthodox stratigraphical methods, but as a check on the accuracy of these. At present, however, the history of the various phases of igneous activity and the earth movements to which they are related must be deduced from the incomplete, and in many cases, unsatisfactory story told by the sediments.

Again, the study of the tectonic history of any area is based largely on the relative attitudes of adjacent sedimentary series, the unconformities that may separate them, and the different degrees to which they may have been metamorphosed, but clearly it will be impossible to place even the important tectonic events in their proper positions in geological history if we are ignorant of the ages of the sedimentary series involved.

Palaeogeographic conclusions too are dependent upon stratigraphical considerations, for although the several different environments under which sediments were deposited may often be determined from the nature of the sediments themselves, this knowledge is of little use in reconstructing the geography of the past if we do not know the ages of the series concerned.

Similarly, palaeoclimatic reconstructions, although based on internal evidence provided by the sediments, are of limited value until they can be arranged in their proper historical sequence. Indeed every aspect of geological history must be based ultimately on purely stratigraphical studies.

PRE-CAMBRIAN.

The Pre-Cambrian history of Queensland probably extended over a thousand million years—twice as long as all the subsequent periods put together. Of the igneous and tectonic activity of this enormous time we have as yet little information, but such as we have indicates that there were at least three important geological revolutions during which major geographical changes may well have been brought about. Each of the marked unconformities in the Pre-Cambrian formations indicates an orogeny and the last, at least, of these mountain-building movements was followed by the injection of great masses of granite which brought with them the raw material for important ore deposits.

Prior to the last of these orogenies there appears to have existed in the north-west of Queensland a well developed geosyncline, the geographical limits and duration of which have not yet been determined; but the final diastrophic epoch of the Proterozoic era was one that had far-reaching effects upon it, and indeed upon the geological development of the whole State. The deep-water sediments of the Mount Isa Series were folded and lifted well above sea level, thus converting the geosynclinal trough into a geanticlinal mountain range. The area thus wrested from the sea was firmly and permanently attached to the continent. From a typically mobile belt it became a typically stable area and has remained so throughout the 500,000,000 years of its subsequent history.

The closing phases of the Pre-Cambrian in the coastal region present a very different picture, and one that is almost the reverse of that just considered. Here the all-important event was the establishment of the great north-south sea-way which was to play such an important role in the geological evolution of the Australian continent.

This great trough, known as the Tasman Geosyncline, was one of the largest and most persistent of such structures that has been produced during the history of the earth. It was comparable in size with the present Mediterranean Sea, and it endured as a major geographical and structural unit for over 300,000,000 years.

The origin of the geosyncline was accompanied, or shortly followed by the great outpouring of basic lavas and tuffs which constitute the Greenstone Series. Such andesitic and spilitic rocks are characteristically associated with the initiation and development of these great structures, and they recur from time to time during the history of the Tasman Geosyncline.

CAMBRIAN.

The Cambrian period illustrates the contrasts between the geological developments of the interior of the State and of the coastal regions, that were so marked a feature of the Palaeozoic history of Queensland; for although marine deposits were laid down in both areas they are of the two distinct types known as transgressive and geosynclinal respectively. The former, which includes the numerous richly fossiliferous beds of the Templeton, Georgina, Pituri and Ninmaroo Series, were deposited in an extensive shallow sea, typical of those which during this period, invaded the interior lowlands not only of Australia but of the continents generally. Such invasions bring about notable geographical changes with a minimum of structural deformation of the continents. They may have been due in some cases, to those unspectacular vertical movements of large continental areas to which the term epeirogenic

has been applied. In other cases they may have been brought about by eustatic changes of sea level during which the continents themselves remained stationary. In all these cases the geographical changes, although usually extensive, are quite superficial and only temporary in character. The impressive Cambrian transgression in the interior of Queensland was quite typical in these respects as the nature of the beds, their distribution and subsequent history, show.

The coastal regions on the other hand saw in the Cambrian the accumulation of deposits of geosynclinal type. These are of great thickness, are distributed along a relatively narrow belt and are in large part, such as would be laid down in deep water. These facts, combined with the continuity of sedimentation and the complete absence of fossils sharply distinguish these geosynclinal deposits of the east from the transgressive deposits of the west. Although there is evidence of considerable movement within the confines of the geosynclinal, the geographical changes due to such mobility are far more localised than those which affected the stable region of the interior.

The oldest rocks within the Tasman geosyncline are the Greenstone Series. These volcanics have already been mentioned when dealing with the Pre-Cambrian history of the coastal regions, but they may belong in whole or in part to the Cambrian period. They were followed by the extensive and continuous deposition of bathyal (deep water) muds, which at a later period were metamorphosed to form the Bunya phyllites.

ORDOVICIAN.

This period presents no striking feature peculiar to itself, but may be regarded as prolonging the conditions of the Cambrian, as these are developed in the interior and coastal regions respectively. Thus, in the interior, there occurred the Toko transgression, similar in nearly all respects to its Cambrian predecessor, differing chiefly in the nature of its fossils, and more particularly in the abundance of cephalopods. After the regression which followed the deposition of the Toko Series, the interior was not again invaded by the sea until Cretaceous times—an interval of nearly 300,000,000 years.

In the coastal regions the deep-water conditions which gave rise to the sediments of the Bunya Series appear to have been prolonged well into this period. Next in succession was the Neranleigh Series consisting largely of typically geosynclinal greywackes, together with the earliest of those highly siliceous radiolarian rocks, that afterwards became such a feature of the Tasman geosyncline.

SILURIAN.

While this period shows no evidence of deposition of any kind in the interior of the State, the accumulation of geosynclinal sediments continued without interruption in the coastal regions, siliceous radiolarian-bearing types being especially prominent. With these there occurred both in the Neranleigh and Fernvale Series interbedded volcanic rocks of an andesitic character.

At the northern end of the geosyncline there appeared for the first time towards the end of the period the conditions necessary for the establishment and growth of coral reefs. Hence we find in the Chillagoe Series the first of those massive reef-limestones containing abundant tabulate and rugose corals that are so characteristic a feature of the following period.

About the end of the Silurian period, or in North Queensland even earlier, an important orogeny appears to have taken place, for the Fernvale and older series are more highly folded and more strongly metamorphosed than

the Devonian coralline limestones that follow. This earth movement probably resulted in the elevation into a land surface of part of the floor of the geosyncline, thus bringing about important, if local, geographical changes, and explaining the fact that over large areas the Fernvale Series does not appear to have been succeeded by Devonian strata. It was probably during this orogeny that the great Brisbane Geanticline, one of the largest structures of its kind in the world, was produced. It may be that its formation was related to the movement in Central Queensland which had the effect of bringing up the representatives of the Coastal Series from their places on the floor of the Tasman geosyncline to the position they now occupy as inliers within the early Palaeozoic sediments. Indeed the Coastal Series may represent a continuation of the same great median geanticline which was developed at this time along the axis of the geosynclinal structure.

Strangely enough no granitic or other major intrusians have yet been discovered which can definitely be associated with these important earth movements, although many of the rhyolitic extrusions that are referred to the early Devonian may be genetically associated with this late Silurian uplift.

DEVONIAN.

In the interior, the early part of the Devonian period possesses as little of stratigraphical interest as did the Silurian before it. But in the later part of the period there came into existence the earliest of those extensive lakes which were to play such an important part in the subsequent geological history of the State. At this time, too, we have the first evidence of the existence of land plants. The first group of these, the Psilophytales, existed until the end of the period, but before they vanished the *Lepidodendron australe* flora had become well established.

Turning to the coastal regions the most conspicuous feature is the occurrence of coralline limestones at many places and on many horizons. Most, if not all of these, are of the nature of coral reefs which grew along the margins of and about islands within the geosyncline. These reef limestones are found as far north as Chillagoe and occur successively at Burdekin, Marble Island, Mount Etna and Marmor, to Silverwood in the extreme south of the State. They are well scattered in time too, no less than five horizons being known already, the lowest of which is very early Devonian and the highest in the upper part of the Middle Devonian. At some places, for example at Silverwood, these limestones appeared during the closing stages of very intense volcanic activity of a spilitic character and were closely followed by the deposition of typically geosynclinal banded radiolarian cherts.

About the end of the period an important orogeny, accompanied by extensive granitic intrusions, took place in the northern portion of the geosyncline. The origin of several important ore deposits in that area is probably related to these activities.

In southern Queensland, however, there is little indication at this time of either strong folding or of granitic intrusions. In place of these were the many extensive intrusions of serpentine which occur between Ipswich and the Rockhampton region and which have disturbed the Middle Devonian limestones without affecting post-Devonian strata. As serpentine belts in other parts of the world are associated with tectonic activity, and more particularly with overthrust faulting on a large scale, it may be that those in Queensland will prove to have considerable structural significance. With the serpentines are found several of those minerals of economic value which are usually associated with this form of igneous activity.

CARBONIFEROUS.

In the interior the lacustrine sedimentation initiated in the Devonian was prolonged into the early part of the Carboniferous. The chief points of interest concern the fossils found in the Drummond Series. *Lepidodendron australe* gives place to the *L. veltheimianum* and the *Rhacopteris* floras. These latter appear to have existed for some time side by side, but the *Rhacopteris* survived *Lepidodendron* by a considerable interval. Other fossils of interest are the freshwater fish which first appear at this time and which are particularly abundant on certain horizons.

In the coastal regions marine deposition still held sway although plant fossils have been recorded from some of the beds. The Rockhampton Series is of interest in that whereas the lower beds appear to be typical of deep water the upper are more characteristic of neritic (shallow water) conditions. This change may indicate an important transition within the history of the geosyncline. Of the littoral deposits, the most interesting are the richly fossiliferous oolitic limestones which were formed very close to the shore line and were possibly similar to the fringing reefs of to-day.

Certain evidence from Newellton, in North Queensland, suggests that there may have been glacial action in that area at this time. If so, it is the earliest known glaciation in the history of the State.

Towards the end of the period there may have been temporary cessation of sedimentation on both coastal and interior regions.

PERMIAN.

From the point of view of the geological evolution of the State, as well as from many other aspects, the Permian period is full of interest. Here for the first time we find that the separate geological stories of the interior and the coastal regions merge into one. The Devono-Carboniferous lakes of the interior are followed by even more extensive lacustrine developments, while the marine geosynclinal conditions of the coastal regions are also gradually replaced by widespread lakes, so that by the end of the period lacustrine conditions were general for the whole State. The geographical and structural changes that brought about this integration were of the very first importance in the geological history of Queensland.

Geosynclines may be compared with living organisms in their restless activity. Their mobility is such that throughout their existence there occur frequent changes in their shape and extent and in the distribution of their parts. Much of this activity is strictly localised, for at the time of its occurrence one part of the geosyncline may be relatively static while another is quite active. It is not altogether fanciful then to compare an evolving geosyncline to a writhing body. If we may use this metaphor, then the Permian witnessed the "death throes" of the Tasman geosyncline. Although the general effect was simply a change from shallow-water deposition to lacustrine conditions, this was not brought about easily but only after many unsuccessful attempts, during which littoral marine deposits were laid down in rapid alternation with freshwater sediments—a combination known as paralic. Geographically as well as historically, this period of transition was one of uncertainty—of frequent and rapid change.

One of the most important aspects of the period was the accumulation of our earliest coal seams. These are widespread and occur on several horizons and constitute by far the most valuable coal measures in the State, including, at Blair Athol, the thickest clean seam of black coal recorded anywhere in the world. Associated with these coal measures are typical representatives of the *Glossopteris* flora, which dominated Gondwanaland at this time. Succeeding the

TABLE A.

THE TASMAN GEOSYNCLINE AS DEVELOPED IN SOUTHERN (AND CENTRAL)* QUEENSLAND.

Eras.	Series.	Nature of Sedimentation.				Epochs of Andesitic and Spilitic Activity.	History of Geosyncline.
		Geosynclinal.	Littoral.	Paralic.	Lacustrine.		
Mesozoic	Esk				Conglomerates, sandstones and shales		Lacustrine Conditions
	Neara				Andesitic boulder beds	Volcanic Epilogue. Almost continuous but somewhat localised	
Palæozoic	Fault Blocks, Upper			Fresh-water shales interbedded with marine sandstones			Transition
	Fault Blocks, Lower		Grits, sandstones			Localised and intermittent (as at Gympie)	Neritic Phase
	*Rockhampton, Upper		Oolitic limestone, grits and sandstones				Transition
	*Rockhampton, Lower	Shales and cherts					Bathyal Phase
	Silverwood, Upper	Banded radiolarian cherts and shales					
	Silverwood, Lower	Small coral reefs, Andesites and spilites				Continuous and on considerable scale	
	Fernvale	Red radiolarian jaspers, green banded cherts and andesites				Intermittent	
		—— passing into ——					
	Neranleigh	Greywackes with quartzites				Occasional and local	
		—— passing into ——					
	Bunya	Grey and green phyllites and slates, with quartzites					
		—— passing into ——					
	Greenstone	Andesites, spilites, porphyrites and basalts				Continuous and prolonged on grand scale Volcanic Prologue	Initiation ?
Proterozoic	? ? ? ?						

* With the exception of the Rockhampton Series, all these formations are well represented within 100 miles of Brisbane.

Rhacopteris flora *Glossopteris* and its associates were present throughout the Permian period, although, by the very end, the typically Mesozoic *Thinnfeldia* flora was in existence side by side with them.

Evidence of glaciation has been found on at least two horizons within the Bowen Series. The coal measures, the *Glossopteris* flora and the interbedded glacials are all characteristic of the southern hemisphere during the Permian.

From time to time during the period violent volcanic activity made itself felt throughout the coastal regions. This may have been genetically connected with the great movement of uplift, accompanied by folding of varying intensity, which brought the history of the Tasman geosyncline to a close. Also associated with the uplift, but following it after a short interval, was the injection of numerous, large, granitic intrusions carrying with them many of the State's most imporant ore-bodies. Possibly as a reaction to the compression which accompanied the elevation of the dying geosyncline, many tensional faults developed as a result of which numerous blocks of the elevated Permian sediments and volcanics were faulted down into the older Palaeozoic rocks.

TRIASSIC.

In this period, for the first time, no part of Queensland was beneath the sea, although large areas were covered by freshwater lakes, particularly in the latter part of the period.

The oldest rocks that have been assigned to the period are those forming the Neara Series, but as they consist almost entirely of andesitic flows and tuffs, essentially similar to those of the Palaeozoic and of a type not since erupted, they may represent the last phase of that volcanic activity characteristically associated with the Tasman geosyncline. It may well be that, just as the Greenstone Series formed the prelude to geosynclinal activity, the Neara Series represented the epilogue.

The typical deposits of the period were those of the Ipswich Series with its well developed *Thinnfeldia* flora, its two remarkable insect horizons, and its important coalfield. Less typical, perhaps, but more widespread is the Bundamba Series, which was laid down in the upper part of the Triassic period and which not only occupied considerable areas of the coastal regions but extended far into the interior of the State, where it was later to provide important aquifers for the Great Artesian Basin.

JURASSIC.

Conditions in this period were very similar in Queensland to those of the previous one, and, as there was no perceptible break in their continuity, the Jurassic may be regarded as essentially a prolongation of the Triassic. But although qualitatively similar, there were important quantitative differences. The most enormous lakes and extensive swamps that Queensland has known were developed, and in them were laid down the sediments of the Walloon Series together with the valuable coal measures that occur at many places. The *Taeniopteris spatulata* flora replaced the *Thinnfeldia* flora and giant dinosaurs roamed the land.

CRETACEOUS.

This period provides interesting alternations of lacustrine and marine conditions. Much of the State appears to have been at or near sea level and was flooded by transgressions from time to time. These invasions of the sea were somewhat similar to those of the Cambrian and Ordovician periods, but differ in that the Cretaceous transgressions affected not only the interior but also the coastal regions. In the former, shallow seas appeared again after an interval of 300,000,000 years and in these the Roma Series and Tambo Series were successively deposited. In the coastal regions there was a short-lived

transgression very early in the period with lacustrine sediments both above and below; later, and contemporaneous with the Roma Series, a more important invasion occurred during which the Maryborough Series was laid down.

These transgressions produced the youngest marine sediments in the State, for after the withdrawal of the waters no part of Queensland was ever again beneath the sea.

Among the numerous marine fossils of the period were a large number of ammonites and many great marine reptiles. The invertebrate fauna is of especial interest in that it suggests a cold, almost glacial, climate for the period.

In the later part of the period freshwater lakes were again well developed in many parts of the State, that in the interior, in which the Winton Series was deposited, having been especially extensive. Those of the coastal regions in which the Burrum Series and Styx Series were deposited, although much smaller in area, include important coal measures. All these series contain the early representatives of the dicotyledenous flora which ultimately replaced *Taeniopteris spatulata* and its associates, and which dominated the plant world for the remainder of our geological history.

The geographical changes during the period, although very important, were brought about without the aid of orogeny. Indeed the State appears to have been as stable during most of the Cretaceous as during the Triassic and Jurassic periods. But at or near the end of the period very important earth movements were in operation within the coastal regions. The area affected by this orogeny was only a very small part of the Australian continent and for this reason its importance is often under-estimated. But the intensity of the movement, as seen in the Maryborough region, and its extent as shown by almost identical conditions at New Caledonia nearly 900 miles away, indicates the importance of this earth movement.

Accompanying this orogeny was the injection of many major masses of granite, syenite, and diorite, followed by the intrusion of a widespread and well developed suite of porphyrites. This igneous activity was, in its turn, associated with the introduction of valuable ores, including those of gold, copper, antimony and mercury.

From all points of view, in spite of its restricted areal distribution, the activity which marked the close of the Mesozoic era in Queensland was of the very first importance.

KAINOZOIC.

The orogeny which introduced the Kainozoic era and which was so marked in the easternmost part of the coastal regions appears to have had little direct effect upon the interior, where the Eyrian Series indicates a close similarity to the lacustrine conditions of the Upper Cretaceous. This great Eyrian lake, which may have persisted into the Oligocene period, was the latest, although it may not prove the last, of a succession of large freshwater basins in the interior that began as far back as Devonian times.

In the coastal regions however the late Cretaceous earth movements had the effect of bringing about considerable changes, the most striking feature of both the Eocene and Oligocene being the large number of small lakes, each of them probably short-lived, that dotted the eastern landscape. Hydrous black coal was formed in one, at least, of the earlier of these lakes at Nagoorin, while brown coals are associated with the later deposits such as those at Waterpark. Oil-shales appear to be common to both.

An important feature of the early Kainozoic was the vulcanicity, which resulted in the outpouring of many basaltic flows such as those of the Silkstone Series.

About the end of the Oligocene there occurred an orogeny which, if it was not of the first importance (it may be described as a disturbance rather

than a revolution) was of unusual interest. This movement, although less intense, resembled that which closed the Mesozoic era, in that it was confined to the same easternmost strip of Queensland. Its effect is seen in the many evidences of disturbance exhibited by the early Tertiary sediments and flows within the affected belt. There have been no orogenic disturbances in the State since this event, but, it may be significant, that one of the most recent of Queensland's extinct volcanoes and the site of the most recent earthquake, are both situated in the Gayndah area, which is about the mid-point of the area affected by this latest orogeny.

Following this disturbance the whole State, together with a great part of the Australian continent, was an area of erosion and was reduced to a condition approaching peneplanation, and on the flattened surface thus formed extensive areas of lateritic soils were produced. Not only was there a minimum of deposition in the Miocene but volcanic activity appears to have been at a minimum too, so that the period is singularly lacking in constructive geological processes.

The Pliocene, by contrast, was a period of intense and almost continuous volcanic activity in Queensland. Extensive areas of basalt and andesite, the result of fissure eruptions, occur associated with rhyolites and trachytes which resulted from more localised central eruptions, the foci of which may be recognised by the accumulations of coarse agglomerate and other pyroclastic material. All these features are developed over much of the coastal regions and are typically represented by the Lamington Series.

About the end of the period the coastal regions appear to have been subjected to a movement of uplift, which was on a considerable scale but which was not uniform in character, some areas tending to lag behind. One effect of this movement was to elevate the Pliocene volcanics into positions where they have since been deeply dissected by stream erosion.

In contrast to the Pliocene period, which as we have seen, was characterised by volcanic violence, the Pleistocene period was one of comparative peace. The eruptions were few in number, sporadic in distribution and intermittent in character except in the northernmost part of the State, where volcanic activity seems to have been more intense and continuous and may have been prolonged into comparatively recent times. The land for the most part appears to have been one of wide rivers and rich alluvial plains covered by a luxuriant mantle of vegetation capable of supporting a large animal population, the most interesting members of which were the giant and bizarre marsupials and the enormous ostrich-like birds.

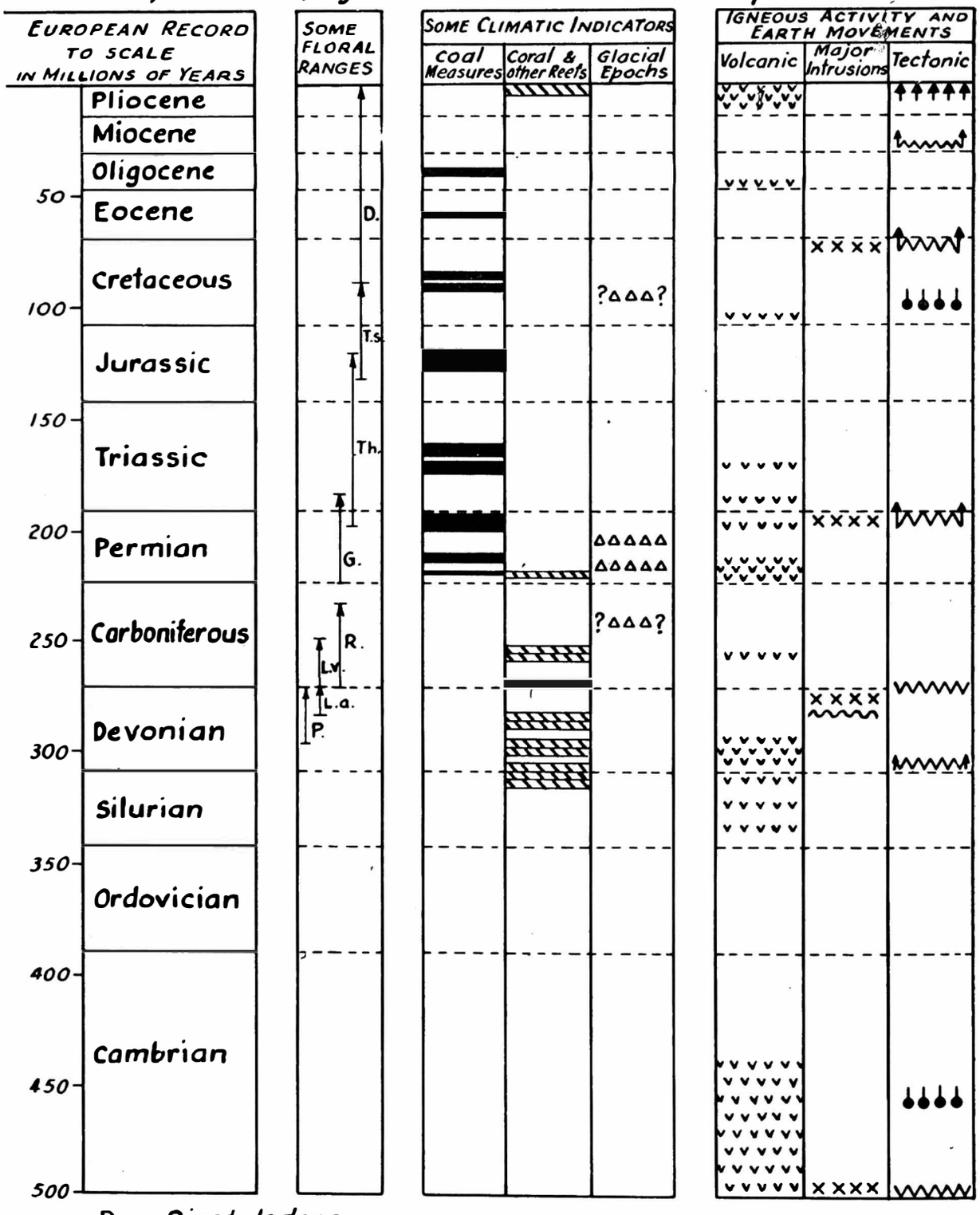
The close of the Pleistocene period was marked by a movement of sea level of the order of 200 feet, which had the effect of "drowning" much of our coastal topography with interesting and beautiful scenic results. The Great Barrier Reef that appears to have been in vigorous growth at the time of the submergence was able to accommodate itself to the rising sea level. This movement was afterwards compensated to a small extent by a negative eustatic movement of the order of 10 feet, which has left many interesting "raised beaches" of various types, high and dry.

Man probably made his first appearance in Queensland, in Recent times, the Talgai skull forming the climax in the palaeontological history of the State.

At present the geological structure of the State impresses us by its stability, but this carries with it no guarantee of permanence. It is improper to look upon the geological scene to-day as a culmination—to regard the geological structure as complete, the geological story as finished. All evidence is against such a view, for the geological processes continue to operate without pause. The geological to-morrow may be as different from the present as was the geological yesterday.

TABLE B.

Floral, Climatic, Igneous and Tectonic Sequences.

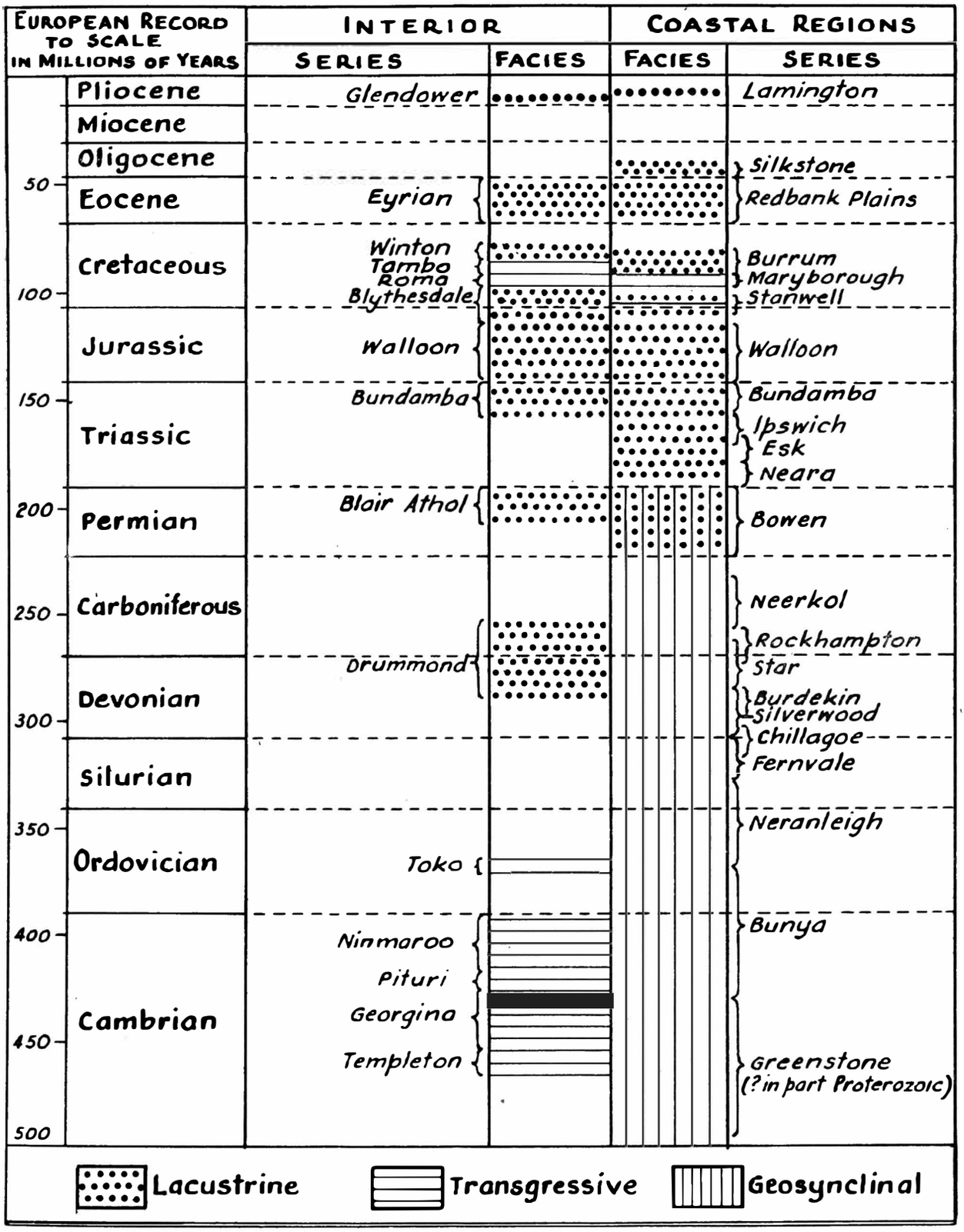


D. *Dicotyledons*
T.s. *Taeniopteris spatulata*
Th. *Thinnfeldia flora*
G. *Glossopteris flora*
R. *Rhacopteris flora*
L.v. *Lepidodendron veltheimianum*
L.a. *Lepidodendron australe*
P. *Psilophytales*

Granite etc. ××××
Serpentine ∿∿∿
Folding ∧∧∧
Uplift ↑↑↑
Subsidence ●●●●

TABLE C.

GENERALISED STRATIGRAPHICAL RECORD FOR QUEENSLAND.



N.B. The scale adopted for Tables B and C is too large to permit the inclusion of Pre-Cambrian formations and too small to show the Post-Pliocene.

PRE-CAMBRIAN.

Our knowledge of the extent and development of the Pre-Cambrian rocks of Queensland is very limited. Although they may well be, and probably are, widely distributed throughout the State, only in the north-west is there direct proof of their existence. There, in an area covering 25,000 square miles, and extending as an irregular belt from the neighbourhood of Selwyn in a north-westerly direction to the Northern Territory border, a distance of approximately 350 miles, is a Pre-Cambrian complex consisting of several unconformable series, which pre-dates sediments known definitely to be of Cambrian age.

The oldest of these Pre-Cambrian Series (and probably the oldest geological formation of the State), is known as the Kalkadoon-Argylla Series. It is made up of the highly metamorphosed gneisses and gneissic granites of Kalkadoon and the hornblende and chlorite schists of Argylla, and includes also certain hornblende and mica schists which have sometimes been regarded as constituting a distinct series, namely, the Leichhardt Series. Such a composite formation may range through a considerable part of Pre-Cambrian time, but the series as a whole has been tentatively placed in the Older Archaeozoic.

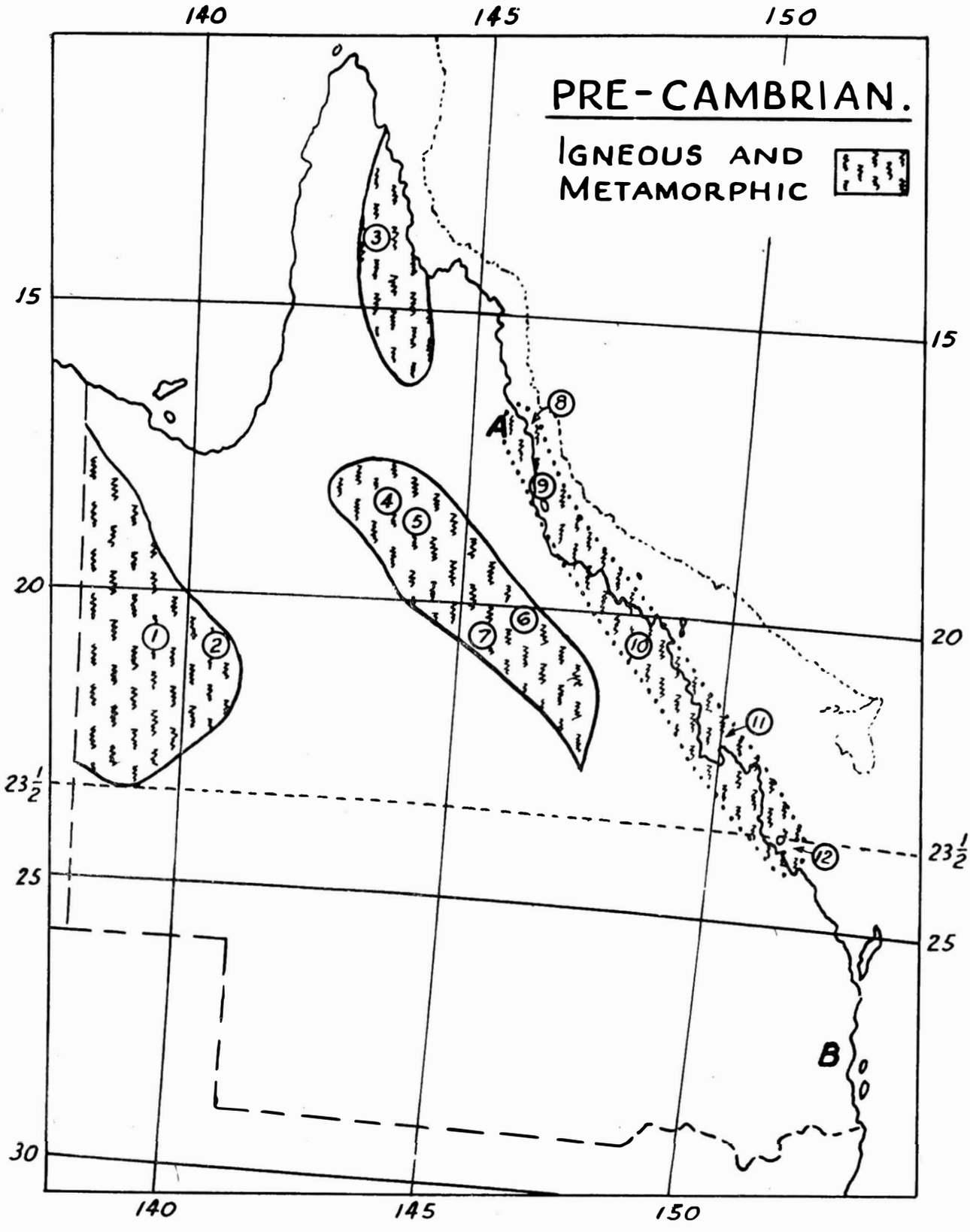
The next oldest rocks in the Pre-Cambrian complex are those of the Soldier's Cap Series. They are not so intensely metamorphosed as the Kalkadoon-Argylla Series, on which they lie with a marked unconformity, and consist of schists, greenstones, slates and quartzites which are typically developed in the Cloncurry region. The series is regarded as of Newer Archaeozoic age.

In contrast with the two highly metamorphosed Archaeozoic Series, the Mount Isa Series which follows, although strongly folded in the lower beds of the type area, is largely made up of relatively unaltered and less folded sediments. These are all of geosynclinal type but are not of uniform lithology throughout, falling naturally into three groups. These, in ascending order, are, a lower group consisting mainly of greenstones, a middle group of quartzites, thin bedded shales and ribbonstones, and an upper group made up chiefly of limestone, which is sometimes assigned to a separate (Corella) series. Of these three groups, the middle is of especial interest, both because the

TABLE D.

THE PRE-CAMBRIAN SEQUENCE IN THE MOUNT ISA AREA.

Palæozoic.	*Cambrian.*	*Templeton Series.*	—
Proterozoic	Newer (Lipalian)	Mount Quamby Series	Gently dipping beds of arkose and auriferous conglomerates
	Older	Mount Isa Series — Upper	Limestones
		Middle	Quartzites and shales with silver, lead, zinc and copper
		Lower	Greenstones
Archæozoic	Newer	Soldier's Cap Series	Schists, greenstones, slates and quartzites
	Older	Kalkadoon-Argylla Series	Gneisses, schists and amphibolites



MAP 1. PRE-CAMBRIAN.

Locality Key.—1. Mt. Isa; 2. Cloncurry; 3. Coen; 4. Etheridge; 5. Einasleigh; 6. Charters Towers; 7. Cape River; 8. High Is.; 9. Barnard Is. and Dunk Is.; 10. Normanby; 11. Stannage Point; 12. Gatcombe Head. Doubtful localities for Newer Proterozoic are—A. Barron R.; B. Near Brisbane.

Mount Isa shales are richly metalliferous on certain horizons, and for the reason that they sometimes show black carbonaceous markings suggestive of primitive fossils. The Mount Isa Series as a whole has been assigned to the Older Proterozoic.

The metalliferous sediments of Lawn Hill which lie unconformably beneath a limestone of Middle Cambrian age are probably the northern representatives of the Mount Isa Series.

What appear to be the uppermost beds of the Pre-Cambrian succession in north-western Queensland are known as the Mount Quamby Series. In contrast with those of the Mount Isa Series, these sediments are almost undisturbed and are composed of non-geosynclinal types consisting essentially of horizontal to gently dipping beds of arkose and auriferous conglomerates lying unconformably above the Mount Isa shales. The series is thus in many respects more closely comparable with the Palaeozoic than with the Proterozoic rocks of the region. Hence it may be best to place it provisionally in the Lipalian.

Apart from the Pre-Cambrian complex of north-western Queensland, the age of which is definitely proved by the presence above it of fossiliferous Cambrian strata, there exist in other parts of the State many series of ancient aspect, some or all of which may also be of Pre-Cambrian age. These are, at least, considerably older than the fossiliferous Devonian sediments that, in places, overlie them with a marked unconformity, but it is impossible to determine with certainty just how much older they are. In such cases we are compelled to rely on indirect lines of evidence in assigning each to its respective place in the geological record. The most important of these less direct methods is based on the intensity of metamorphism of these rocks relative to that of rocks of known age. This criterion, while useful in determining the relative ages of two or more series found within a limited area, is difficult to apply over more extensive regions, for the same series may well be more strongly metamorphosed in one area than in another. The following suggestions with regard to the ages of these old series should therefore be regarded as tentative only.

We have seen that, in north-western Queensland, Pre-Cambrian Series of several different ages have been recognised and it may be that as many or more are represented elsewhere in the State. It is certain that at least two old series are present, for in several areas they are found side by side. In addition there is evidence of at least one other series elsewhere.

These supposedly Pre-Cambrian rocks, while somewhat widely scattered, may be roughly grouped into four regions which will be referred to as the Central Area, the Northern Area, the Coastal Area, and the Area of the Tasman Geosyncline.

Within the Central Area are found two series of rocks both of ancient aspect, but one of which is much more strongly metamorphosed than the other. The older series is made up largely of gneissic granites and para-gneisses of sedimentary origin, together with some schists. Typical are the older rocks of the Cape River and Etheridge goldfields and the Dargalong and Einasleigh Gneisses.

Within the Cape River and Etheridge fields there also occurs a younger series of less metamorphosed schists that are probably equivalent to the schists of the Charters Towers, Gilbert and Woolgar regions.

TABLE E.

PROBABLE PRE-CAMBRIAN DEVELOPMENTS ELSEWHERE.

Grouping according to degree of metamorphism.	Central Area.	Northern Area.	Coastal Area.	Tasman Geosyncline.	
				North.	South.
Slates and schists				Barron River Series (in part)	Greenstone Series
Mainly schists, some gneisses	Cape River (younger) Charters Towers, Etheridge (younger), Gilbert and Woolgar		Coastal Series (including Gatcombe Head Series, Stannage Point, Normanby, Dunk Island, Barnard Island, High Island		
Mainly gneisses, some schists	Dargalong Gneisses, Einasleigh Gneisses, Cape River (older), and Etheridge (older)	Frome Series, Coen, Hamilton, and Pascoe River			

In the Northern Area it would appear that only the equivalents of the older rocks of the Central Area are present. These consist of the gneissose and other strongly metamorphosed rocks of the Frome Series, together with similar rocks at Coen, Hamilton and Pascoe River.

On the other hand what is here named the Coastal Series appears to have representatives of only the younger series of the Central Area. The outcrops of these, although widely separated, are arranged in an almost straight line measuring about 600 miles in length and running in a general north-westerly direction. The most southerly of these isolated areas is on Facing Island where the strongly metamorphosed schists of Gatcombe Head are developed. Successively in a north-westerly direction rocks of a similar type and degree of metamorphism occur at Stannage Point, Normanby, Dunk Island, and Barnard Islands, the last and most northerly known outcrop being at High Island near Cape Grafton. These occurrences appear to be inliers arranged along the median axis of that great and long enduring gulf or trough known as the Tasman geosyncline.

Perhaps the youngest of the Pre-Cambrian formations in eastern Queensland is the Greenstone Series that forms the basal part of the Brisbane Schists. These and similar rocks in Northern Queensland which form part of the Barron River Series are for the most part basic volcanic rocks which have been considerably metamorphosed to greenstone schists. These form the oldest known deposits within the Tasman geosyncline. Since the Greenstones lie conformably beneath sediments of supposedly lower Palaeozoic age they may, like the Mount Quamby Series, be the equivalent of the Lipalian Series elsewhere.

CAMBRIAN.

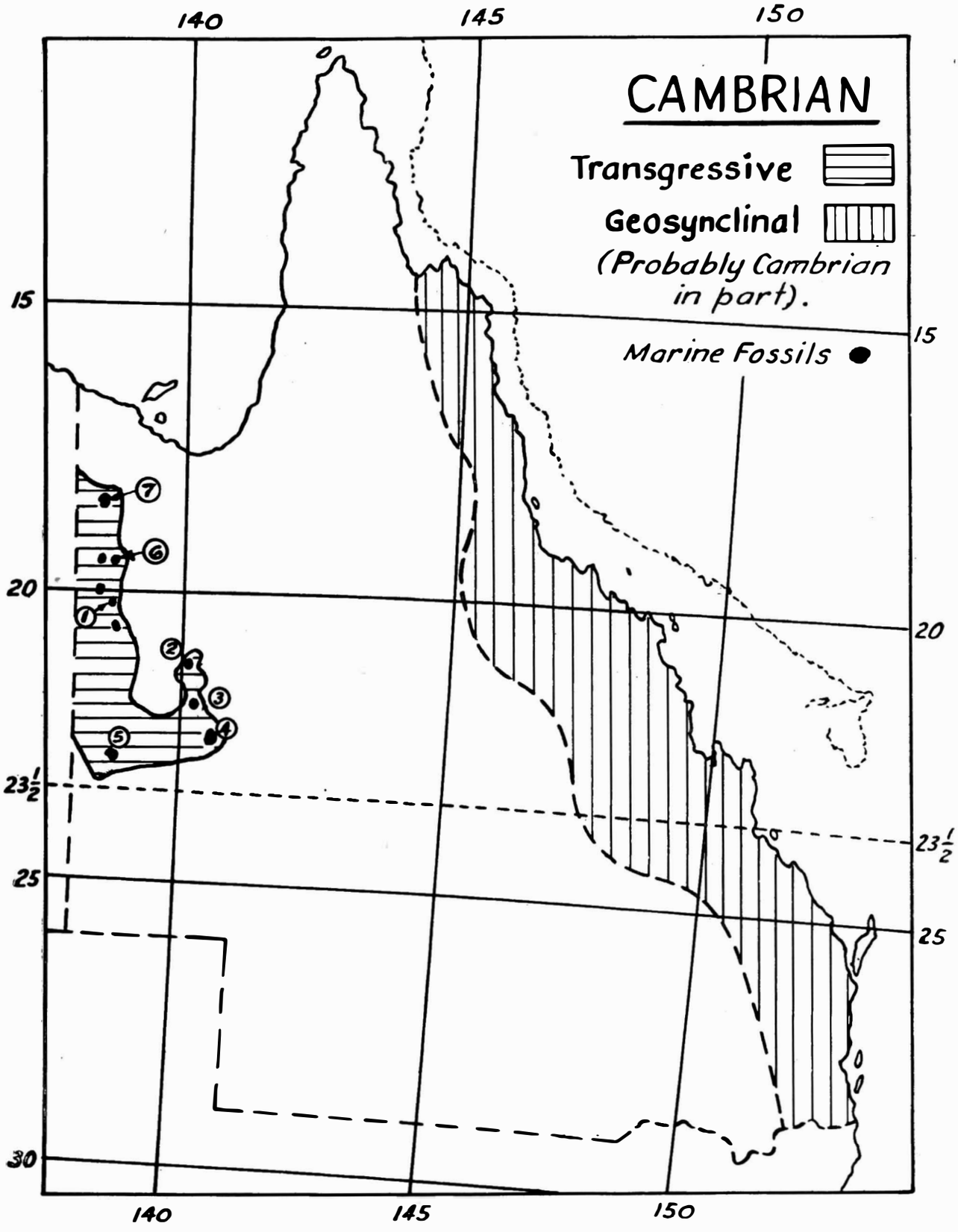
An extensive area of sediments that can be certainly assigned to the Cambrian period occupies much of the northwestern part of Queensland. In addition at a number of points in eastern Queensland there occur rocks which may also prove to belong to this period.

The former area covers approximately 60,000 square miles of the State, and is made up of rocks that were laid down as marine sediments in shallow seas which spilled over the Pre-Cambrian continent as typical transgressions. The deposits thus formed, in common with some other equally ancient rocks of similar transgressions in other parts of the world, have never been seriously disturbed by earth movements and still lie almost horizontally on the upturned edges of the Pre-Cambrian rocks on which they were laid down.

The included fossils, which are all marine organisms of one kind and another, are in places extraordinarily abundant. They are of interest not only for their stratigraphical value, which is here our chief concern, and for the clues which they, as facies fossils, supply to the conditions of deposition of the enclosing sediments, but also for the light that they shed on the evolution of several groups of the invertebrates. Of these groups the sponges are represented by *Protospongia*. The echinodermata are of the most primitive kinds yet discovered. Two genera are present and these have been named *Peridionites* and *Cymbionites*. The brachiopoda include such well known genera as *Eoorthis, Acrotreta, Lingulella* and *Obolus*. The mollusca are represented by *Orthotheca*, a curious genus thought to be related to the modern pteropods, and by the early nautiloid *Ellesmereoceras*. These all have their special points of interest, but it is the trilobites, which occur on some horizons in great abundance, that hold the greatest stratigraphical significance. No fewer than seventy distinct species of those primitive crustaceans have been identified and described. Some of these with suitably restricted ranges have been used in defining all but the uppermost of the eleven faunal zones to be mentioned later. In addition may be listed *Amphoton, Dinesus, Eurostina, Notasaphus, Pagetia, Paradoxides, Phalacroma* and *Proceratopyge*.

The marine sediments which contain this fascinating array of fossils appear to belong to an unbroken sequence which, beginning in the upper part of the Lower Cambrian, continues through the Middle and Upper Cambrian. In spite of its apparent continuity the sequence can be divided on lithological grounds into four series which, in ascending order, are known as the Templeton, Georgina, Pituri and Ninmaroo Series respectively. These have been further subdivided on palaeontological grounds into eleven well-defined faunal stages.

The Templeton Series, the oldest fossiliferous series of Queensland, received its name from the Templeton River, a tributary of the Georgina, in the bed of which some of the earliest fossils were obtained. The rocks consist essentially of sandstones, siltstones, banded cherts and other non-calcareous sediments. On the evidence of the Trilobites the series has been divided into two stages. The older of these, the *Redlichia* stage, is closely comparable with the uppermost part of the Lower Cambrian beds as developed in China, while the succeeding *Xystridura* stage occurs within the lower part of the Middle Cambrian. The Templeton Series is also developed on the Barkly Tableland and at Lawn Hill but as a limestone facies.



MAP 2. CAMBRIAN.

Locality Key.—1. Yelvertoft; 2. Duchess; 3. Chatsworth; 4. Black Mt.; 5. Glenormiston; 6. Thorntonia; 7. Lawn Hill.

The Georgina Series which conformably succeeds the Tempelton Series occupies a large area in the basin of the Georgina River. It is essentially a calcareous series and is made up for the most part of grey limestones containing trilobites and other marine fossils. It has been divided into seven stages, four of which, the *Agnostus seminula*, *Phoidagnostus*, *Papyriaspis* and *Anomocare* Stages, occur within the Middle Cambrian, the remaining three, namely the *Eugonocare*, *Glyptagnostus* and *Rhodonaspis* Stages being placed in the Upper Cambrian.

The Pituri Series (named after another tributary of the Georgina River), which in turn conformably succeeds the Georgina Series, shows a lithological reversion to non-calcareous types and consists of sandstones and shales with a

TABLE F.

STRATIGRAPHICAL SUMMARY OF THE CAMBRIAN DEPOSITS OF NORTH-WEST QUEENSLAND.

—	European Zones.	Queensland Stages.	Queensland Series.
Ozarkian (Transition beds)	Lower Ozarkian (undifferentiated)	*Ellesmereoceras*	Ninmaroo Series Calcareous. For the most part limestone
Croixian ..	*Acerocare* *Peltura longicornis* *Peltura scarabæoides* *Peltura minor* *Ctenopyge* *Eurycare*		
	Orusia lenticularis	*Elathriella*	Pituri Series. Non-calcareous. For the most part sandstones and shales
	Olenus *Agnostus pisiformis*	*Rhodonaspis* *Glyptagnostus* *Eugonocare*	
Acadian ..	*Lejopyge lævigatus* *Paradoxides forschammeri* *Paradoxides davidis* *Conocoryphe æqualis* *Hypagnostus parvifrons* *Paradoxides hicksi*	*Anomocare* *Papyriaspis* *Phoidagnostus* *Agnostus seminula*	Georgina Series. Calcareous. For the most part grey limestones
	Ctenocephalus exulans *Triplagnostus atavus* *Paradoxides œlandicus*	*Xystridura*	Templeton Series. Non-calcareous. For the most part sandstones, siltstone, siltstones and banded cherts
Waucobian	*Lapworthella* *Protolenus* *Strenuella* *Eodiscus bellimarginalus* *Callavia* *Holmia kjerulfi* *Acrothele prima* *Obolella groomi* *Volborthella* *Platysolenites* *Discinella holsti*	*Redlichia*	

minimum thickness of 100 feet in the Glenormiston area. The series is far less extensive than either of the preceding series and is, moreover, confined to a small part of the Upper Cambrian. It includes the *Elathriella* stage.

The Ninmaroo Series received its name from a prominent hill near Warenda Station, to the north-east of Boulia. It is quite detached from the earlier series and occurs as a number of small isolated inliers. Lithologically the series shows a reversion to calcareous types similar to those found in the Georgina Series. Somewhat surprisingly these beds are more highly folded than the earlier Cambrian Series to the north and west, but this disturbance may have been only a local development. In age the series may belong in part to the Upper Cambrian proper, but the only recognised faunal stage, the *Ellesmereoceras* stage, which occurs near the top of the series has been referred to that debatable portion of the geological record that is regarded by some authorities as the top of the Cambrian and by others as the base of the Ordovician.

In striking contrast with the known Cambrian deposits of north-western Queensland are those rocks in the eastern part of the State that are regarded as possibly belonging to the same period. The latter include the Greenstone Series, 10,000 feet thick, and part of the Barron River Series near Cairns. These have already been mentioned as possibly belonging to the uppermost part of the Proterozoic. They appear to have been deposited in relatively deep water in an elongate geosyncline the middle of which may have corresponded roughly in position with the present coast line. The deposits were largely volcanic in nature, they are highly tilted, considerably metamorphosed and completely unfossiliferous. They could hardly be less like the known Cambrian deposits of the north-west. Nevertheless radical differences such as these so often distinguish geosynclinal deposits, which in general have had an exciting history, from transgressional sediments which have been hardly disturbed since their formation, that these so-dissimilar formations may well be coeval.

It may be appropriate to mention here certain schists, slates and greywackes of the Herberton, Irvinebank and Koorboora districts that appear to be pre-Silurian and which, since they seem to be later than the Etheridge (Younger) rocks, may well be Cambrian at least in part.

ORDOVICIAN.

The distribution of the Ordovician deposits of Queensland resembles that of the Cambrian, in that the only series that can be placed with certainty, is found in the western part of the State, although very extensive developments in eastern Queensland are tentatively assigned to this period.

With one doubtful exception the only fossiliferous strata are those of the Toko Series which occurs almost on the border separating Queensland from the Northern Territory and which gets its name from its development in the Toko Range.* The series occupies only a relatively small area within the State and is of unknown thickness. It is made up of calcareous and arenaceous sediments lying almost horizontally, and separated from Cambrian beds by strong faults. The strata are all of shallow water types, and carry the characteristic fossils of such a facies; nevertheless they can be divided stratigraphically into two stages, which, lithologically and faunally are quite distinct. The lower of these is a limestone containing many cephalopods including *Actinoceras, Deiroceras, Calhounoceras, Endoceras* and *Vaginoceras* and has been designated the Actinoceroid stage. In addition to the cephalopods there have been recorded the brachiopod genera *Raphinostoma, Ophileta* and *Chonetes,* and the lamellibranch *Isoarca.* No trilobites are present.

The upper part of the series, which has been called the Asaphid stage, differs from the lower stage in that it is made up essentially of sandstones and in these the most important fossils are trilobites of the Asaphid group. Both stages occur within the middle part of the Ordovician period.

TABLE G.

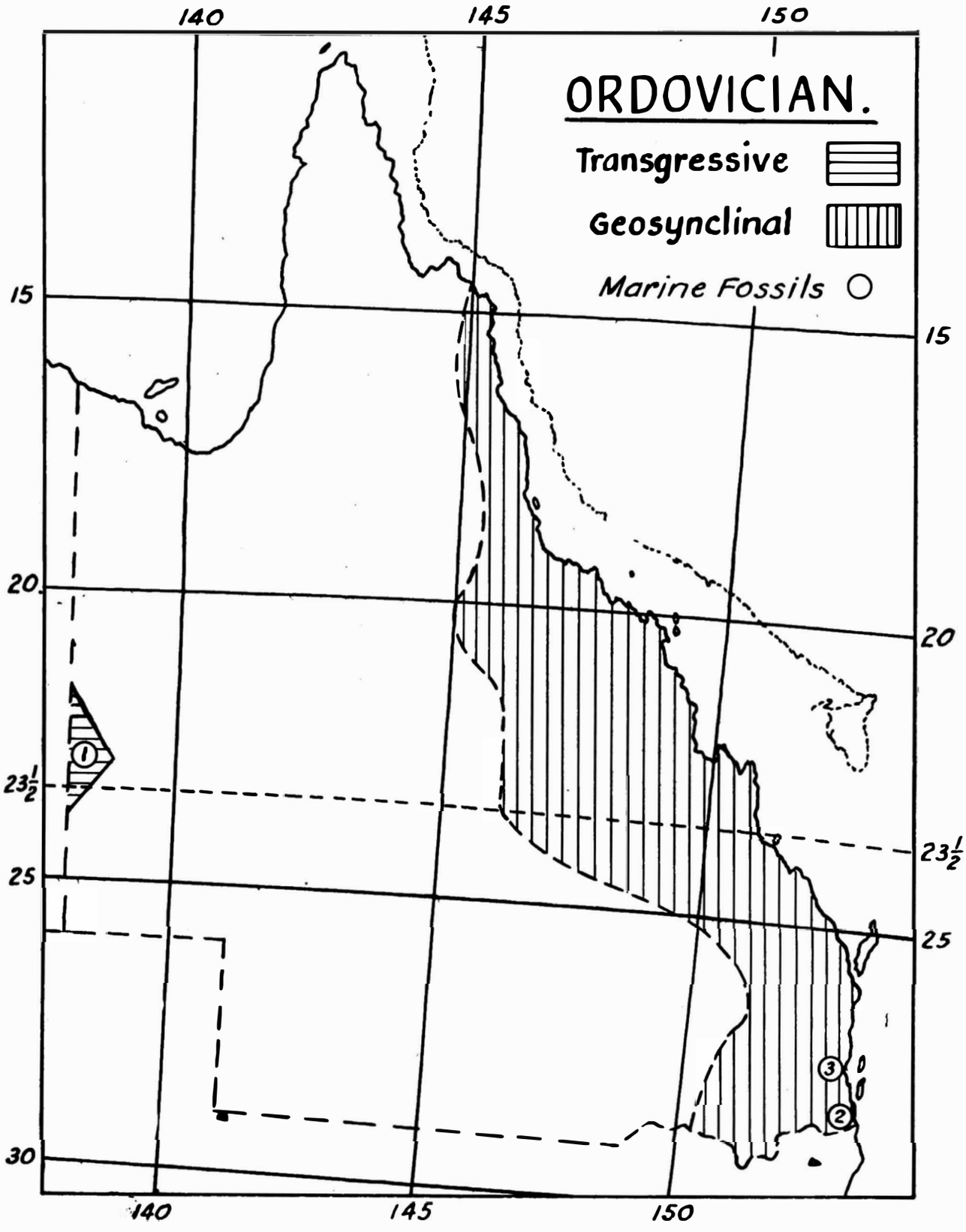
ORDOVICIAN DEPOSITS OF WESTERN QUEENSLAND.

Ordovician	Upper		
	Middle	Toko Series	Asaphid Stage (sandstones with trilobites)
			Actinoceroid Stage (limestones with nautiloids, brachiopods and lamellibranchs)
	Lower	Faulted junction with	
Cambrian		*Cambrian Marine Sediments*	

The Toko Series comprises the last marine deposits to be laid down in western Queensland for a very long time. The marine conditions which had existed, although not perhaps continuously, from Pre-Cambrian to Middle Ordovician times, then gave place to a land area that was not again submerged by the sea until Cretaceous times.

In contrast with the known Ordovician sediments of the west, which (like the Cambrian series in the same region), can be described as undisturbed, shallow-water transgressional deposits, the beds supposedly of this age in

* The Toko Series was formerly known as the Glenormiston Series, but this name is inappropriate and has been abandoned.



MAP 3. ORDOVICIAN.

Locality Key.—1. Toko Range; 2. Tweed Heads; 3. Brookfield.

eastern Queensland are highly disturbed, deep-water muds and other geosynclinal deposits. They are typically represented by the slates, phyllites, schists and quartzites of the Bunya Series, as developed around Brisbane and at Kenilworth and Kin Kin. At Petrie and near Kilcoy they lie conformably upon the Greenstone Series. The sediments of the Bunya Series, where least altered by metamorphic processes, consist of shales very like those which normally constitute the graptolitic facies. Nevertheless they are completely unfossiliferous, with the exception of one specimen of a Diplograptid found at Tweed Heads on the extreme south-eastern margin of the State. This suggests an Upper Ordovician age for the series, but as the solitary fossil was found towards the top of the series, which measures 18,000 feet in thickness, it is possible that the lower part of the series may belong to the Cambrian period.

Towards the top of the Bunya Series are found phosphatic horizons, well developed within the city of Brisbane, containing the minerals turquoise and wavellite. The Emu Park Series* which is well displayed near the mouth of the Fitzroy River and on the adjacent islands also contains these rather uncommon minerals, and, since it resembles the Bunya phyllites in other respects too, it may be regarded as a northerly extension of that series within the Tasman geosyncline.

Part of the Barron River Series, as well as certain metamorphosed sediments of the Herberton area, may also be equivalent to the Bunya Series and thus possibly be of Ordovician age.

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* This serial name is here used in a narrower sense than that originally used by Whitehouse, and is roughly equivalent to Richard and Bryan's "Emu Park Phosphatic Schists."

SILURIAN.

In this period the chief stratigraphical interest shifts from western Queensland, where the only fossiliferous strata of earlier periods have been found, to the east, where the main fossiliferous deposits of Silurian age occur. There are other considerable developments, the age of which has not been definitely proved, but which may well belong to the Silurian. These too, are restricted to the eastern part of the State, within the area of the Tasman geosyncline.

The strongest evidence for a Silurian age occurs in the rocks of the Chillagoe Series.* These consist of limestones and shales, the former of which weather into a very characteristic karst topography of pinnacles and caverns, some of which are quite extensive and very beautiful. They appear originally to have been reef-like masses and they contain many fossils including *Halysites, Heliolites, Favosites,* and *Tryplasma.* Although these range beyond the Silurian the presence of *Entelophyllum yassense* with them is indicative of an Upper Silurian age of part at least of the strata. But there also occur within the series *Xystriphyllum* and species of *Pseudamplexus* and *Grypophyllum* that are usually restricted to Devonian strata. The coralbearing limestones are of such considerable thickness that they may belong in part to Upper Silurian, in part to Lower Devonian and possibly in part to Middle Devonian.

This uncertainty is in some respects reminiscent of the Cambro-Ordovician relationship already noted, and we shall find further parallels in the later periods. Indeed the presence of such transitional series is a characteristic feature of the stratigraphical history of the State.

In addition to its development in the type area, the Chillagoe Series is well represented at Mungana, and probably includes the calcareous sediments of O.K. Still further to the north near Palmerville, similar limestones containing *Halysites* and *Favosites* occur, associated with quartzites, schists and interbedded andesites. These too may be safely included in the series. To the south of Chillagoe the sandstones of the Mount Garnet area, which contain somewhat indistinct impressions of the tribolite *Calymene,* cyathophylloid rugose corals and the tabulate coral *Favosites,* may also be equivalent to the Chillagoe Series.

The Broken River Series† is well displayed in the bed of the river of that name, which is a tributary of the Burdekin. It consists of more than 20,000 feet of shales, sandstones, conglomerates and limestones, the last of which contain the corals *Favosites, Heliolites,* and *Amplexus,* together with stromatoporoids, and crinoid stems. The series has, in the past, been assigned to the Devonian, but although the fossil evidence is not conclusive, other considerations—the lithology and folded nature of its strata—suggest that it is probably Silurian, or (like the Chillagoe Series) possibly transitional between the Silurian and Devonian.

With the Broken River Series should probably be placed the metalliferous sediments—unfossiliferous quartzites and slates with limestone lenses—of the Kangaroo Hills area.

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* The Chillagoe Series as here used includes the Palmerville Series and O.K. Series of Jensen.

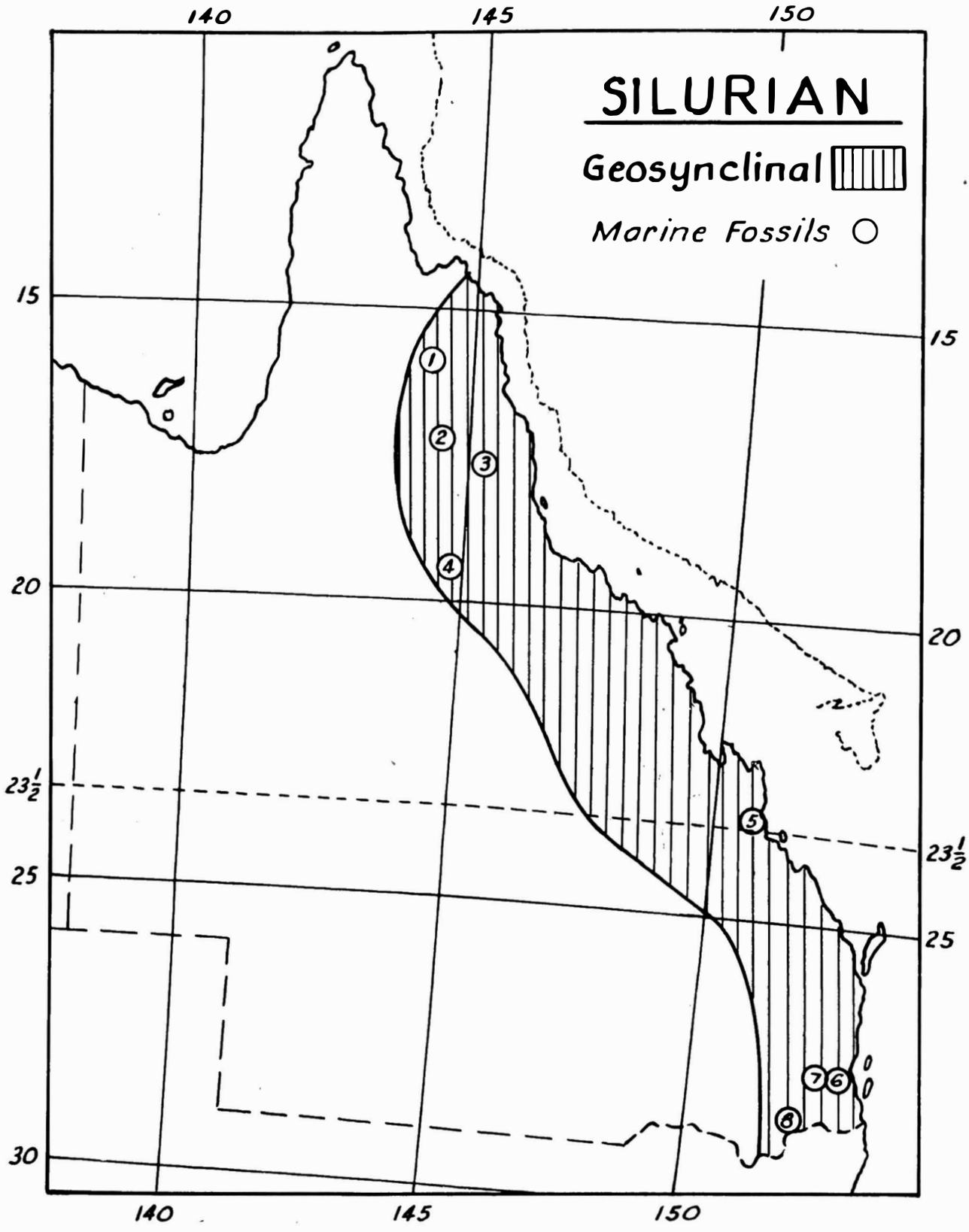
† This serial name is here used for the first time. It is based on the excellent and detailed description of R. L. Jack.

TABLE H.

Deposits of Silurian Age.

Northern Area. Geosynclinal (marginal).				Southern Area.* Geosynclinal (central).		
Fossils.	Lithology.	Series.	Age.	Series.	Lithology.	Fossils.
		Chillagoe Series.	*Devonian.*			
Corals	Limestones, jaspers and shales	Chillagoe Series and Broken River Series ?	Upper Silurian	Fernvale Series	Jaspers, andesites and quartzites	Radiolaria
Corals, stromatoporoids and crinoid stems	Shales, sandstones, conglomerates, limestones and slates					
			Lower Silurian	Neranleigh Series	Greywackes, quartzites, slates and jaspers	Graptolites and radiolaria
			Ordovician	*Neranleigh Series*		

* Similar rock types to those found in the southern area are known at intervals throughout the Tasman geosyncline.



MAP 4. SILURIAN.

Locality Key.—1. Palmerville; 2. Chillagoe; 3. Mt. Garnet; 4. Broken R.; 5. Broadmount; 6. Brookfield; 7. Fernvale; 8. Bald Mt.

In addition to the Chillagoe Series (Silurian in part) the Broken River Series (probably Silurian) and their equivalents, there exist, within the Palaeozoic sequence of the Tasman geosyncline, several formations that may be tentatively placed in this period.

Conformably above the Bunya Series is the Neranleigh Series which it seems best to treat here, although it may be in part Ordovician.

In the type area, between Neranwood and Beenleigh, this series is made up essentially of greywackes, but these are not so persistent either laterally or vertically as are the phyllites of the underlying Bunya Series. As one moves either south or north from the type area the greywackes become less prominent and other lithological types partly take their place. At the very base of the series the greywackes are interbedded with phyllites, and somewhat higher there is in some places a marked development of basic volcanic rocks. Further up in the series the greywackes are interbedded with banded slates and shales, while towards the upper limits strongly banded quartzites and red jaspers become increasingly important. Fossils are extraordinarily rare except for radiolaria which have been found in four different jasper horizons within the series. These, although of interest as indicating a bathyal facies, are of little value in determining the age of the series, but fortunately there have been collected from Upper Brookfield, near Brisbane, two diplograptids, probably belonging to the genus *Orthograptus*. These graptolites suggest an Upper Ordovician or a Silurian age for this portion of the series.

Rocks that are the probable equivalents of the Neranleigh greywackes occur at intervals as far north as Keppel Islands. Other beds similar in general character which may also prove to be related to the series are found west of Mackay and in the Cairns hinterland.

Succeeding the Neranleigh Series without any structural unconformity or any sudden lithological change is the Fernvale Series, which forms the uppermost part of the Brisbane Schists and is typically developed at Fernvale in the Brisbane Valley. The series is very siliceous and frequently manganiferous, the most striking lithological feature being the presence of massive and thin-bedded jaspers, some of which contain enormous numbers of radiolaria. Interbedded andesites and andesitic tuffs are also characteristic. This series may also be placed tentatively in the Silurian but on a higher horizon than the Neranleigh Series.

Beds closely resembling the Fernvale Series in that they are largely jasperoid and manganiferous, and which may well be equivalent, occur at Bald Mountain (Warwick), Pine Mountain (Ipswich), in the valley of the Mary River, at Gladstone, and at Broadmount (Rockhampton).

DEVONIAN.

The Devonian deposits, like the Silurian, appear to be restricted to the eastern half of the State. In keeping with this parallelism of distribution is the fact that, in some places at least, there is evidence of continuous sedimentation from one period to the other. The sediments are in large part those typical of geosynclinal conditions; others, less typical, may mark the western margin of the Tasman geosyncline; while still others, fresh-water deposits, appear to have been laid down in lakes, beyond the limits of the geosyncline proper.

The most interesting of these deposits are the coralline limestones which appear to have formed reefs in the Devonian sea. These limestones are found at numerous localities from Chillagoe in the north, to Silverwood in the extreme south of the State. At many places they are richly fossiliferous, rugose and tabulate corals being particularly abundant. A study of these has shown that the many limestone lenses were not formed contemporaneously, as had been early assumed, but represent at least five different horizons ranging from the bottom of the Lower Devonian to the top of the Middle Devonian. Some of these limestone horizons have been determined with considerable confidence, others have been tentatively placed, while at many localities the fossil corals are too few in number, too poorly preserved, or too affected by metamorphism to make precise determinations of age possible. In the case of these last, considerations of the lithology of the associated sediments, their geographical distribution, and their relationships to underlying and overlying series sometimes make it possible to place them in their approximate positions in the geological record. The limestones are, however, not always coralline. That at Marmor is composed, for the most part, of the fragmentary stems of very large crinoids.

Perhaps the oldest sediments of the period may be represented by the upper parts of the Chillagoe Series and Broken River Series. These have already been treated with the Silurian.

The next oldest rocks may be those of the Mount Etna series which is developed in the neighbourhood of Rockhampton. This series is at least 15,000 feet thick and consists of rhyolites and rhyolitic tuffs, with interbedded limestones, shales and radiolarian cherts. The Mount Etna limestone has been assigned to the Coblenzian (upper part of the Lower Devonian) on the basis of the rugose and other corals which include *Acanthophyllum, Calceola, Rhizophyllum, Radiophyllum, Pseudamplexus, Chlamydophyllum, Tryplasma, Favosites, Heliolites* and *Plasmopora.* It is reasonable to expect that a series as thick as that at Mount Etna, will prove to extend over a very considerable area, and it is likely therefore that some, at least, of the many limestone lenses that occur in central Queensland should be correlated with that of Mount Etna; but on the other hand it would be unwise to assume that they are all restricted to the one stratigraphical horizon. A list of those limestones tentatively assigned to the Lower Devonian appears in the accompanying table.

The Silverwood Series, which is developed to the south of Warwick has a maximum thickness of 11,000 feet and is made up of a lower half consisting largely of andesites, andesitic tuffs and spilites, and an upper half of banded radiolarian cherts and cherty shales. Almost at the top of the andesitic rocks, and thus approximately in the middle of the series, is an horizon of coralline limestone occurring as isolated lenticular outcrops. The principal fossils present are:—*Acanthophyllum, Prismatophyllum, Fasciphyllum, Pseudamplexus,*

Chlamydophyllum, Spongophyllum, Xystriphyllum, Favosites, Thamnopora and *Heliolites.* This horizon has been placed in the uppermost part of the Lower Devonian, or the lowest part of the Middle Devonian. It thus appears to be somewhat younger than the Mount Etna limestone.

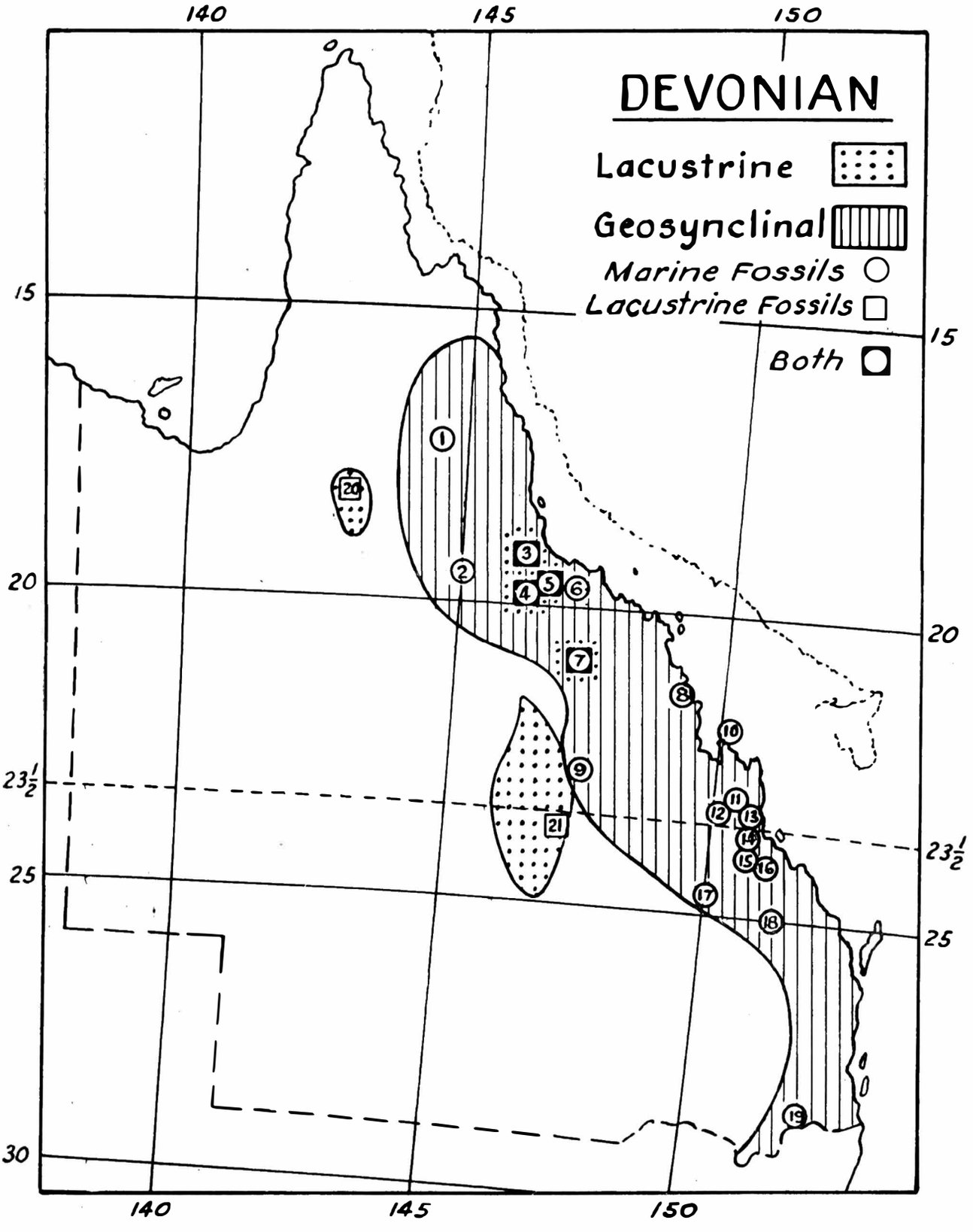
The Peak Downs Series occurs in the Clermont district along the Douglas and Drummond Creeks, and extends south to Anakie. The series which consists of shales, often calcareous, includes at least one limestone horizon which has been referred to the Couvinian (lower part of the Middle Devonian). It thus represents a somewhat later development than the Silverwood Limestone. The more important fossils of the Douglas Creek Series comprise rugose and tabulate corals such as *Acanthophyllum, Spongophyllum, Xystriphyllum, Favosites, Thamnopora, Striatopora, Gephuropora* and *Heliolites.*

The Burdekin Series was one of the earliest formations to be investigated in Queensland. It is best developed in the valleys of the Burdekin and Fanning Rivers, but is also well represented at Reid Gap near Townsville. The series in the type area is made up of conglomerates, sandstones, calcareous shales and limestones totalling 7,000 feet in thickness, of which the basal conglomerates occupy 400 feet. The limestone is particularly striking, being a massive development no less than 450 feet thick. It contains numerous well preserved fossil corals which indicate a Givetian (Upper Middle Devonian) age. This is the uppermost coralline limestone horizon recognised to date in the Devonian deposits of Queensland. The fauna is a very rich one and contains over thirty distinct corals, including species of *Dohmophyllum, Lyrielasma, Yabeia, Calceola, Disphyllum, Favistella, Stringophyllum, Favosites, Alveolites, Thamnopora* and *Heliolites.* In addition the bryozoan *Amphipora,* the brachiopods *Stringocephalus, Atrypa* and *Gypidula* (*"Pentamerus"*), and the nautiloids *Gyroceras* and *Phragmoceras* have been recognised.

TABLE J.

DEVONIAN CORALLINE LIMESTONES.

European Divisions.			Horizons Determined by Fossil Evidence.		Approximate Positions Based in part on Fossil Evidence.
Devonian	Upper	Famennian ..			
		Frasnian ..			
	Middle	Givetian ..	Burdekin River, Fanning River, Reid Gap		Ben Lomond (near Bowen)
		Couvinian ..	Douglas and Drummond Creeks		
	Lower	Coblenzian ..	Silverwood Mount Etna		Boyne River, Cawarral, Hunter Island, Kroombit, Marmor, Moronish, Mount Larcombe, Phillpot Creek, Raglan
		Gedinnian	? Chillagoe and	? Broken River	
Silu.	Upper		Mungana	Series	



MAP 5. DEVONIAN.

Locality Key.—1. Chillagoe; 2. Clarke R.; 3. Star R.; 4. Burdekin Downs; 5. Fanning R.; 6. Reid Gap; 7. Ukalunda and Mt. Wyatt; 8. Grasstree; 9. Douglas and Drummond Creeks; 10. Hunter and Marble Is.; 11. Mt. Etna; 12. Morinish; 13. Cawarral; 14. Ulam and Marmor; 15. Raglan; 16. Mt. Larcombe; 17. Kroombit; 18. Yarrol; 19. Silverwood; 20. Gilberton; 21. Drummond Ra.

TABLE
PRINCIPAL DEVON-

		South Queensland.	Central Queensland.		Bowen
			Coastal.	Inland.	Coastal.
Carboniferous			*Rockhampton Series*	*Drummond Beds (Upper)*	
DEVONIAN	Upper		Rockhampton (training Wall Quarries) indurated green sediments /and at Canoona and Cannindah	Drummond Beds (lower) red sediments	
	Middle	Banded radiolarian cherts	Banded radiolarian cherts		?
				Shales	Ben Lomond Lst.
				Douglas Ck. Lst.	?
				Shales	
	Lower	Silverwood Lst. lenses	Mt. Etna Lst.		
		Andesitic (and spilitic) flows and tuffs	Ryholitic flows and tuffs		
Upper Silurian		*Bald Mountain Jaspers*			

In addition to the Lower and Middle Devonian Series that we have so far considered, the ages of which have been based on interbedded fossiliferous limestone horizons, there occur other fossiliferous series the stratigraphical positions of which have been less precisely determined. Thus at Ukalunda, near the Mount Wyatt goldfield, a marine series occurs consisting of green shales and sandstones, and containing the corals *Calceola, Aulopora* and *Romingeria,* the bryozoan *Fenestella,* the brachiopods *Dalmanella, Leptostrophia, Schizophoria* and *Chonetes,* and the lamellibranch *Pterinea.* This series appears to be at least as old as the Couvinian.

With the passage from Middle Devonian to Upper Devonian in Queensland there was a change in many areas from marine to lacustrine conditions of sedimentation. But this change was brought about only gradually and intermittently, as is shown by the occurrence of transitional beds, of marine and fresh-water fossils occurring in the same strata, and of "paralic" (that is alternating marine and lacustrine) sediments.

Thus, to the east of the Fanning River, the limestone of the Burdekin Series, (the last of the Middle Devonian coralline reefs), is overlain by a calcareous shale that contains, in addition to corals and brachiopods, the plant *Dicranophyllum australicum.* This, the oldest fossil plant yet described from

K.

IAN OCCURENCES.

Area.	Townsville Hinterland.			Cairns Hinterland.	Facies.
Inland.	Burdekin Basin.	Star Basin.	Gilbert River Area.		
	? Upper part of Dotswood Beds	*? Upper part of Star Series*		*Silver Valley Beds*	
Mt. Wyatt calcareous sandstones and shales	Dotswood brown and red sandstones and shales	Star Series; sandstones shales and limestones	Gilberton red shales and sandstones	Hodgkinson Beds. Blue to green shales, greywackes and conglomerates	Paralic or Lacustrine
Ukalunda Beds blue and grey shales and sandstones	Burdekin Lst. Basal Conglomerate				Marine
	Broken River Lst. ?			Chillagoe Lst. (upper)	
	Broken River Lst. ?			*Chillagoe Lst. (Lower)*	

Queensland also occurs higher in the sequence in what are known as the Dotswood beds. Another very interesting plant, also recorded from the Fanning River area is *Schizopodium davidi*, a member of the primitive botanical group known as the Psilophytales.

Again at Mount Wyatt a series of green and brown calcareous shales and sandstones occurs containing both the typical Upper Devonian brachiopod "*Spirifer disjunctus*" and a species of plant closely allied to *Lepidodendron australe.*

In the Cairns hinterland too, we see evidence of transition to fresh-water conditions, for the Hodgkinson Series, which consists of at least 21,000 feet of shales, sandstones, grits, conglomerates and greywackes, contains rugose corals and has also yielded *Lepidodendron australe.*

Species identical with, or closely allied to *L. australe,* appear to have been quite wide-spread in Upper Devonian strata, for they have also been found at Gilberton, in north Queensland, (where they are found associated with representatives of the Psilophytales), and at several places in central Queensland including Canoona, Cannindah and the training wall quarries near Rockhampton.

Among the strata which we here include in Upper Devonian are certain beds that have sometimes been assigned to the Carboniferous period. The most important of these is the Star Series.* This is typically developed in the basin of the Star River to the west of Townsville and consists of sandstones, shales, conglomerates and some limestone. The contained fossils include *Actinocrinus, Fenestella, Leptaena, Chonetes, Schizophoria, Spirifer disjunctus, Retzia, Aviculopecten, Bellerophon, Porcellia, Orthoceras, Beyrichia, "Phillipsia,"* and the plant *Lepidodendron australe.* This assemblage has been regarded by some as indicative of Lower Carboniferous age, but by others as more suggestive of Upper Devonian time.

In the same category may now be placed the lower part of the Drummond Series, which is made up of sandstones and laminated shales, including certain beds which are conspicuous on account of their striking red colour. That part of the series which can be assigned to the Devonian period contains, among other fossils, numerous fresh-water fish and *Lepidodendron australe.*

* This serial name is here used in its original restricted sense.

CARBONIFEROUS.

The distribution of the strata of this period in Queensland is essentially similar to that of the Devonian, in that the deposits are restricted to the eastern half of the State, and consist for the most part of marine strata with isolated areas of lacustrine beds to the west and north. The marine beds are however, not all so typically geosynclinal as those of the preceding period, shallow water facies being far more strongly represented.

The most interesting rocks are the oolitic limestones. These are widely distributed over an area measuring 360 miles in length, (with Cape Hillsborough and Mundubbera as its extreme northern and southern points), and some fifty miles in breadth. They provide important information both as to the conditions of deposition and as to the age of the beds. In their first role, as indicators of facies, they provide clear evidence of deposition in shallow water, closely adjacent to a shore line. In their second role as indicators of age, one in particular forms a very useful horizon for stratigraphical work, for (1) its outcrops are distinctive and easily recognised, (2) it is found over a wide geographical range, and (3) the contained fossils indicate that it is restricted to a short time interval. In their way these oolitic limestones are just as characteristic of our Carboniferous deposits, as are the reef-like masses of coralline limestone of the Devonian.

Again we find, in some areas, continuity of sedimentation from one period to the next, for there is no apparent break in the local succession from the Devonian to the Carboniferous.

Although for many years the Star Series was regarded as typical of the Carboniferous rocks of Queensland, we have seen that most, if not all of it, may be better placed in the Devonian. It is quite possible, however, that the uppermost part of it may be Lower Carboniferous.

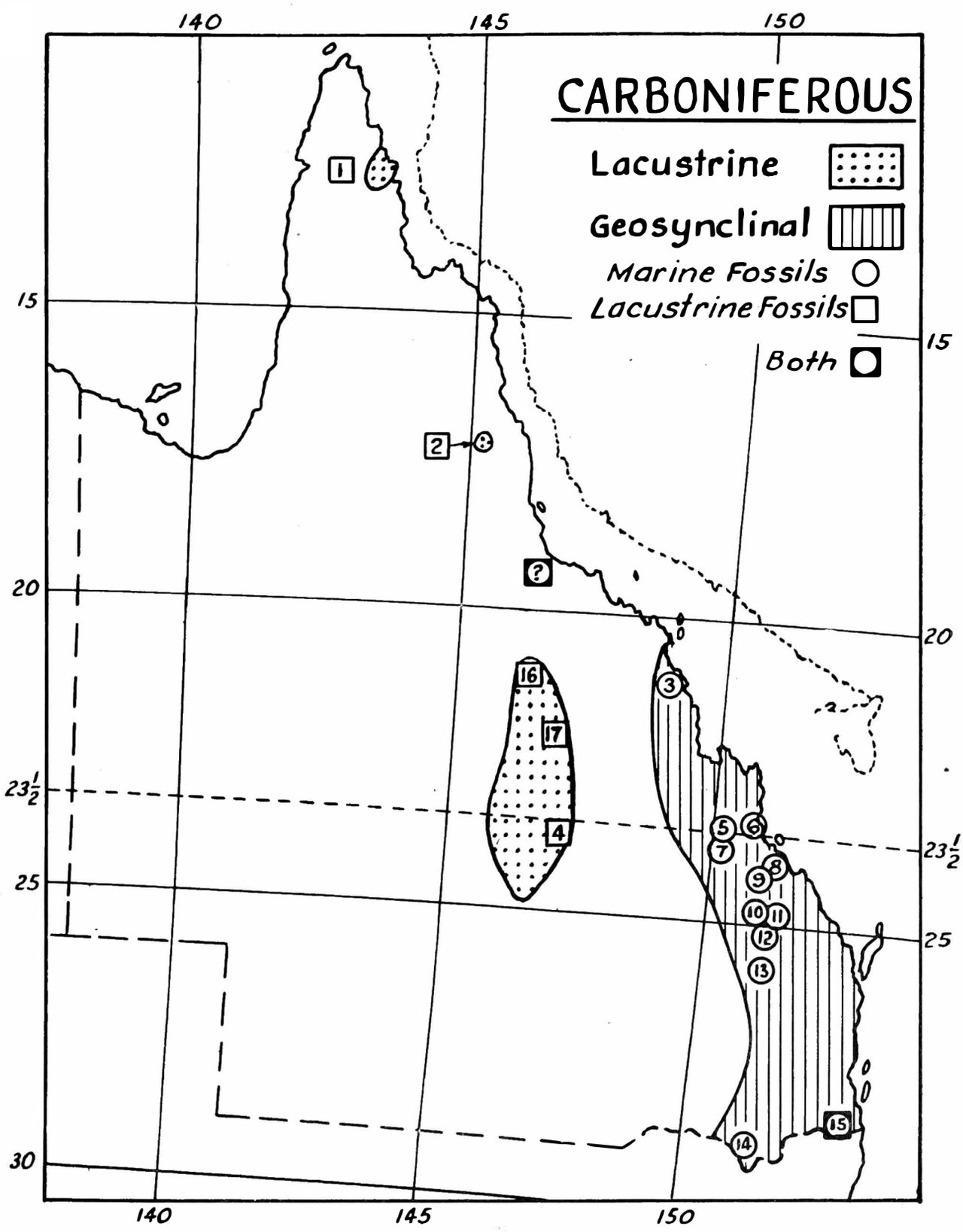
Of the certain occurrences of Carboniferous strata in Queensland, the sequence in the Rockhampton area is most nearly complete. In range, these beds extend from the base of the Dinantian (the very bottom of the period), at least to the uppermost parts of the Moscovian. Indeed, it is possible that Uralian deposits may also be present, although they have not yet been recognised.

The Rockhampton Series, which forms the lower part of this sequence appears to lie conformably above the *Lepidodendron australe* beds which have been assigned to the uppermost part of the Devonian. The lowest recognisable horizon in the series, as thus defined, is the *Michelinia* Limestone which must be regarded as the very base of the Tournaisian, for the *Protocanites* Bed which follows may be correlated with the *Protocanites lyoni* zone of Europe, which is there recognised as the base of the Carboniferous system. In addition to the genus which gives it its name, this bed contains another goniatite cephalopod, namely, *Pseudarietites*. The succeeding beds of the series are marine shales, cherts, grits (often tuffaceous) and oolitic limestones containing the brachiopods *Choncte*s, and *Schizophoria* and the gastropods *Mourlonia* and *Loxonema*. The uppermost of the oolitic limestones, and the one which is regarded as forming the top of the Rockhampton Series, is the Lion Creek Limestone. This forms a most important stratigraphical horizon. It has yielded many fossils including the corals, *Symplectophyllum*, *Amygdalophyllum*, *Aphrophyllum*, *Carcinophyllum*, *Lithostrotion*, *Orionastraea*, *Aulina*, *Michelinia*, *Syringopora*, *Palaeacis*, and the brachiopods *Leptaena* and *Spirifer*. This fauna indicates a position for the Lion Creek Limestone almost at the top of the Visean.

TABLE L.

DEPOSITS OF CARBONIFEROUS AGE.

			Marine, shallow geosynclinal		Marine and Lacustrine	Lacustrine
			Rockhampton	Cannindah	Other areas (not contiguous)	Drummond Range
Lower Permian			*Dinner Creek Series*			
Carboniferous	Uralian		? ← ? — Neerkol Series →			
	Moscovian		Grits, andesites and mudstones			? ← Upper Drummond Series →
			Protoretepora Horizon		Silver Valley Beds (fresh water)	Yellow and green sandstone and shales
			Grits and mudstones		Mount Barney inlier including fresh water and marine beds	
			Pustula Horizon			
	Dinantian	Visean	Lion Creek Limestone	Cannindah Limestone	Cania, Riverleigh and Texas Limestones	
			Shales, cherts, grits, and oolitic limestones	Volcanics and marine sediments with several limestone horizons	Oolitic limestone in andesitic volcanics near St. Helens Pascoe River Beds (fresh water) ? Upper part of Star Series ?	
		Tournaisian	*Protocanites* Bed *Michelenia* Limestone			
			← Rockhampton Series →			
Upper Devonian			*Lepidodendron australe beds at Training Wall Quarries*	*Sediments with Lepidodendron australe*	*Star Series*	*Lower Drummond Series*



MAP 6. CARBONIFEROUS.

Locality Key.—1. Pascoe R.; 2. Newellton; 3. St. Helens; 4. Drummond Ra.; 5. Lion and Neerkol Creeks; 6. Rockhampton; 7. Station Creek, Mt. Morgan; 8. Mt. Grim; 9. Diglum; 10. Cania; 11. Many Peaks; 12. Cannindah; 13. Riverleigh and Mundubbera; 14. Texas; 15. Mt. Barney; 16. Bullock Creek, Natal Downs; 17. Elgin Downs. The queried locality marks the upper part of the Star Series which may be Carboniferous.

Succeeding the Rockhampton Series without structural discontinuity is the Neerkol Series, the base of which is formed by the *Pustula* horizon. The brachiopod which gives the horizon its name has frequently been referred to as *Productus brachythaerus.* It is accompanied by other brachiopods such as *Productus* (proper), *Dielasma, Spirifer* and *Martiniopsis.* Bryozoa (sea mats) are also plentiful, and include the genera *Stenopora,* (?) *Evactinopora, Protoretepora, Fenestella* and *Polypora* (?) In addition, the lamellibranchs *Parallelodon* and *Nuculana* and the gastropod *Mourlonia* have been collected from this prolific horizon.

Within the upper portion of the grits, mudstones and andesites that constitute the Neerkol Series, is a bed containing an extraordinary wealth of bryozoans, and more particularly the genus *Protoretepora.* This *Protoretepora* horizon is so distinctive and clearly defined that it has proved very valuable as a "marker zone." The upper limit of the Neerkol Series cannot be precisely defined, but the series appears to extend well up towards the top of the Moscovian and may even include Uralian beds, although no fossils diagnostic of this age have as yet been collected.

In other parts of Queensland the Carboniferous sequences appear to be far less complete than that in the Rockhampton district.

The section at Cannindah resembles that at Rockhampton in a general way, being made up largely of marine sediments, including several limestone horizons, and more particularly in that the basal beds immediately overlie a series containing *Lepidodendron australe,* while the uppermost bed is an oolitic limestone closely comparable lithologically and in fossil content with that at Lion Creek. The chief difference between the two sequences is that volcanic rocks are more strongly represented in the Cannindah section.

Less complete marine sequences are also found near Cape Hillsborough, at Cania, at Riverleigh (near Mundubbera) and at Texas in the extreme south of the State. Each of these occurrences includes a limestone horizon, most of which have been definitely correlated with the Lion Creek horizon of the Rockhampton Series.

At Mount Barney there occurs a small isolated inlier of Carboniferous rocks completely surrounded by strata of Mesozoic age. This contains both marine and fresh-water sediments, the former of which have been correlated with the Neerkol Series and more particularly with the *Pustula* horizon at its base. The latter contain *Rhacopteris.*

The fresh-water beds of Carboniferous age are widely scattered. The best development is that at the Drummond Range. The sequence there follows, without structural unconformity or any apparent time break, the Lower Drummond Series of Devonian age. Although fossil fish are found on several horizons (one bed is literally packed with their remains), there is reason to believe that they are fresh-water palaeoniscids, so that the series may be regarded as an essentially lacustrine one. Lithologically these upper beds of the Drummond Range section present alternations of shale and sandstone. Strangely enough, while the shales are almost barren, the sandstones contain many fossils. These include a species of *Lepidodendron*—not *L. australe,* which is more characteristic of the Devonian—but the typically Carboniferous *L. veltheimianum.* This with *Cyclostigma* is found at Elgin Downs and Bogantungan. Higher in the succession, *Lepidodendron* disappears and its place is taken by members of the very different *Rhacopteris* group, as at Mount Budge. This change from the *Lepidodendron* flora to the *Rhacopteris* flora, marks an

important development in the succession of plant life in Queensland. The exact stratigraphical limits of the two floras has not yet been determined. But since *Rhacopteris* occurs in the Mount Barney inlier, associated with marine beds that have been referred to the *Pustula* horizon, it would appear to have replaced *Lepidodendron* by the beginning of the Moscovian.

Far to the north, in the Cape York Peninsula, the Pascoe River Beds of ferruginous and micaceous sandstones and clay shales, have been found to contain *Lepidodendron* stems, the wood *Pitys,* and leaves of *Cordaites.* These lacustrine beds may be somewhat older than the small outlier formed by the Newellton beds in the Silver Valley, which contains *Aneimites ovata* and other members of the *Rhacopteris* group. Associated with these are rhythmically banded shales which may be "varves" of glacial origin.

PERMIAN.

As with the deposits of the Silurian, Devonian and Carboniferous periods, the strata of the Permian are restricted to the eastern half of the State.

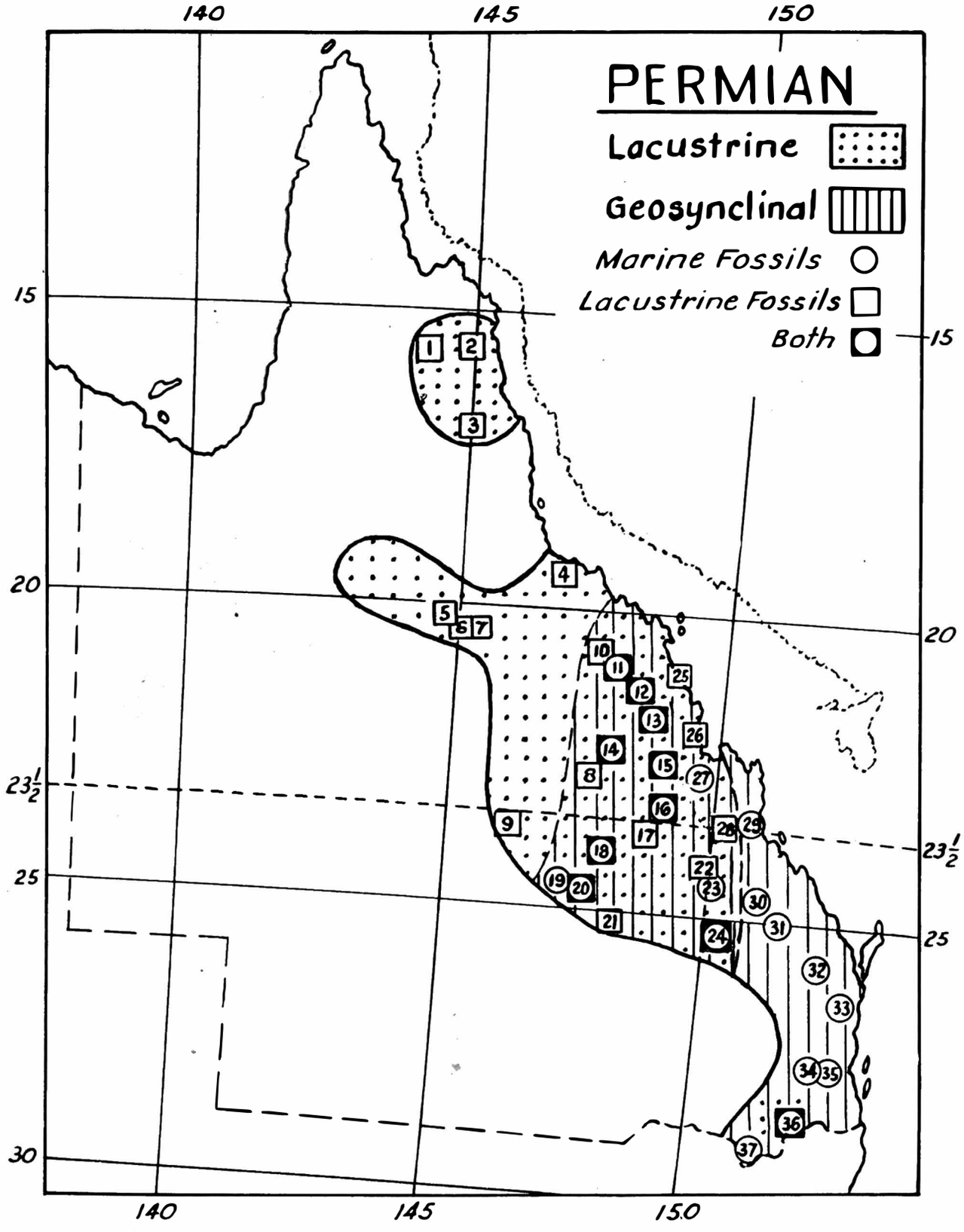
Again, as with the earlier chapters of our geological history, it is difficult to draw the dividing line between successive periods. Indeed, in this case, it is so difficult that for many years the uppermost Palaeozoic formations of the State have been designated "Permo-Carboniferous." Although both plants and animals are represented by very numerous fossils, these are of the southern or "Gondwanaland" type and are so different from the late Palaeozoic fossils of Europe and North America that they cannot be closely compared. Hence the correlation of our deposits with those of the type areas of the northern hemisphere must be based on indirect and somewhat unsatisfactory methods. This difficulty, and it is serious enough, is made even worse by the fact that the overseas authorities are not agreed as to where the dividing line between the Carboniferous and Permian periods should be placed in the European type areas. Not until both these problems have been solved will workers in Queensland be able to use the term Permian with exactitude. Nevertheless, it is our opinion, that most, if not all, of the formations in Queensland that have customarily been referred to the Permo-Carboniferous will ultimately be assigned to the Permian, and that no great harm will be done, and the stratigraphy simplified by the elimination of that cumbrous term.

The Permian rocks of Queensland include both marine and fresh water deposits, while the flows and ashes of contemporaneous volcanic activity are also strongly represented. The distribution of the several facies is rather well marked and is broadly similar to that of the Devonian and Carboniferous periods. Thus, the most northerly and westerly developments are purely lacustrine, the most southerly and easterly are predominantly marine, while in between these areas both lacustrine and marine deposits are found, and in close proximity.

The marine sediments are not typically geosynclinal, although the geographical position that they occupy, together with their common conformity with underlying Carboniferous sediments (in many cases of definitely geosynclinal nature), suggest that they may well represent the final marine phase of the great Tasman geosyncline. It is noteworthy that the most nearly typical geosynclinal deposits of the period are found at Gympie, the easternmost of the Permian occurrences.

The change from marine deposits of a bathyal (deep-water) nature to those of neritic (shallow water) affinities, that was noted in the Carboniferous, is followed in the Permian by a further transition from neritic to lacustrine conditions, which is exhibited by alternating stages of marine and fresh water deposits within the area previously occupied by the geosyncline proper. By the end of the period this second transition was complete and lacustrine conditions prevailed.

We saw that, notwithstanding the fact that coal measures were the characteristic deposits of the Carboniferous period in Europe and North America, these were not represented in Queensland (or indeed in any of the "Gondwanaland" countries). In the Permian the position is reversed, for while Europe and North America are quite without coal seams of that age, the southern continents have them in abundance.



MAP 7. PERMIAN.

Locality Key.—1. Little R.; 2. Oakey and Coal Creeks; 3. Mt. Mulligan; 4. Stewart's Ck.; 5. Galah Gorge; 6. Oxley Ck.; 7. Bett's Ck.; 8. Blair Athol; 9. Jericho; 10. Collinsville; 11. Bowen R.; 12. Mt. Britten and Nebo; 13. Saltbush Park; 14. Logan Downs; 15. Yatton and Mt. Bora; 16. Mackenzie R.; 17. Tolmies and Bluff; 18. Springsure; 19. Mantuan Downs; 20. Nardoo; 21. Carnarvon Ck.; 22. Dawson; 23. Banana; 24. Cracow; 25. St. Helens; 26 Oakey Creek; 27. Tooloombah and Wilangi; 28. Dinner Creek; 29. Lakes Ck.; 30. Cania; 31. Yarrol; 32. Gigoomgan; 33. Gympie; 34. Cressbrook Ck.; 35. Northbrook; 36. Silverwood; 37. Silverspur.

Wherever, as in Queensland, these Permian coal measures are found, they have associated with them a very characteristic suite of fossil plants, collectively known as the *Glossopteris* flora. This assemblage is very different both from the characteristic *Lepidodendron-Calamites* flora of the Carboniferous coal measures of the northern hemisphere, and from the *Rhacopteris* flora of the barren Carboniferous of the southern hemisphere.

Another very interesting feature that the Queensland Permian deposits share with those of Gondwanaland generally, is the presence of glacial deposits. Those in Queensland are of especial interest in that they occur well within the tropics.

Of the numerous Permian deposits that are scattered over a large part of the State, by far the most important are those within the Great Bowen syncline, an enormous structure measuring 400 miles in length and up to 150 miles in breadth. The Bowen Series, from which the syncline gets its name, is typically developed in the northern part of the structure, in the valley of the Bowen River, and has been traced south, successively through the extensive valleys of the Isaacs, Mackenzie and Dawson Rivers.

This widespread and thick series varies greatly in lithology. Not only are there variations from place to place, but there are frequent changes in the succession of strata at each individual locality. This variability is due to the unstable geographical conditions which characterised the period. The complexity resulting from these variations of facies and of stratigraphical sequence makes it difficult to give a generalised account for all the Permian deposits within the Bowen syncline and it would seem advisable to restrict our attention in the first place to an examination of the series as seen in the type area.

As typically developed the Bowen Series commences with a remarkable outburst of volcanic activity. This was sustained long enough for the accumulation of over 5,000 feet of volcanic rocks, ranging in type from flows to tuffs, and agglomerates, and in composition from basalts and andesites to rhyolites. The continuity of this great volcanic series is however interrupted by some 400 feet of fresh-water sediments. These have two special points of interest, namely the appearance of the *Glossopteris* flora (represented here solely by *Glossopteris*), and the presence, near Mount Devlin, of the oldest coal seam yet found in Queensland. This rather poor seam is the fore-runner of the extensive and valuable Middle Bowen coal measures of Collinsville that immediately succeed the volcanics of the Lower Bowen. These coal measures are about 700 feet thick and are for the most part typically lacustrine deposits (with the fossil plants *Glossopteris, Nummulospermum, Noeggerathiopsis* and *Dadoxylon*), but they, somewhat surprisingly, include one distinct marine horizon. This latter resulted from an incursion of the ocean that was merely transient, but following the deposition of the coal measures the sea returned, to stay for a sufficiently long time to allow the deposition of the 2,400 feet of marine sediments which, with the Collinsville coal measures, constitute the Middle Bowen. These persistent marine beds have several points of interest. They include, at the base, a sandstone horizon which has weathered into a striking escarpment known as "The Wall" and which thus forms a conspicuous and useful horizon. Higher in the series there has been found evidence of contemporaneous glaciation, consisting of groups of boulders, and very large isolated boulders embedded sporadically in fine sandy or muddy strata. Although the curious distribution of the boulders might possibly be explained in other ways, the simplest and most likely explanation is that they were dropped from floating ground-ice. Somewhat similar evidence of glaciation is found again about 800 feet higher in the series.

Numerous fossils are found on many horizons in the marine sediments of the Middle Bowen. Indeed some strata are so crowded with fossils that they form easily recognisable and stratigraphically valuable horizons. Of these

may be mentioned the A.M.M. bed, so called because of the vast number of specimens of the genera *Agathiceras* (more correctly known as *Bellerophon*), *Mourlonia* and *Merismopteria;* the Big *Strophalosia* horizon containing almost incredible numbers of *S. clarkei* and the "*Derbyia senilis*"* horizon, similarly crowded with its particular species.

Other genera characteristic of the Middle Bowen but occurring in less concentrated form are the rugose coral *Euryphyllum,* the crinoid *Tribrachyocrinus,* the bryozoa *Stenopora, Fenestella* and *Protoretepora,* the brachiopods *Dielasma, Spiriferina, Spirifer, Martiniopsis* and *Productus,* the lamellibranchs *Maeonia, Aviculopecten, Deltopecten, Chaenomya, Cleobis, Astartila, Solemya* and *Stutchburia,* the gastropod *Naticopsis* and the pteropod *Hyolithes.*

Succeeding the Middle Bowen are the essentially freshwater beds of the Upper Bowen which total nearly 10,000 feet. These begin with a small thickness of characteristic freshwater shales with which are associated coal seams and the plant fossils *Phyllotheca, Glossopteris, Sphenopteris, Cladophlebis* and *Dadoxylon.* Immediately above these coal measures is an horizon which is of unusual interest on account of the remarkable development of fossil wood which is found in abundance on every weathered outcrop.

In view of what we have noted in the earlier formations of the series, it is not surprising to find within the predominantly lacustrine beds of the Upper Bowen, evidence of yet another temporary invasion of the sea in a bed containing abundant *Orthothetes* (*Derbyia*) together with the other brachiopods *Linoproductus* and *Spirifer,* the bryozoan *Stenopora,* the lamellibranchs *Aviculopecten,* and *Merismopteria,* the gastropods *Bellerophon* and *Mourlonia* and others.

Another noteworthy feature of the uppermost beds of the Bowen Series is the relatively important place occupied by volcanic ash and interbedded tuffs—an interesting reversion to the volcanic activity that played such an important part in the early history of the series.

In all, the Bowen Series embraces no less than 18,000 feet of strata, and, as we have seen, includes interesting alternations of marine, lacustrine, volcanic, and glacial horizons. These have been somewhat arbitrarily separated into the three major divisions, Upper, Middle and Lower Bowen, and these in their turn have been subdivided on lithological and other grounds. Details of these and their probable equivalents in other areas are shown in Table M.

Of the other occurrences of Permian strata within the Bowen basin, and they are numerous, those in the neighbourhood of Springsure have been studied in closest detail. There, the total thickness of strata is considerably less than that met with in the type area, and the succession presents a number of important differences. The equivalents of the Lower Bowen Series, although comparable in thickness, are distinguished by a complete lack of volcanic rocks and the development, in place of these, of a series of alternating marine and freshwater strata. Of the five stages that have been differentiated on lithological grounds, that known as the Dilly stage is of especial interest. In the first place evidence of great aridity is supplied by the presence of the mineral gypsum in such quantities that the formation is sometimes known as the Gypseous stage. Evidence of glacial conditions is also found within the stage. Of the numerous fossil remains of animals and plants present the most important are the bryozoans *Stenopora, Protoretepora* and *Fenestella,* the brachiopods *Linoproductus, Strophalosia, Spirifer* and *Dielasma* and the lamellibranchs *Aviculopecten* and *Eurydesma.*

* More correctly *Orthothetes* sp.

The Coral stage too contains many marine fossils of interest including the corals *Euryphyllum, Cladochonus* and *Trachypora,* the brachiopod *Martiniopsis,* the lamellibranch *Aviculopecten,* the gastropod *Bellerophon* and the pteropod *Conularia.*

The Middle Bowen as developed in the Springsure district presents a general resemblance to that of the Bowen River in that marine, lacustrine, and glacial deposits are all well represented, and a more particular similarity in the presence of the Big *Strophalosia* horizon.

The most characteristic marine fossils found are the coral *Euryphyllum,* the bryozoans *Stenopora* and *Fenestella,* the brachiopods *Strophalosia, Linoproductus, Dielasma, Spirifer* and *Martiniopsis,* the lamellibranchs *Maeonia, Aviculopecten* and *Deltopecten,* and the gastropods *Ptychomphalina* and *Platyceras.*

One striking and important difference from the typical Middle Bowen is the relatively poor development of coal measures in the Springsure district.

The Upper Bowen as here developed is generally similar to that of the type area in being essentially a lacustrine series with the *Glossopteris* flora and in containing, towards the base, a development of tuffaceous rocks enclosing a prominent horizon with much fossil wood.

Of the developments of Permian strata beyond the Bowen basin to the east and south, some may represent outliers of the main structure, that have been preserved either owing to their having been down-faulted into old resistant rocks or that have survived due to the vagaries of the denudational processes. Others of these isolated areas may, on the other hand, never have been directly connected with the strata of the Bowen syncline.

Of the down-faulted areas perhaps the most interesting are those which form a group near Warwick. Here the Fault Block Series is developed and, like the deposits of the Bowen basin, consists of both marine, lacustrine and volcanic rocks, this full development being in contrast with the other infaulted Permian areas which do not contain freshwater beds.

The Fault Block Series is composed of a number of isolated blocks, no one of which contains the full stratigraphical sequence. However, by comparing the sequences shown in the different blocks and correlating those parts which are sufficiently similar in lithology and fossil content, a fairly complete, if somewhat uncertain, record may be compiled. Several different schemes of correlation, based on these methods, have been advanced by various authors, but we favour the interpretation now presented for the first time in Table N.

According to this view the oldest Permian deposits in the area are the marine sediments of the Condamine Block, containing the corals *Trachypora* and *Cladochonus,* the bryozoan *Fenestella,* the lamellibranch *Aviculopecten,* and the gastropods *Naticopsis, Pleurotomaria* and *Ptychomphalina.*

The approximately equivalent *Eurydesma* beds received their name from the remarkable fossil shell bank, quite like a present-day oyster bank, crowded with specimens of the thick-shelled lamellibranch *Eurydesma,* with which are associated many other marine fossils, notably the bryozoa *Stenopora* and *Fenestella,* the brachiopods *Linoproductus, Dielasma, Martiniopsis,* and the lamellibranchs, *Cardiomorpha, Maeonia, Chaenomya* and *Aviculopecten.*

The Eight-Mile Creek beds, although apparently coeval with the above, were deposited in shallower water and are characterised by the presence of the brachiopod *Martiniopsis,* with which are found *Spirifer* and *Dielasma,* the bryozoa *Fenestella, Polypora,* the lamellibranchs *Edmondia, Aviculopecten, Deltopecten* and the gastropod *Platyschisma.* Interbedded with these marine deposits is at least one freshwater bed containing *Glossopteris* and *Noeggerathiopsis.*

At a somewhat higher horizon but in another fault block the Wallaby beds contain a rich flora consisting of *Phyllotheca, Gangamopteris, Glossopteris* and *Noeggerathiopsis.* Immediately above this freshwater bed there occurs a richly fossilferous marine stage which has yielded seventeen different genera, including the bryozoa *Fenestella* and *Protoretepora,* the brachiopods *Orbiculoidea, Strophalosia, Spirifer* and *Martiniopsis,* the lamellibranchs *Solenopsis, Mytilus* and *Astartilla* and the gastropod *Keenia.*

The uppermost part of the Fault Block Series is seen in several of the individual blocks, and especially in the Rhyolite Range beds, to be made up of a considerable thickness (at least 2,000 feet) of lavas and tuffs which are for the most part of a rhyolitic character.

The other infaulted areas at Cressbrook Creek, Northbrook, Gympie, Lakes Creek and Silverspur are typically marine deposits which are frequently richly fossiliferous on certain horizons, fossils common to several of them being the corals *Trachypora* and *Cladochonus,* and a large species of the brachiopod *Linoproductus.*

Lakes Creek in particular has a wealth of bryozoa, including at least fifteen species of the genera *Fenestella, Minilya* and *Polypora.*

At Silverspur scattered boulders within finer sediments occur, which are suggestive of glacial conditions.

At Gympie the marine beds are intercalated with extensive developments of contemporaneous tuffs, mostly of an andesitic nature, that gave rise to the so-called greywackes, greenstones and diabases that figure so prominently in the series. Near the top of the beds the "Phoenix slates" contain boulders to which a glacial origin has been attributed. The highly carbonaceous shales that occur at several horizons are of especial interest in that they have played an important part in bringing about the deposition of the gold which made Gympie one of the most prominent goldfields in the State.

The other areas of Permian strata found east of the Great Bowen Syncline all possess points of interest. At Gigoomgan, the most southerly of these outcrops, there occurs a very remarkable development consisting of over 1,100 feet of limestone made up almost entirely of the fragmentary remains of minute calcareous algae. The rocks of the Styx River localities are also essentially marine, the most interesting fossil in this case being *Eurydesma cordatum.* At Dinner Creek, near Rockhampton, there occurs a series of freshwater sediments in which the plant *Glossopteris* is found on a very low horizon. Indeed this is probably the earliest representative of the genus yet found in Australia. *Glossopteris* is also found, although on a somewhat higher stratigraphical level, associated with the coal measures of St. Helens, near Mackay. Similar coal measures are found at Oakey Creek, near St. Lawrence, but these, although probably also Permian, have not yielded *Glossopteris.*

In addition to the Permain developments already mentioned, there exist extensive areas in which freshwater beds of Permian age are found. These are grouped in two distinct regions, one to the west of and contiguous with the main Bowen basin; the other, a separate area, well to the north. Within both these regions more or less isolated lacustrine beds are found which are lithologically similar and which all contain the characteristic fossil *Glossopteris.* At Betts' Creek this plant is found with *Taeniopteris,* while at Jericho the associated genera are *Thinnfeldia* and *Schizoneura.* Several of the occurrences contain coal seams, some of which, like those at Blair Athol, are of great economic importance. Mount Mulligan and Little River are of interest as the Permian strata at those places have been downfaulted into very hard resistant old rocks and thus preserved from erosion. Structurally these faulted blocks are similar to those already dealt with earlier in this chapter.

TABLE M.

THE SUCCESSION OF PERMIAN DEPOSITS IN THE GREAT BOWEN SYNCLINE.

	Springsure District.		Bowen Basin.		
	Carborough Series (Triassic)		*Redcliffe Series (Triassic).*		
Upper Bowen	Lacustrine 5,000′	Greenish to yellowish sandstones shales and Carnarvon Red Member clays with grey shales, massive sandstones and coal seams Tuffs with Fossil Wood Horizon	Lacustrine 9,600′	Mainly tuffs, some sandstones and shales with coal seams Marine horizon Tuffs with Fossil Wood Horizon Shales and coal with *Glossopteris* flora	
Middle Bowen	Mainly marine, some lacustrine 900′	Soft sandstones and calcareous Big *Strophalosia* Horizon fossil beds. Marine glacial beds. Coal Measures.	Marine 2400′	Coral Creek Beds, 550′	Sandstones Glacial deposits
				Collinsville Stage, 850′	*Derbyia senilis* Horizon Sandstones and shales Big *Strophalosia* Horizon A.M.M. Bed. Glacial deposits
				Basal Beds, 1000′	Siliceous sandstones. "The Wall" Sandstone
			Lacustrine 700′	Collinsville coal measures 700′	Sandstones, shales and Marine Horizon conglomerates ; five seams
Lower Bowen	Paralic, 5,500′	Catherine or Consuelo stage Coral or Ingleara ,, Serecold or Aldebaran ,, Dilly or Gypseous ,, Staircase ,,	Volcanics and Lacustrine 5400′+	Mt. Devlin Volcanics, 2000′	Rhyolitic tuffs and shales. Basalts, andesites and tuffs
				Mt. Devlin coal measures 400′	Sandstones and congl. with *Glossopteris* flora. Andesites. One seam.
				Mt. Toussaint Volcanics, 3000′ ?	Andesitic flows tuffs and Agglomerates
			Granite and metamorphics		

TABLE N.

THE DOWN-FAULTED AREAS TO THE EAST AND SOUTH OF THE GREAT BOWEN SYNCLINE.

	Fault Block Series (Silverwood).						Other Faulted Areas.				
	Marine and Lacustrine						Marine				
	Condamine Block	Stanthorpe Road Block		Eight Mile Creek Block		Tunnel Block	Cressbrook Creek	Northbrook	Gympie	Lakes Creek	Silverspur
		Eurydesma Beds	Wallaby Beds	Eight Mile Creek Beds	Rhyolite Ra. Beds						
LOWER PERMIAN (scale: 7000', 6000', 5000', 4000', 3000', 2000', 1000', 0')	Rhyolitic tuffs and tuffaceous grits / Calcareous / *Cladochonus* and *Trachypora*. marine sediments	Cherty shales / *Cladochonus* sandstones *Eurydesma* conglomerates and grits	Marine shales / Lacustrine shales	Volcanics lavas and tuffs mostly acid / shallow water marine inter-bedded / *Glossopteris* with fresh water. / Basal congl.	Volcanics lavas and tuffs mostly acid / shallow water marine sediments	acid lavas / marine grits etc.	Rhyolites / Compact / *Cladochonus* and *Trachypora*. mudstones / large *Cladochonus*, and felspathic / *Conularia* sandstones	Tuffaceous conglomerates and shale with *Cladochonus*, *Trachypora* and other marine fossils	Limestones, sandstones, carbonaceous shales, conglomerates, glacial boulders, and interbedded tuffs with *Cladochonus*, *Eurydesma*?, and other marine fossils	Mudstones and grits with *Cladochonus* *Trachypora* abundant bryozoa, Productids and other marine fossils.	Tuffaceous shales sandstones glacial boulders? and conglomerates with *Cladochonus* and other marine fossils

TABLE O.

OTHER AREAS TO THE EAST OF THE GREAT BOWEN SYNCLINE.

	Marine and Volcanics		Marine		Lacustrine and Volcanics					
	Styx River (Tooloombah and Wilangi)		Gigoomgan		St. Helens (Mackay)		Oakey Creek (St. Lawrence)		Dinner Creek (Rockhampton)	
Mesozoic		*Cretaceous coal measures*								*Jurassic sandstones*
Upper Permian										
Middle Permian		Siliceous sandstones								
	1500′	Fine micaceous fossiliferous sandstones								
	4800′	Black sandy shales tuffaceous sandstones			700′+	Coal Measures with *Glossopteris*	2000′+	? Coal Measures (*Glossopteris* absent.)		
Lower Permian	1000′	Andesites and interbedded conglomerate	1100′	Algal limestone	12,000′	? Coal measures with fossil plants and interbedded basalts (*Glossopteris* absent)	3000′+	? Andesitic volcanics, tuffaceous sandstones and acid volcanics.	5400′	Andesites some tuffs and rhyolites
	500′	Marine sediments with *Eurydesma cordatum* etc.	1100′+	Calcareous shales and fossiliferous limestone					3200′	Conglomerates with interbedded shales, sandstones and rhyolites. *Glossopteris* from about middle up.
	1600′+	Andesites etc.		Limestones sometimes algal						
Pre-Permian						*Andesitic volcanics with oolitic limestone (Rockhampton Series.)*				

TABLE P.

ISOLATED AREAS OF PERMIAN LACUSTRINE BEDS IN NORTH AND CENTRAL QUEENSLAND.

	Little River (Fault Block)	Oakey and Coal Creek	Mount Mulligan (Fault Block)	Stewarts Creek	Galah Gorge	Oxley Creek	Betts Creek	Blair Athol	Jericho
		Tertiary ? Sandstones.	*Triassic Sandstones*		*Basalt*	*Tertiary ? Sandstones*	*Tertiary ? Sandstones*		*Mesozoic Sandstones.*
Upper Permian				300′ or more of coaly shales and conglomerates with *Glossopteris* flora.	Porous sandstones with lenticular coal seams and *Glossopteris* flora	1,300′ of sandstones and shales with two coal seams and *Glossopteris* flora	Conglomerates sandstones and shales with *Tæniopteris* and *Glossopteris*	Over 400′ of sandstones and conglomerates with three coal seams and *Glossopteris* flora.	Sandstones with *Thinnfeldia* and *Glossopteris*
Middle Permian									
Lower Permian	Sandstones and shales with *Glossopteris* flora and numerous thick coal seams	Sandstones shales and fireclays with *Glossopteris* flora and three thin coal seams	Sandstones and shales with *Glossopteris* flora and three coal seams						
		Slates and quartzites	*Volcanics and Hodgkinson Series.*	*Quartzites*	*Pre-Cambrian metamorphics of Cape River*	*Pre-Cambrian metamorphics of Cape River*	*Slates and quartzites.*	*Peak Downs Series*	

TABLE Q.

GENERAL DISTRIBUTION AND STRATIGRAPHY OF THE PERMIAN.

—	West and north of Bowen syncline (Lacustrine)	Great Bowen Syncline (Marine, Lacustrine and Volcanics)			East and south of Bowen Syncline (Marine, Lacustrine and Volcanic)	
					Down-faulted Areas	Other Areas
				Important Localities.		
Upper Permian	Betts Creek, Blair Athol, Galah Gorge, Jericho, Oxley Creek,	Upper Bowen		Bowen R. area, Dawson Mackenzie Area, Isaacs River, Springsure.		
Middle Permian		Middle Bowen	Marine	Bowen R. Area, Eaglefield, Grosvenor Downs, Logan Downs, Mt. Britton, Saltbush Park, Springsure.		Oakey Creek, St. Helens and Styx River.
			Coal Measures	Collinsville to Grosvenor Downs and beyond.		
Lower Permian	Little River, Mt. Mulligan, Oakey and Coal Creeks.	Lower Bowen		Bowen River Area, Cracow, Dawson — Mackenzie Basin, Mt. Britton, Saltbush Park, Springsure, Yatton.	Cressbrook Creek, Gympie, Lake's Creek, Northbrook, Silverspur and Silverwood (Fault Block Series)	Dinner Creek, Gigoomgan, Oakey Creek, St. Helens and Styx River.

TRIASSIC.

The distribution in Queensland of Triassic deposits is very different from that of all the earlier periods.

We have seen that, throughout the Palaeozoic era, the deposition of marine strata played an important, usually a dominant, part in the stratigraphical history of the State, whereas, by contrast, the sediments of the Triassic were all laid down under freshwater. In particular, the region of the great Tasman geosyncline, which had dominated the geography of the eastern half of the State from the Cambrian to the Permian, shows not the slightest indication of the presence of marine strata in the Triassic.

This great geographical change, although it roughly coincides with the beginning of the Mesozoic era, was in fact the culmination of a process of transition which, as we saw, was clearly indicated by the succession of events in the Bowen basin during the closing stages of the Palaeozoic. It may well be significant that the oldest Triassic rocks known in the State are the result of the intense and prolonged eruption of andesitic material, for volcanic activity of this type is characteristic of geosynclines in general and was frequently displayed in the history of the Tasman geosyncline.

The lacustrine beds which dominate this period contain numerous characteristic fossil plants. These are known collectively as the *Thinnfeldia* flora on account of the prominence of that genus. Although quite distinct from the *Glossopteris* flora of the Permian period, the two were in existence side by side for a short time before the end of the Palaeozoic. The new flora once established persisted, as we shall see, with certain evolutionary changes, until at least the middle of the Jurassic.

In addition to those Triassic series, the age of which has been determined on the evidence of these plants, there exist in the State many extensive deposits which, although lithologically similar, have not yet yielded fossils. These may be in part Triassic, but similar barren lacustrine beds range from as early as Permian to as late as Cretaceous times, and the subdivision of these and the precise allocation of their parts to their respective periods has not yet been finalised.

Of such regions the most interesting and important is that which forms the wide and complex intake belt of the Great Artesian Basin. The Triassic strata which form part of this belt, extensive though they may be, probably represent only the eastern outcrops of much more extensive beds which now lie hidden beneath the upper strata of this enormous structure.

The oldest Triassic beds found in the State are those for which the name Neara Series is proposed.* The series consists essentially of andesitic boulder beds. The boulders are of andesite and porphyrite ranging up to 3 feet in diameter but for the most part somewhat larger than a cricket ball. In some occurrences the boulders are nearly all smoothly rounded, in others they are quite angular. These boulders are set in a matrix of andesite and andesitic tuff. The only recognisable fossil collected from the series is the cycad-like plant *Nilssonia princeps.* This extraordinary volcanic series, part of which at least was laid down under water, covers an area which, although

* This new serial name is proposed to replace "Lower Esk Series." It is based on the name of the parish in which the series is typically developed.

narrow, stretches almost unbroken from Deep Creek in the south to the neighbourhood of Goomeri and Kilkivan in the north (where it is known as the Kinbombi beds), a distance of at least 80 miles. The nature of the series and its distribution suggest that it was laid down as a piedmont deposit at the foot of a range of late Palaeozoic or early Mesozoic volcanoes.

The Esk Series* which succeeds the Neara Series without perceptible unconformity, was laid down in lakes and swamps but is too calcareous to be regarded as typically lacustrine. Forming the lowest part of the series as now defined is the Acid Tuff stage made up largely of tuffs interbedded with shales and sandstones. Above the Acid Tuff stage are the Esk shales grading laterally into the Bellevue conglomerates. The former contain many fossil plants, the most interesting of which are a very large species of the "horse tail" *Schizoneura* which evidently grew in swamps of those days and was gradually smothered by silt in the position of growth, and species of the pteridosperm *Thinnfeldia* with very large pinnules. Other fossils found are the ferns *Cladophlebis, Todites, Asterotheca* and *Dictyophyllum,* the pteridosperms *Sphenopteris* and *Stenopteris,* the ginkgos *Ginkgoites* and *Phoenicopsis,* and the Bennettitales and related forms, namely *Taeniopteris, Pterophyllum, Nilssonia* and *Pseudoctenis.*

The Esk Series can be traced, although not continuously, to the north where, near Goomeri, it is known as the Manyung series. This series consists of conglomerates, sandstones and calcareous shales containing *Schizoneura, Thinnfeldia, Taeniopteris, Nilssonia, Ginkgoites* and *Pteruchus.*

Still further north, at Mundubbera, beds that may be correlated with some confidence with the Esk Series rest unconformably on Carboniferous strata.

The Triassic beds about which we have the most complete information are those forming the Ipswich Series. These, although also lacustrine, are of a quite different facies from the Esk Series in being non-calcareous. The lithological differences resulting from this are quite striking. Although the Ipswich Series may be in part equivalent to and a local varient of the Esk Series, it is for the most part younger. Although it occupies only a small part of the State, it is full of geological interest and, in addition, is of great economic importance. The constituent beds appear to have been deposited only in part under quiet lacustrine conditions, for the variable nature of the strata and the evidence they show of contemporaneous movements are more suggestive of accumulation under piedmont conditions.

The series has an ascertained thickness of 4,000 feet and is divisible into several stages, the most important being the Tivoli stage, and the Blackstone stage. Both these are richly fossiliferous and contain numerous coal seams.

Almost at the base of the Ipswich Series there occurs the Mount Crosby insect bed which contains the earliest fossil insects known in Queensland, and which promises to be one of the most prolific beds of its kind in the world, for already fossil insects to the number of several thousands have been collected from this horizon. The great majority of these have not yet been critically examined, but the following have been named and described: *Eoses,* possibly the earliest of the butterflies, and primitive cockroaches of the genus *Triassoblatta.*

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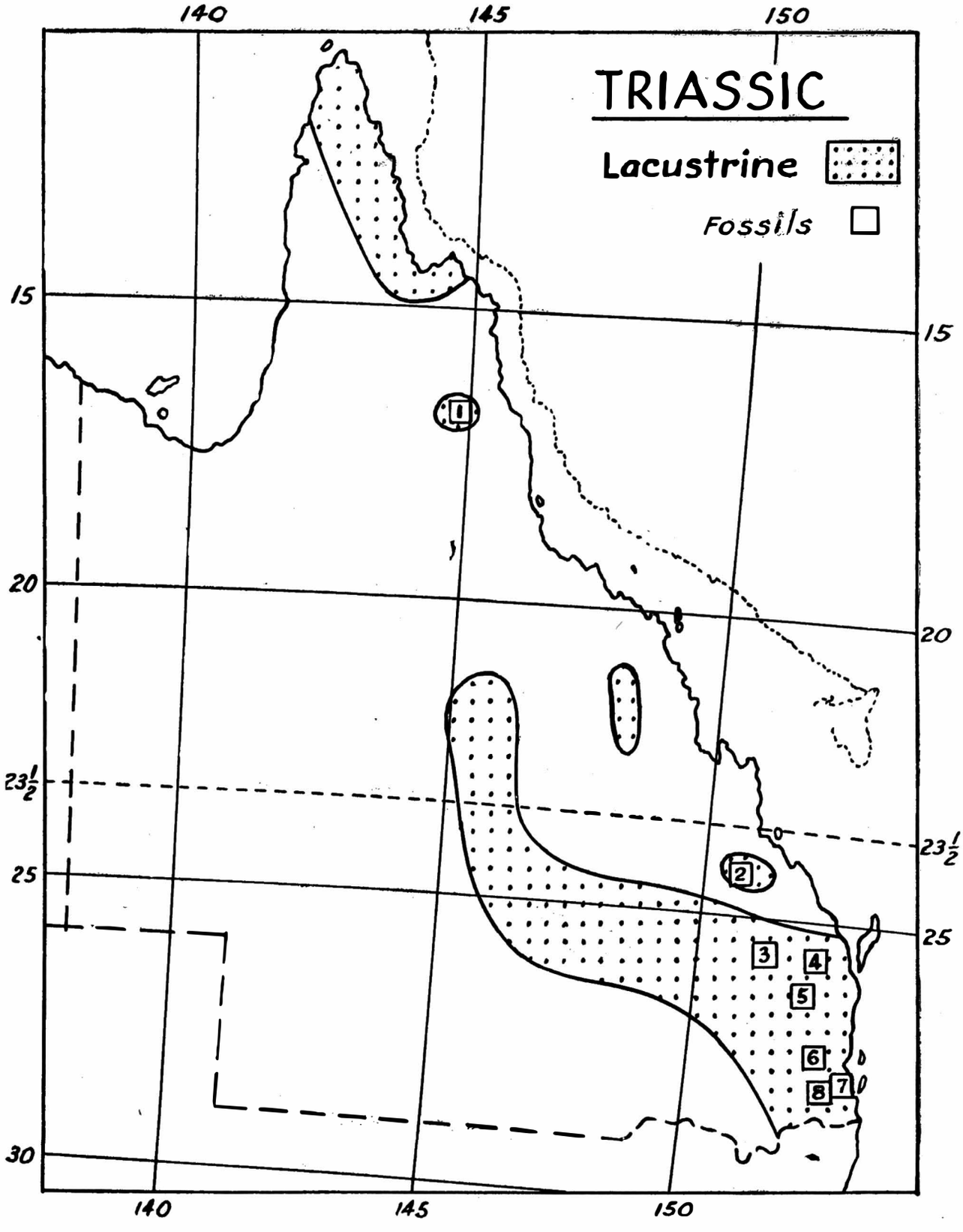
* Name used in a restricted sense for what was previously known as the "Upper Esk Series."



MAP 8. TRIASSIC.

Locality Key.—1. Mt. Mulligan; 2. Callide; 3. Mundubbera; 4. Brooweena; 5. Goomeri; 6. Esk; 7. Brisbane; 8. Ipswich.

The beds between the insect beds and the Tivoli stage are also of interest as containing a thick and heavy conglomerate and several beds of tuff. These latter, although only poorly developed, are regarded as the equivalents of the Acid Tuff stage of the Esk Series (already mentioned) and of the Brisbane Tuff (to be dealt with later).

For the most part the Tivoli stage consists of sandy shales, the lower members of which are brown and yellow in colour, the upper members grey. Within these shales are found a number of important coal seams, and many fossil plants.

The Tivoli stage is succeeded by the barren sandstones of the Cooneana stage which are in turn followed by the Blackstone stage. This is made up largely of blue and grey shales and felspathic sandstones and includes a number of valuable coal seams. The shales have yielded numerous exquisitely preserved fossil plants forming a suite similar in many respects to that of the Tivoli stage.

Fossil plants common to both the Tivoli and the Blackstone stages include the "horse tails" *Neocalamites* and *Schizoneura,* the ferns *Cladophlebis* and *Rienitsia,* the pteridosperms *Thinnfeldia* and *Stenopteris,* the ginkgoes *Ginkgoites* and *Czekanowskia,* the Bennettitales *Taeniopteris, Doratophyllum* and *Pseudoctenis,* and the freshwater lamellibranch *Unio.* Forms which occur in the Tivoli stage and lower beds, but not in the Blackstone stage, include the pteridosperm *Johnstonia, Linguifolium* which may be related to the cycads and *Yabeiella* (with its seed *Fraxinopsis*) which may be a primitive dicotyledon. In the Blackstone stage we find the following forms which are absent from the Tivoli stage: the fern *Dictyophyllum,* the pteridosperm *Sphenopteris,* the Ginkgo *Phoenicopsis* and the small bivalved crustacean *Estheria.*

Almost at the top of the Blackstone stage occurs the famous Denmark Hill insect bed. So many specimens have been collected and described from this prolific horizon that it is possible to gain some idea of the insect population of the time. A census of individual specimens shows that the different insect groups were present in the following percentages:—Beetles (e.g., *Andemosyne*) 50, Cicadas (e.g., *Ipsvicia*) 15, Cockroaches (e.g., *Triassoblatta*) 13, Bugs (e.g., *Dunstania*) 6, Dragon flies (e.g., *Triassolestes*) 2·5, Scorpion flies (e.g., *Stereochorista*) 1·2, Praying Mantis (e.g., *Triassomantis*) 1, Locusts (e.g., *Triassolocusta*) 1, Lacewings (e.g., *Triassopsychops*) 0·6, and various groups now extinct 9·7. It is of particular interest that the Ipswich Series should finish as it began with an important fossil insect horizon.

Only the lower part of the Ipswich Series is developed in and about the city of Brisbane, but it presents some interesting features. Resting as it does on the upturned edges and very irregular surface of the Brisbane schists, it provides a striking example of a "buried landscape" unconformity. Nearly at the base of the series is the Brisbane tuff. This forms a solid mass over 200 feet thick, which provides conspicuous sections and outcrops. A small thickness at the base appears to be a normal, but very compact, fine grained rhyolitic tuff. Within and immediately below this are found numerous silicified (sometimes opalised) tree trunks up to 160 feet in length. A microscopical study of the finely preserved woody structures shows that these trees were largely conifers and included the genus *Cedroxylon.*

The upper part of the Brisbane tuff appears to have been expelled as a *nuee ardente*—an incandescent mixture of volcanic ash and gas—which was so hot that on settling it welded itself into a solid mass, the lithology and structures of which closely resemble those of a rhyolite flow. Numerous trees

and fragments of fossil wood are also found in this welded tuff. These were all charred by the intense heat of the falling ash and are now in the form of charcoal or, in some extreme cases, of graphite.

The Ipswich Series is also represented in the Maryborough hinterland, but here it contains no coal seams and but few fossils, and is known as the Brooweena Series. Still further north in the Callide Valley, valuable coal measures occur that may be correlated with the Ipswich Series on the evidence of the fossil plants which include: *Cladophlebis, Thinnfeldia, Ginkgoites* and *Pterophyllum.*

Other Triassic developments within the State that may prove to be equivalents of the Ipswich Series are found at Bompa and Mount Mulligan.

Lying immediately above the Ipswich Series in the type district is the Bundamba Series. At its base there is developed a conspicuous horizon (once assigned to the top of the Ipswich Series) known as the Aberdare Conglomerate. Succeeding this are massive sandstones, some interbedded shales with one thin coal seam and the fossil plants *Neocalamites, Cladophlebis, Thinnfeldia, Ginkgoites, Sphenobaiera* and *Taeniopteris* and the freshwater mollusc *Unionella.*

The massive sandstones give rise on weathering to a characteristic topography and barren sandy soil. These may be traced as far south as Warwick, where numerous fossil trees occur, and to the north via Landsborough to the Maryborough area, where very similar sandstones are known as the Myrtle Creek Series. The Mondure Series, which overlies the Manyung Series in the Gloomeri district is also a likely equivalent.

Lastly, reference may be made again to the extensive belt of lacustrine strata to the east of the Great Australian Basin, a considerable portion of which (the Dooloogarah Series) may also prove to be contemporaneous with the Bundamba Series.

TABLE

THE DEPOSITS OF THE

Note: * Indicates

	Maryborough Area.		Moreton Area.							
			Brisbane–Border.		Aspley (Brisbane).	Ipswich–Rosewood.		Brisbane Valley Wivenhoe, and Esk.		Goomeri.
Post Jurassic		*Graham's Creek Series (Volcanics)*		*Basalts with interbedded sandstones and shales (Tertiary)*	*Petrie Series (Tertiary)*	*Redbank Series (Tertiary)*				*Basalts*
Upper Jurassic										
Middle Jurassic	Tiaro Series.	Shales* and sandstones with coal seams	Walloon Series.	Shales* and sandstones with coal seams		Rosewood Stage.* Olive to brown shales, soft sandstones and coal seams				
Lower Jurassic						Marburg Stage.* felspathic sandstones and shales				
Upper Triassic	Myrtle Creek Series.	Massive Siliceous Sandstones	Bundamba Series.	Massive Siliceous Sandstones		Massive Siliceous Sandstones Aberdare conglomerate	Bundamba Series.	Massive Siliceous Sandstones	Mondure Series.	Sandstones and clay shales
Middle Traissic	Brooweena Series.	Blue grey shales and sandy shales Purple shales Purple conglomerates	Ipswich Series.	Grey to brown shales and sandstones Conglomerates Brisbane Tuff	Grey to brown shales and sandstones Grits "Esk" facies* and Brisbane Tuff with Fossil Tree Horizon	Denmark Hill Insect Bed Blackstone Stage Blue grey shales, sandstones and coal seams Cooneana Stage. Sandstones Tivoli Stage. Yellow to brown shales, sandstones and coal seams Conglomerates Brisbane Tuff Mt. Crosby Insect Bed	Esk Series.	Bellevue conglomerates (equals Esk shales*) with thin coal seams Acid Tuff Stage	Manyung Series.	Conglomerates shales* and sandstones*
Lower Triassic							Neara Series.	Andesitic boulder beds	Kimbombi Series.	Andesitic boulder beds, etc.
Pre Triassic		*Permian ?*		*Brisbane Schists (Lr. Palaeozoic)*	*Bunya Series (Ordovician)*	*Brisbane Schists (Lr. Palaeozoic)*		*Fernvale Series (Silurian)*		*Fernvale Series (Silurian)*

B.

TRIASSIC AND JURASSIC LAKES.

Calcareous Strata.

	Mundubbera.	Mulgeldie.	Cracow.	Margin of Artesian Basin (e.g. Orallo).	Darling Downs.	Other Areas.
		Basalts and clays (Tertiary)		*Roma Series (Cretaceous Marine)*	*Diprotodon Beds Basalts (Tertiary)*	
				Blythesdale Series. (Lower) (Upper). *Transitional phase (Cretaceous)*		
				Friable and porous sandstones grits and conglomerates		
		Mulgeldie Coal Measures. Shales and fossiliferous ironstone with coal seams		Cunno Series. Sandstones,* shales and mudstones with coal as at Cornwall and Alcurah	Shales* and sandstones* with coal as at Killarney, Oakey, and Tannymorel	Caloundra Pascoe R. Beds. Laura Series
				Rhaetosaurus Horizon		
		Soft yellow and red sandstones and shales		Attica Series. Friable sandstones	Sandstones ?	
Bundamba Series.	Siliceous sandstones and conglomerates	Bundamba Series. Massive siliceous sandstones	Sandstones with conglomerate at base	Dooloogarah Series. Sandstones, conglomerates and fossiliferous white shales	Massive sandstones	Carborough (equals Redcliffe) massive sandstones in Great Bowen Syncline. Landsborough
Esk Series.	Shales* and sandstones*					Bompa Callide Coal Measures Cape Moreton Mt. Mulligan
		(faulted junction)	Cracow Series. Lavas, tuffs and agglomerates			
	Rockhampton Series (Carboniferous)	*Rockhampton Series (Carboniferous)*	*Lower Bowen (Permian)*	*Bowen Series (Permian)*	*Palaeozoics*	

JURASSIC.

The distribution of Jurassic strata in Queensland as represented on geological maps of the State, is strikingly similar to that of the Triassic period. There are two reasons for this remarkable parallelism. In the first place there can be little doubt that geographical conditions in the Jurassic of Queensland were in fact very like those of the preceding period; that the Jurassic was here virtually a prolongation of the Triassic. But in addition to this continuity of conditions, and partly because of it, there is considerable difficulty in distinguishing the deposits of the two periods, on either lithological or palaeontological grounds. Indeed this difficulty proved so real that the earlier geologists found it advisable to use the compound name Trias-Jura to include all the Lower Mesozoic deposits of the State. This position has been improved by a closer study of the palaeobotanical evidence, and, where fossils are plentiful, the containing beds may now be assigned with confidence to their proper periods; but there remain extensive areas which have not yet yielded fossil collections adequate for this purpose.

The Jurassic, like the Triassic, was essentially a period of lakes*, one of which, Lake Walloon, appears to have covered an area of over a quarter of a million square miles, most of it in Queensland, but extending into the neighbouring States.

The Walloon Series is typically developed in the Walloon coalfield near Ipswich. Here the series is divisible on lithological grounds into two stages, which may be separated by a small disconformity or non-sequence. The lower of these is of Lower Jurassic age and is known as the Marburg stage. This consists essentially of about 700 feet of sandstones, often false bedded, with some interbedded shales. The stage is not a richly fossilferous one, nevertheless the freshwater mussel *Unio,* the labyrinthodont *Austropelor* and the plants *Cladophlebis, Brachyphyllum* and *Taeniopteris spatulata* have been recorded.

The succeeding Rosewood stage of Middle Jurassic age measures 1,100 feet in thickness and differs in many respects from the lower stage. In spite of their undoubtedly freshwater origin many of the beds are so strongly calcareous as to be virtually limestones, and these frequently exhibit cone-in-cone structure. In addition to the calcareous shales and sandstones, which form 60 per cent. of the sediments, there occur a number of conspicuous but relatively thin red bands containing numerous fossil plants that are often strikingly preserved as white outlines on a red background. By the use of these red bands and the contained fossils the Rosewood stage can be readily correlated with almost identical beds at Purga, Kalbar, Boonah, Harrisville and Beaudesert. The fossils found within the stage as thus laterally extended include: *Equisetites, Cladophlebis, Dictyophyllum, Phyllopteris, Sphenopteris, Sagenopteris, Taeniopteris, Otozamites* and *Brachyphyllum.* In addition the petrified wood *Osmundites* is not uncommon, and it has been suggested that the associated fronds of *Cladophlebis* may represent the foliage of this extinct treefern. The cypress-like conifer *Cupressinoxylon* is also represented by fossil wood. To these fossils must be added the dinosaur footprints found at Lanefield.

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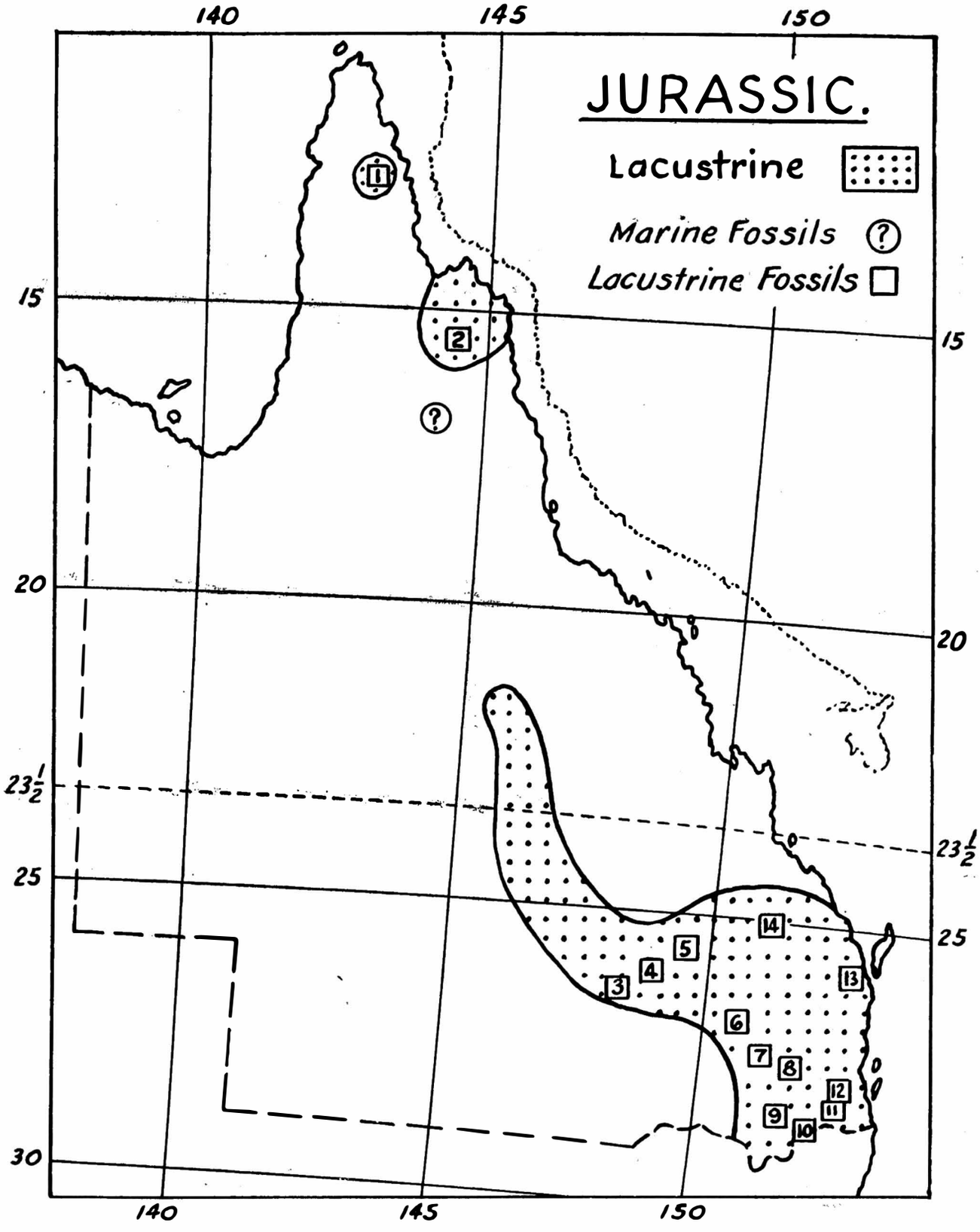
* There is a record of the occurrence of the Lower Jurassic ammonite *Coroniceras* on the Walsh River in Northern Queensland, but it is improbable that marine Jurassic beds do in fact occur there.



MAP 9. JURASSIC.

Locality Key.—1. Pascoe R.; 2. Laura; 3. Orallo and Injune; 4. Durham Downs; 5. Taroom; 6. Chinchilla; 7. Dalby; 8. Oakey; 9. Durikai; 10. Killarney and Tannymorel; 11. Beaudesert and Boonah; 12. Rosewood and Walloon; 13. Tiaro; 14. Mulgeldie; ? Walsh River (from which a marine fossil has been doubtfully recorded).

Within the Rosewood stage occur the important Walloon Coal Measures containing numerous somewhat lenticular seams. Their distribution and the nature of the seams themselves suggest that they were originally formed in swamps. The almost horizontal attitude of the beds, their lenticularity, and the paucity of outcrops makes stratigraphical work difficult, but fortunately the Lanefield index bed, with its characteristic colour and lithology, forms a useful marker about 30 feet beneath the important Lanefield seam.

Beds closely similar to those of the Walloon Series as developed in the type locality are well displayed on the Darling Downs and have been traced to the southern boundary of the State. Both the Marburg sandstones and the Rosewood Coal Measures are well represented, the latter particularly at Clifton and Tannymorel, where they contain the fossils *Unio, Cladophlebis* and *Taeniopteris spatulata.*

Further to the west and stretching in a north-westerly direction similar beds are met with successively at Oakey, Chinchilla, Orallo and Injune. At Bymount these beds have yielded a suite of fossil plants some of which are identical with those of the Walloon Series proper, but others of which are quite distinct. They are *Elatocladus, Cladophlebis, Taeniopteris, Otozamites, Thinnfeldia, Johnstonia, Coniopteris* and *Ptilophyllum.*

At Durham Downs is an important horizon distinguished by the presence of the dinosaur *Rhaetosaurus brownei.*

The north-westerly extension of the Walloon Series consists of a lower portion to which the name Attica Series has been given, and which is probably the local equivalent of the Marburg stage. This consists of very friable sandstones that seldom outcrop, the surface being a mass of deep, loose, white sand which appears to act as one of the collecting grounds for water entering the Great Artesian Basin.

Lying above the Attica Series and probably to be correlated with the Rosewood stage of the Walloon Series is the Cunno Series, a local name for calcareous sandstones, shales and mudstones also occurring as a marginal fringe of the Artesian structure.

Representatives of the Walloon Series are also found in the coastal regions of southern Queensland, although these may not be as numerous as was once supposed. They are well developed to the west of Maryborough, where they are known as the Tiaro Series. This series conformably succeeds the Myrtle Creek Series and consists of soft friable shales, often carbonaceous, sandy shales and soft micaceous sandstones. The shales are in many places fossiliferous, the commonest fossil being *Cladophlebis.* Within the series are numerous coal seams but, unfortunately, the economic value of these has been much reduced by the metamorphic effects of the many intrusions which penetrate them. At Mount Bopple the thermal metamorphism has been so severe that the whole coal seam has been converted into graphite.

The Tiaro Series is succeeded by the Graham Creek Series of tuffaceous sediments. These may also be Jurassic in whole or in part, but are more probably Cretaceous in age.

Other areas in which freshwater beds of Jurassic age occur are at Mulgeldie, where coal measures occupy a down-faulted basin surrounded by Palaeozoic marine sediments. Here both the Marburg and Rosewood stages of the type area appear to be well represented. The latter contains several coal seams with which are associated the fossils *Cladophlebis, Taeniopteris* and *Otozamites.*

Distant outliers are found also in the far north at Laura, and in the valley of the Pascoe River. In each of these areas carbonaceous shales and poor coal seams are found. Fossils are rare, but *Cladophlebis* and *Taeniopteris* have been recorded from Laura and *Otozamites* and *Brachyphyllum* from the Pascoe River.

One special interest of the Jurassic deposits of Queensland is that they contain evidence of the presence of giant dinosaurs and other large animals. The most striking evidence is that at Durham Downs where the remains of the large herbivorous dinosaur *Rhaetosaurus brownei* have been unearthed. Over a ton of fossil bones have been collected and this represents less than half of one complete skeleton. It is estimated that this giant reptile measured over 40 feet in length.

A second interesting find was made at the Lanefield Extended Colliery, where there occur, embedded in the top of the Lanefield seam, the three-toed footprints of a dinosaur. These prints were evidently made when the animal roamed the swamps in which the Rosewood Coal Measures were accumulating. Careful measurements show that the middle toe was at least 18 inches long and that the animal had a stride of about 6 feet 6 inches. At one place an impression about 6 feet long is probably that of portion of a tail.

Still a third piece of evidence of the existence of large vertebrate animals is provided by a fragment of a labyrinthodont to which the name *Austropelor* has been given. This was collected from the sandstones of the Marburg stage at Lowood. It is estimated that the skull of this amphibian probably measured 2 feet in length.

Possibly there should be added here a reference to the fossil reptile *Agrosaurus*, which was reported many years ago from "North-east Australia."

CRETACEOUS.

The Cretaceous deposits in Queensland present many distinctive features that mark them off sharply from those of the earlier and later periods.

Beds of this age occupy a large proportion of the State, and the area originally covered by them must have been even larger.

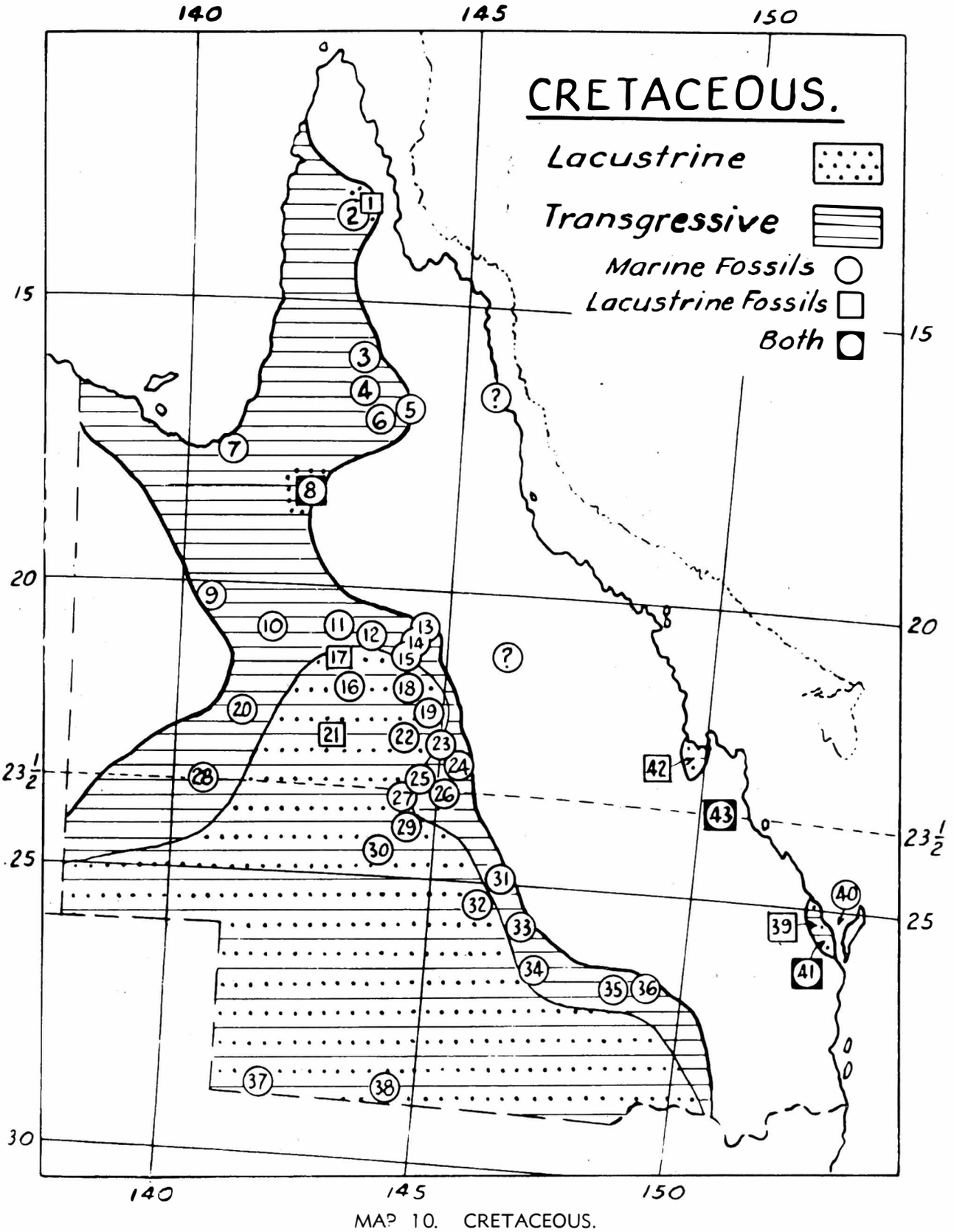
Although ushered in by freshwater conditions similar to those in which the Jurassic beds had been laid down, and although extensive lacustrine beds are found, too, on several higher horizons, the Cretaceous in Queensland is essentially a period of marine transgressions and, as such, is radically different, not only from the other Mesozoic periods, but from most of the palaeozoic periods too. The closest parallel is to be found away back in the Cambrian period when similar marine transgressions flooded the north-western portion of the State.

The Cretaceous transgressions were typical of those which invaded all the continents during that period. They represent a series of marine inundations over a nearly flat (peneplaned) continental mass, and although some of these floodings were only transient they nevertheless covered large areas of the State. The Cretaceous in Queensland closed with a reversion to extensive freshwater lakes similar to those which ushered in the period.

The oldest fossiliferous beds of this age within the State are those of the Stanwell Series. These form an isolated basin about 20 miles west of Rockhampton. They are for the most part lacustrine beds consisting of porous sandstones and carbonaceous shales. This alternation of pervious and impervious strata and their structural arrangement has given rise to a small isolated artesian basin in which the pressure water is stored in the sandstones. The shales, in addition to forming an impervious cover for this artesian system, are of value in that they contain a number of coal seams, although these have not yet been developed. Within these shales are also found the fossil cones of the tree *Araucarites* (the Mesozoic ancestor of our well known Bunya and Hoop Pines (*Araucaria*), the "horsetail" *Equisetites*, the ferns *Cladophlebis* and *Phyllopteris*, the cycad-like plants *Taeniopteris* and *Ptilophyllum* and the conifer *Elatocladus*.

Within this essentially freshwater series there has been found an horizon, only a foot or so thick, containing numerous remains of marine shells, especially those of the genus *Iotrigonia*. This *Iotrigonia* bed, as it may be called, represents the first of the Cretaceous transgressions. Although only transient this is of great palaeogeographic as well as stratigraphical interest. It is doubly fortunate that the contained fossils provide not only definite information as to the age of the *Iotrigonia* bed itself, but also gives us information as to the age of the enclosing freshwater beds of the Stanwell Series, the floral evidence from which is inadequate. The principal marine fossils include several species of the lamellibranchs *Iotrigonia, Pisotrigonia, Indotrigonia, Pseudomonotis, Astarte, Panope,* and the belemnite *Hibolites*. A consideration of this suite (and more especially of the particular species present) indicates that the beds of the Stanwell Series were laid down in the earliest part of the Cretaceous period, namely the Valanginian.

The Blythesdale Series, which is found fringing much of the Great Artesian Basin and which lies above the Cunno Series, was probably also laid down very early in the period. It consists of soft grey, very friable and very



MAP 10. CRETACEOUS.

Locality Key.—1. Plutoville; 2. Mein and Rokeby; 3. Palmer R.; 4. Mitchell R.; 5. Walsh R.; 6. Lynd R.; 7. Bynoe R.; 8. Croydon; 9. Granada; 10. Julia Creek; 11. Richmond; 12. Marathon; 13. Glendower; 14. Hughenden; 15. Walker's Tableland; 16. Sesbania; 17. Wyangarie; 18. Rockwood; 19. Muttaburra and Mt. Cornish; 20. Tooleybuck; 21. Winton; 22. Kensington; 23. Bowen Downs; 24. Aramac; 25. Beaconsfield; 26. Saltern Creek; 27. Longreach; 28. Warenda; 29. Wellshot; 30. Barcoo R.; 31. Tambo and Glanmire; 32. Dunstan; 33 Toliness; 34. Victoria Downs; 35. Roma; 36. Yuleba; 37. Yalpunga; 38. Lake Numalla; 39. Howard and Burrum; 40. Woody Island; 41. Maryborough; 42. Styx R., 43. Stanwell; ? Port Douglas; ? Natal Downs.

porous sandstones, grits, and conglomerates and is, so far as is known, an entirely freshwater series, no representatives of the Stanwell *Iotrigonia* bed having been found.

Succeeding the Blythesdale Braystones there is a very extensive development which, on account of the characteristic landscape it produces, was called the Rolling Downs Formation. This consists of sandstones, shales, concretionary limestones and calcareous sandstones, for the most part of marine origin, covering three-fourths of Queensland, and extending from the Palaeozoic ranges of the east coast to the western and southern boundaries of the State.

Within this comprehensive formation are two marine series separated by a disconformity, and thus representing two separate transgressions, each of which was of wide geographical extent but of restricted duration. The earlier of these known as the Roma Series is considerably later than the *Iotrigonia* bed of Stanwell. The series which is 1,500 feet thick and ranges over a large part of the Aptian has been divided into five stages, each of which is characterised by its own ammonite assemblage. The lowest (but least certain) of these is the Coilotan stage which is followed successively by the Ancyloceratan, Australiceratan, Tropaeuman, and Ammonitoceratan stages.

The Roma Series is richly fossiliferous and contains among others the large sponge *Purisiphonia,* the crinoid *Isocrinus,* the lamellibranchs *Maccoyella, Coilotis, Pseudavicula, Fissilunula, Tatella, Cyrenopsis,* the gastropod *Natica,* the ammonites *Ancyloceras, Australiceras, Tropaeum, Ammonitoceras* (from which four of the stages receive their names), *Toxoceratoides, Aconeceras* and *Sanmartinoceras.* The whole assemblage constitutes a cold water fauna closely comparable in some respects with the faunas of the same age from Patagonia and Spitsbergen and suggestive of glacial or near-glacial conditions. Other points of interest include the belemnites *Tetrabelus* and *Peratobelus* which occur jumbled together in countless profusion on one horizon at the top of the series, and the occurrence of *? Coscinodiscus* the oldest known Australian diatom.

In addition to the genera listed above, there are present at the base of the series and in the Australiceratan stage numerous logs of coniferous wood, many of them riddled with the tunnels of boring lamellibranchs similar to *Teredo* which does so much damage to piles and wooden ships to-day.

Above the Roma Series, from which it is separated by an important stratigraphical break, and forming the upper part of the Rolling Downs Formation, is the Tambo Series. This, which is over 1,000 feet thick, has, on fossil evidence, been assigned to the Upper Albian and more particularly to the *Hysteroceras orbignyi* and *H. varicosus* zones of that stage. The fossils described from the series are very numerous and exhibit a wide variety of forms. They include the brittle star *Ophiocantha,* the lamellibranchs *Aucellina* and *Inoceramus,* the ammonites *Beaudanticeras, Puzosia, Hamites, Anisoceras, Myloceras. Labeceras* and *Appurdiceras,* the crabs *Prosopon* and *Hoploparia,* the large dragon-fly *Aeschnidopsis,* the fish *Portheus, Belonostomus* and *Lamna,* the giant turtles *Cratochelone* and *Notochelone* and the great swimming reptiles *Kronosaurus* (the largest of the Australian forms, the teeth of which have been replaced by translucent barytes), *Cemobosaurus, Icthyosaurus* (18 feet long) and *Plesiosaurus,* and the dinosaur *Austrosaurus* which attained a length of 50 feet.

Following the regression of the Tambo sea there was a reversion to lacustrine conditions, as the result of which there appeared in the same area an enormous freshwater lake in which the Winton Series was laid down. The

series which appears to be quite conformable with the Tambo Series, and which shows no other evidence of any stratigraphical break, may have been deposited immediately after that series in Cenomanian times. The sediments are for the most part sandstones and shales with small coal seams at Winton, Marathon, Hughenden, Aramac and Tambo. The beds are fossiliferous and contain the freshwater mussel *Unio,* the conifers *Araucarites* and *Protophyllocladus* (probably the ancestor of the celery top pine) and Dicotyledenous leaves, together with considerable quantities of undescribed fossil wood. The fossils provide no evidence of the exact upper limit of the series but it probably continued to at least the end of the Turonian.

Returning to the coastal area we find the Graham's Creek Series which appears to have accumulated at some time after the Stanwell Series and before the Maryborough Series. This is essentially a volcanic series, being composed of a very considerable thickness of tuffs and tuffaceous sediments, and lies with apparent conformity above the Tiaro Series. Unfortunately, no fossils have been found, so that the exact age is uncertain.

The Maryborough Series, which conformably follows the Graham's Creek Series, may nevertheless be separated from it by a non-sequence. It is a marine series, 600 feet thick, consisting of shallow-water grits and sandstones followed by a thick band of impure cherty rocks, which on account of their resistance to weathering forms a conspicuous and useful horizon. The contained fossils indicate that the series may be referred to the upper part of the Lower Aptian and, consequently, may be correlated with the Australiceratan stage of the Roma Series. The fossils include the crinoid *Isocrinus,* the lamellibranchs *Maccoyella, Fissilunula, Cyrenopsis, Nucula, Malletia* and *Radula,* the gastropod *Natica,* the ammonite *Australiceras,* the belemnite *Peratobelus* and the crab *Glyphaea.* Associated with these marine fossils, but not necessarily indicating freshwater conditions, are the plants *Equisetites, Sphenopteris, Taeniopteris. Ginkgoites, Ptilophyllum, Araucarites* and *Pagiophyllum.*

Conformably succeeding the marine beds of the Maryborough Series are the freshwater beds of the Burrum Series. This may be assigned to the Upper Aptian with a possible extension to at least the Lower Albian. The series consists of about 5,000 feet of lacustrine strata, including many coal seams, the most valuable of which are concentrated within about 700 feet of strata in the middle of the series. Many fossil plants have been obtained from the series including the genera *Cladophlebis, Sphenopteris, Stenopteris, Phyllopteris, Microphyllopteris, Taeniopteris, Ptilophyllum, Nilssonia, Ginkgoites, Araucarites, Brachyphyllum, Elatocladus, Pagiophyllum,* and *Podozamites.* The freshwater lamellibranchs *Corbicula* and *Rocellaria* (a boring organism) have also been recorded.

Further north along the coast the coal measures of the Styx River are comparable in many respects with those of the Burrum Series, but the floral evidence and, more particularly, the presence of dicotyledenous leaves suggests a higher horizon and one possibly equivalent to, or somewhat below that of the Winton Series. For these reasons the Styx Series has been tentatively placed in the Upper Albian. The recorded fossils are *Cladophlebis, Nathorstia, Phyllopteris, Taeniopteris, Otozamites, Araucarites, Podozamites* and the leaves of dicotyledenous plants.

In the Cape York Peninsula beds of Cretaceous age have been found at a number of points over a wide area.

TABLE S.

THE DEPOSITS OF THE CRETACEOUS TRANSGRESSIONS AND LAKES.

			Artesian Basin.		Maryborough.		Rockhampton.		Cape York Peninsula.
			Tertiary.		*Eyrian Series.*		*Basalt.*		
CRETACEOUS	Upper	Danian							
		Maestrichtian							
		Campanian							
		Santonian							
		Coniacian							
		Turonian			?	Lacustrine			
		Cenomanian			Winton Series			? Lacustrine	Mein
	Lower	Albian	Upper		Tambo Series			Styx Series	Beds (Paralic)
			Lower				? Burrum Series	Lacustrine	
		Aptian	Upper	Roma Series	Ammonitoceratan Stage	Marine			
					Trop an Stage				Plutoville Beds (Lacustrine)
			Lower		Australiceratan Stage		Maryborough Series	Marine	Rokeby Beds (Marine)
					Ancyloceratan Stage				
					? Coilotan Stage				
		Barremian				Lacustrine	Graham's Creek Series	Volcanic	
		Hauterivian			Blythesdale Series				
		Valanginian						Stanwell Series	(Paralic)
		Jurassic					*Tiaro Series*		

From Rokeby the forms recorded are *Fissilunula, Tatella, Trigonia, Maccoyella, Mytilus, Peratobelus* and fragmentary lammelibranchs. This fauna definitely places the beds as the equivalents of the lower part of the Roma Series.

At Mein the occurrence suggests deposition under paralic conditions, for of the lamellibranchs recorded, *Unio* is restricted to freshwater, while *Malletia, Nucula* and *Idonarca* are characteristic of salt water.

The Plutoville beds consist exclusively of freshwater strata (including poor coal seams) with a flora consisting of *Ruffordia, Hausmannia, Nathorstia, Nilssonia, Pagiophyllum, Brachyphyllum* and *Elatocladus.*

Near Moreton telegraph station a hitherto unrecorded suite of marine fossils, which suggests a Cretaceous age, has been found.

Beds at the Hann River have yielded impressions of lamellibranchs which have been doubtfully referred to *Cyrenopsis* and *Tatella.* It is probable that these beds too should be placed in the Cretaceous.

EOCENE.

When our stratigraphical record reaches the Kainozoic era the scale of operations, as far as the accumulation of sediments is concerned, appears to be of smaller magnitude than in either the Palaeozoic or Mesozoic eras. Outcrops are smaller in area and less continuous. Thicknesses are considerably less. But, on the other hand, the volcanic rocks are impressive by their bulk and extent.

The sedimentary series are nearly all of lacustrine origin. Some may be estuarine but none is marine. The consequent absence of marine fossils makes both determination and correlation of the isolated outcrops difficult and uncertain. Hence there has been a tendency in the past to lump all our Kainozoic deposits indiscriminately together under the name Tertiary. The fact that the whole era is only the equivalent in time of one palaeozoic period provides some excuse for that course. Nevertheless, recent researches indicate that our Kainozoic deposits are sufficiently important to warrant an attempt at their more precise placement. They are more widespread, thicker, and probably represent a greater number of horizons than is generally recognised. We have therefore endeavoured to assign all our Kainozoic deposits, if only provisionally, to their respective periods, although we have not felt warranted in preparing a separate map for each.

Although they may not represent the oldest tertiary beds within the State the Eyrian Series probably provides the clearest link between the Mesozoic and Kainozoic eras, for although unconformably related to the Cretaceous strata, it was deposited in a very extensive lake similar in kind and position to that in which the Winton Series was laid down.

The Eyrian Series now consists of numerous, more or less isolated, flat-topped hills which present a characteristic mesa topography. These residual outliers are the remnants of a formation of sandstones and shales that once extended over a considerable part of Queensland and reached as far as Lake Eyre, from which place the series gets its name. Typical developments occur at Wompa, Mitchell and Winton, and from these much fossil wood and numerous dicotyledenous leaves, including those of *Eucalyptus*, *Cinnamomum* and *Banksia*, have been collected. These, although they are inadequate for more precise determination of age, indicate that the Eyrian Series was probably laid down in the early part of the Kainozoic era.

Isolated areas of other early Kainozoic deposits are found at several places in the coastal regions, but unlike those of the interior these small developments do not represent the remnants of a once continuous formation, but indicate simultaneous deposition in a number of small independent lakes.

The best known of these occurrences is that of the Redbank Plains Series which, in addition to its development in the type area, is found at Oxley, Darra and a number of other localities near Brisbane. The series consists of several hundred feet of sandstones, clays and fissile shales which lie unconformably upon the Ipswich Series. Numerous fossils have been collected from the series, among them the mussel *Unio*, the fish *Epiceratodus* (ancestor of the Queensland lung fish), *Phareodus*, *Notogoneus* and *Percalates*, the ostracods *Erpetocypris*, *Cypridopsis*, and *Stenocypris*, sponge gemmules, the "swift moth" *Euporismites*, the plant-hopper *Scolypopites* and other insects including beetles, bugs, water-bugs, scorpion-flies, flies, grasshoppers and termites—the last closely related to the living "white ant" of North Queensland. Plants too are well

TABLE T.

The Deposits of the Kainozoic.

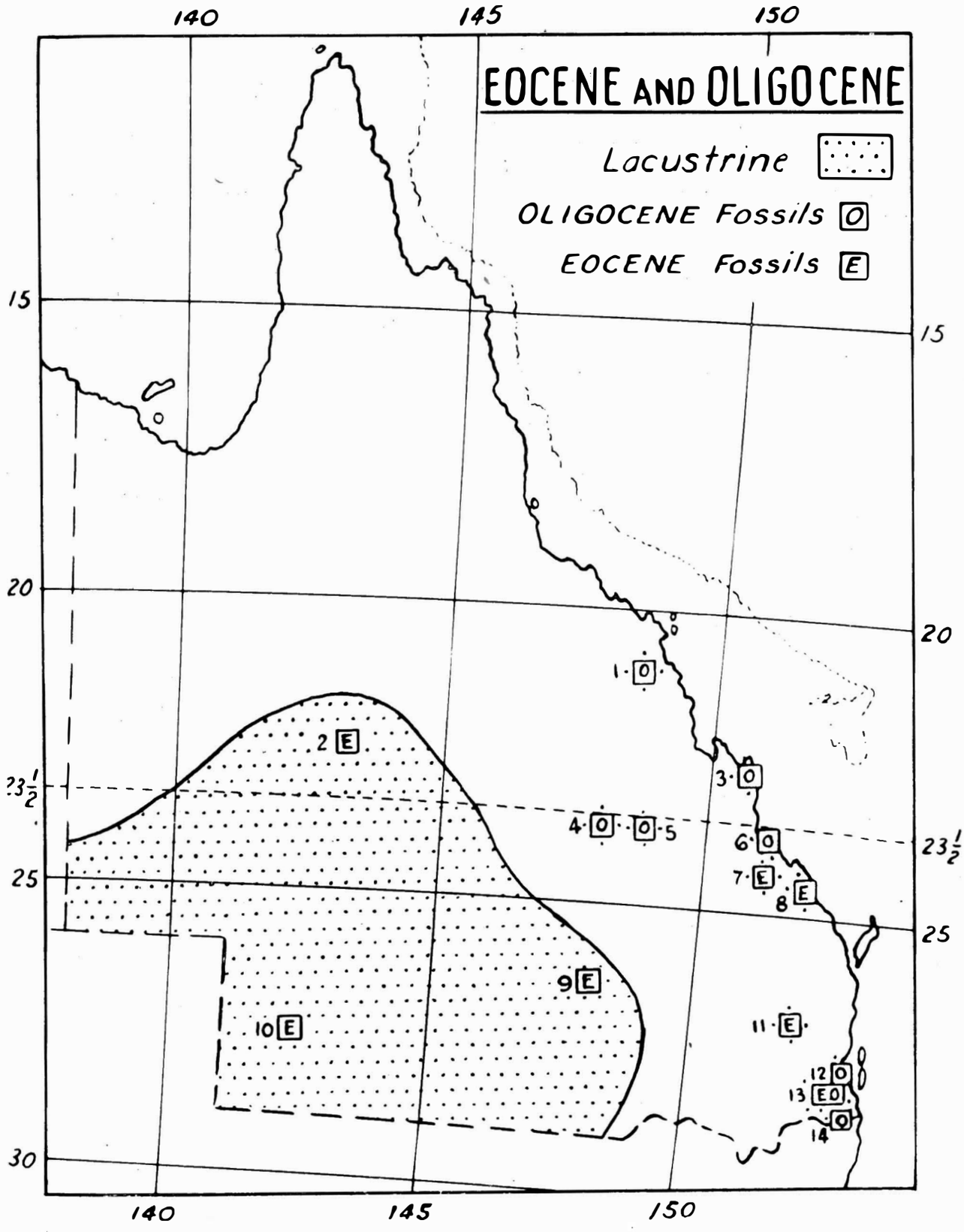
	Period.	Series and Deposits.	Typical Lithology.	Characteristic Fossils.
Kainozoic — Quarternary	Recent	Coral Reefs	Limestones and calcareous muds	Foraminifera, calcareous algæ, corals, etc.
		Beaches	Sands	Shells of many living species
		Dunes	Wind blown sand hills	Shells of many living species
		Alluvial Flats	Immature sandy and black soils, clays and gravel	Stone axes, scraper and other artifacts
		Kitchen Middens	Aboriginal shell banks	Edible shellfish and dugong, artifacts
		Cave Deposits	Calcareous earth with organic material	Gastropods and marsupials
		Calcareous Tufa	Limestones	Gastropods and dicotyledons
		Alluvial Terraces	Mature sandy and black soils, clays and gravels	Corals, molluscs and crustacea
		Raised Beaches	Cemented coral and shelly detritus, sands	
		Coastal Sandrock	Consolidated sands with carbonaceous detritus	
	Pleistocene	Extinct volcanoes	Basalts and andesites	
		Fixed dunes	Vegetated sand hills	Seeds and woody fragments
		Old alluvial plains	Black and other soils	
		Diprotodon Beds	Black soils, sands, gravels and bone breccias	Marsupials, birds, reptiles, fish
		Helicidæ Limestones	Limestones and bone breccias	Gastropods and vertebrates
Tertiary	Pliocene	Glendower Series	Sandstones, conglomerates and some shales	
		Lamington Series	Volcanics, tuffs, clays, lignite and tripolite	Diatoms, dicotyledons, wood
	Miocene	Duricrust and Red Earths	Siliceous and ferrugineous cappings Deep red lateritic soils	
	Oligocene	Duaringa	Clays, oilshales, sandstones and basalt	Insects, fish, dicotyledons
		Emerald	Clays and shales	Dicotyledons
		Plevna	Clays, tuffs and oil shales	Dicotyledons
		Waterpark	Sandstones, shales, clays and brown coal	
		Narrows	Shales, oil shales and sandstones	Gastropods and ostracods
		Beaudesert	Clays, shales and carbonaceous shales	Lamellibranchs and gastropods
		Silkstone	Limestones and basalts interbedded	Gastropod
		Petrie	Shales, oil shales, brown coal and grits	Ostracods, fish and angiosperms
	Eocene	Eyrian	Sandstones and shales	Dicotyledons, wood
		Lowmead	Shales, oil shales, clays and sandstones	Dicotyledons, lamellibranchs, ostracods
		Nagoorin	Sandstones, shales and hydrous black coal	Wood
		Redbank Plains	Soft sandstones, shales and oil shale	Dicotyledons, ostracods, insects, fish

represented, one horizon near Dinmore being crowded with innumerable impressions of dicotyledenous leaves. Unfortunately this rich flora has not yet been properly investigated. Remains of the angiospermous wood *Pataloxylon* have also been found.

At Goodger, near Kingaroy, shales similar to those at Oxley have yielded dicotyledenous leaves and a well preserved fossil flower of modern aspect.

The Lowmead Series, which is probably coeval with the Redbank Plains Series, occurs in the coastal area between Bundaberg and Gladstone and is well developed at Lowmead, where bores have penetrated nearly 500 feet of strata, including some oil shales, and at Baffle Creek. The most numerous fossils are minute ostracods, but the freshwater mussel *Unio* and some dicotyledenous leaves have also been recorded.

In the Boyne Valley near Many Peaks, the Nagoorin Series, which consists of sandstones and shales (some of which appear to be oil bearing) with fossil wood, may be provisionally placed in this period. Within the series one thick seam of hydrous black coal is known at Nagoorin and at Ubobo.



MAP 11. EOCENE AND OLIGOCENE.

Locality Key.—1. Plevna (O); 2. Winton (E); 3. Waterpark (O); (4) Emerald (O); 5. Duaringa (O); 6. The Narrows (O); 7. Nagoorin (E); 8. Lowmead and Baffle Creek (E); 9. Mitchell (E); 10. Wompa (E); 11. Goodger (E); 12. Petrie (O); 13. Redbank Plains (E) and Silkstone (O); 14. Beaudesert (O).

OLIGOCENE.

Except in central and western Queensland, from which the great Eyrian lake may, by this time, have disappeared, conditions in this period seem to have been very similar to those of the Eocene, in that there appear to have been a number of small freshwater lakes scattered over a large part of the State.

The Silkstone Series, which is typically developed near Ipswich, may be regarded as characteristic of the period. The series follows the Redbank Plains Series conformably and without any noticeable discontinuity in sedimentation. Although shales and sandstones are present it consists very largely of a alternations of basalts and limestones aggregating at least 400 feet overlying 500 feet of basalt. The limestones, individual beds of which reach 50 feet in thickness, are unusual in several respects. Originally laid down as impure limestones in freshwater lakes studding basaltic lava plains, they have since been successively dolomitised and silicified by solutions whose intersecting courses have produced a strikingly brecciated appearance. Within these limestones numerous shells of the minute freshwater gastropod *Planorbis* have been collected.

Similar siliceous limestones, that may well be equivalent to those of the Silkstone Series, have been found at Pine Mountain and at Childers.

The Petrie Series, to the north of Brisbane, is several hundred feet thick and is made up of shales (some of them oil-bearing), sandstones, brown coal and limestone together with interbedded basalts. It may be contemporaneous or nearly so with the Silkstone Series. The fossils so far determined include the ostracods *Cypris, Cypridopsis, Erpetocypris* and *Ilyodromus.* Among other interesting but as yet unnamed forms are mussels related to *Valesunio* and *Hyridella,* fish, insect galls and numerous leaves closely resembling the present-day trees *Eucalyptus, Acacia, Melaleuca, Callistemon, Gmelina* and the sedge *Eleocharis.*

Near Beaudesert bores have been sunk on a series consisting of clays and shales (some of them carbonaceous) in which have been found numerous ostracods together with freshwater lamellibranchs and the gastropod *Melania.*

In the district known as The Narrows (between Gladstone and Rockhampton) over 250 feet of shales (including some oil shales) have been proved. These contain many fossils, including a fish fauna that appears to be somewhat younger than that of the Redbank Plains Series. The complete fossil list includes the fish *Lutjanus, Percalates, Scleropages* and *Epiceratodus,* the ostracods *Cypris, Cypridopsis, Cyprinotus, Stenocypris, Erpetocypris* and *Ilyodromus,* the gastropod *Planorbis* and fragments of an unnamed crocodile.

At Duaringa, in the Dawson Valley, there occurs a series of sandstones, hard biscuit-like shales and clays. These include small bands of lignite and at least one bed of oil shale. The series is over 1,000 feet thick and contains many interesting fossils. Of these probably the most unusual are fragments of small perch-like fish which have been converted into amber-coloured opal, and the insect larvae of a dragon-fly, which has been named *Austrolestidium.* There are in addition many unnamed dicotyledenous leaves. Similar rocks which have been correlated with those of Duaringa occur at Selma, near Emerald.

At Waterpark, near Port Clinton and about 40 miles north of the mouth of the Fitzroy River, a series of freshwater sediments occurs. The beds which occupy a small basin contain several seams of brown coal. Although no fossil evidence of age is available the series is placed provisionally in this period.

At Plevna, near Eungella, still another of these freshwater deposits has been found. The beds are approximately 300 feet thick and consist in the lower part of shales, some of which are oil-bearing, and in the upper part of clays and tuffs, which in turn lie beneath a volcanic series that has been assigned to the Pliocene period. The shales contain dicotyledenous leaves.

MIOCENE.

If we are correct in our placements of a number of doubtful Kainozoic formations, the Miocene was stratigraphically the most barren period in the geological history of Queensland.* The numerous small freshwater lakes characteristic of early Tertiary times seem to have quite disappeared and deposition appears to have been at a minimum. The whole area apparently formed one continuous land surface which was gradually reduced by the denudational forces to an almost featureless, level "peneplain."

On this extensive surface lateritic soils were formed, remnants of which have survived until the present day. In some places these "fossil soils" take one of the several forms included in the term "Duricrust," while elsewhere they may be better described as "Red Earth Residuals." The variety of these superficial deposits is due in part to the nature of the underlying rock, in part to the degree of maturity reached by the soil-forming processes, and in part to the depth of overlying material that has since been removed by erosion. These old Duricrust soils for the most part are very infertile, but some varieties included within the Red Earth Residuals are agriculturally important.

* For this reason we have thought it unnecessary to prepare a map of this period.

PLIOCENE.

In Queensland the Pliocene period was, above all else, a time of intense and prolonged volcanic activity. A wide range of volcanic rocks was erupted, the more important of which may readily be recognised by the characteristic topographical features that they now present. Thus the basalts appear as more or less extensive plateaux intersected by gorges and canyons and clothed with luxuriant rain forests; the rhyolites show as scarps and cliffs over which numerous waterfalls pour; the rhyolitic tuffs and agglomerates present ragged walls weathered into irregular caverns; the trachytes occur as isolated peaks and groups of nearly vertical pinnacles. These features are well displayed at intervals along the whole eastern coast of the State from Cooktown to the southern border and extending, as at Springsure, for a considerable distance into the interior.

Of the several types of volcanic activity represented, the outpourings of vast quantities of basaltic and andesitic lava was by far the most important. These basaltic floods were spilled out over great areas of the relatively flat surface, blotting out most of the Miocene peneplain, but forming in its place a comparably flat surface of lava plains.

The volcanic activity, although intense, widespread and prolonged was, however, not continuous, and, during the frequent pauses, localised but interesting deposits accumulated in the numerous small depressions.

Although these conditions appear to have been general in the coastal regions, they have been most closely studied in the south-eastern corner of the State, where an extensive development of volcanic rocks and interbedded freshwater deposits is well displayed. These, since they are typically developed in the Lamington National Park and adjacent areas, may be called, we suggest, the Lamington Series. In all, this series measures over 3,000 feet thick. Most of this is made up of alternations of basaltic, andesitic and rhyolitic flows, of which the basalts are the most abundant. But in addition to these and intermixed with them, are considerable developments of pyroclastic rocks ranging from coarse agglomerates to fine ashy tuffs. Some of the latter show clear signs of having been laid down under water in the ephemeral lakes that were so characteristic a feature of the period.

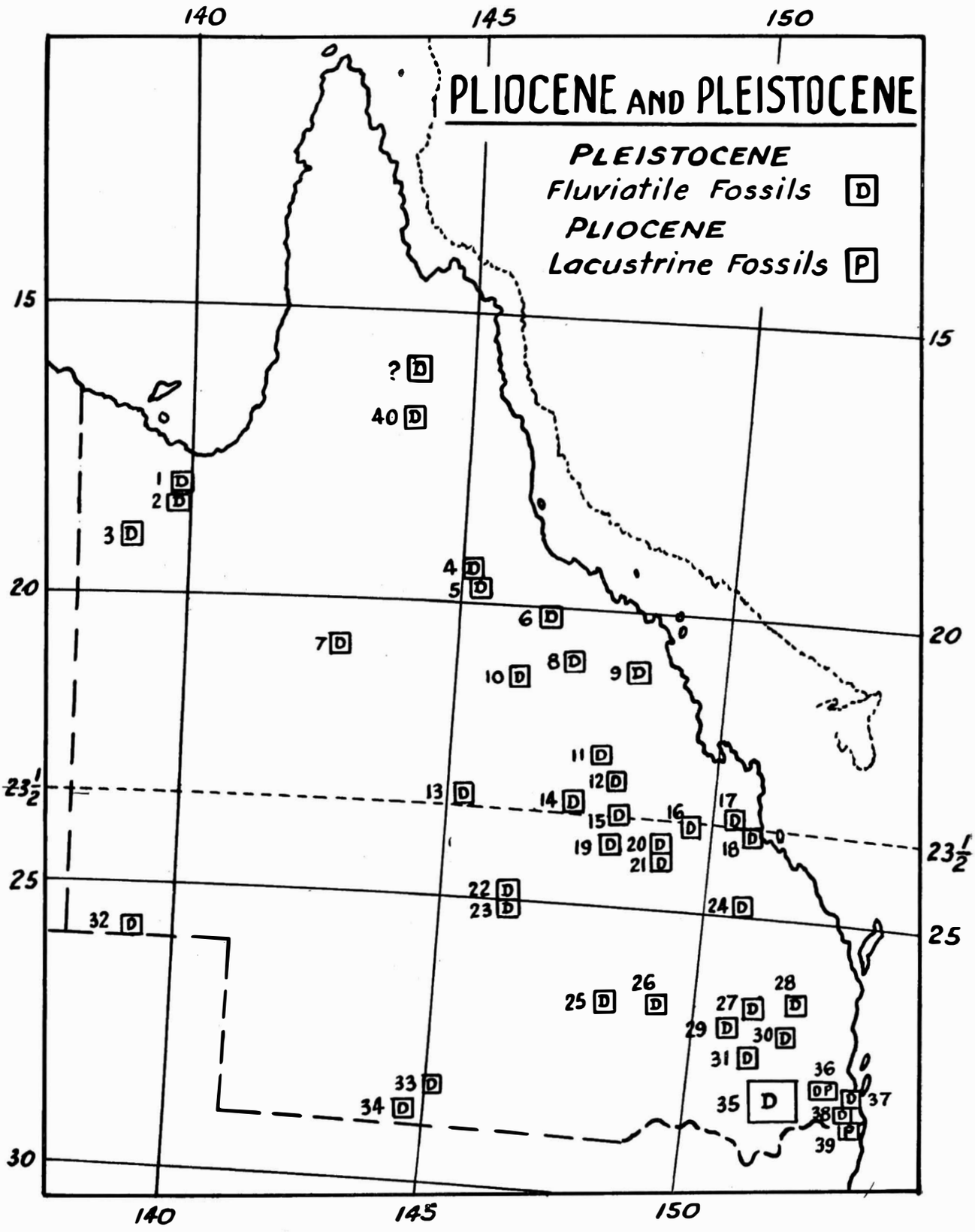
In still smaller and more localised lakelets, deposits of diatomaceous earth were formed, due to the accumulation of myriads of siliceous skeletons of minute diatoms which appear to have flourished under these conditions. Such diatomaceous earths are well exhibited near Gatton. At Mount Meerschaum, near Nerang, the angiospermous wood *Pataloxylon* is associated. Many of these diatomaceous deposits no longer appear in the original form of light "earths," but have been converted into masses of common opal, some of which, as for example those at Binna Burra, are very beautiful. Microsections of one of these opaline masses from Point Danger show fragments of the diatoms themselves and of other associated pond-loving organisms.

Interbedded with the basalts there have been found also several more typical freshwater deposits consisting for the most part of shales and clays. These sometimes include lignitic brown coal, as below Curtis Falls, on Tambourine Mountain. At other places as at the southern end of the same mountain these sediments contain numerous impressions of dicotyledenous leaves.

There is little doubt that closer inspections of many of the other volcanic accumulations of Pliocene age in eastern Queensland will disclose interbedded freshwater deposits similar to those of the Lamington Series.

In Western Queensland the only noteworthy deposits of this age appear to be the Glendower Series, which are typically developed in the Flinders River valley. This, which may prove to be a relatively widely dispersed series, is, in contrast to the coastal developments, arenaceous and non-calcareous, consisting mainly of sandstones and conglomerates together with some white shales.

It may be that this is the place to mention the unique discovery of a fossil insect, within a crystal of clear selenite, at a depth of 260 feet, in a copper lode. The lode itself occurs at Mount Elliott, within rocks of Pre-Cambrian age, but the fossil, *Austrodictya corbouldi,* one of the long-horned grasshoppers, appears to be no older than Late Tertiary.



MAP 12. PLIOCENE AND PLEISTOCENE.

Locality Key.—PLIOCENE: 36. Rosewood; 39. Lamington. PLEISTCCENE: 1. Floraville; 2. Leichhardt; 3. Riversleigh; 4. Maryvale; 5. Bluff Downs; 6. Gilgunyah; 7. Maxwelton; 8. Sellheim; 9. Urannah; 10. Natal Downs; 11. Logan Downs; 12. Peak Downs; 13. Myros; 14. Anakie; 15. Wyuna; 16. Duaringa; 17. Mt. Etna; 18. Marmor; 19. Fernlees; 20. Gogango; 21. Castle Creek; 22. Tambo; 25. Lansdowne; 24. Rawbelle; 25. Muckadilla; 26. Broadmere; 27. Boyneside; 28. Boat Mt.; 29. Chinchilla and Brigalow; 30. Nanango; 31. Dalby; 32. Birdsville; 33. Eulo; 34. Caiwarroo; 35. Darling Downs; 36. Rosewood; 37. Eight-Mile Plains; 38. Albert R. and Knapps Creek; 40. Wrotham Park; ? Hann Expedition.

PLEISTOCENE.

The Pleistocene period in Queensland presents two features of especial stratigraphic interest, namely the great development of fluviatile (river) deposits, and the occurrence in these of the bones of an unique vertebrate fauna.

Beds that can be confidently referred to this period are scattered over the length and breadth of the State, from Darling Downs in the far south-east to Floraville in the far north-west, from the Paroo River in the extreme south-west to Wrotham Park in the extreme north-east.

The deposits consist in many places, as for example on the Darling Downs where they are most fully developed, of heavy black alluvial soils as much as 100 feet in depth. But, as might be expected from a series scattered over such a great area, several variants from this typical lithology are met with. Thus at Peak Downs, only the uppermost 20 feet consist of black alluvium, the remainder to a depth of at least 188 feet being composed of sands and gravels. In the Chinchilla district, the beds consist of a hard conglomerate of argillaceous grit and gravel (the Chinchilla conglomerate), which overlies beds of sand of considerable but unascertained thickness. At Maryvale in northern Queensland the deposits are composed of a bone breccia (the "Diprotodon Breccia") and indurated muds; at Riversleigh, in north-western Queensland, similar bone-beds are encased in limestone, while at Marmor and Gore the fossils are found in irregular solution cavities in Palaeozoic limestones.

These deposits appear to have been laid down on the flood plains of giant rivers, or to have accumulated in swamps or small lakes. The beds are usually more extensive and at a somewhat higher level than the present alluvial deposits and, in places, as at Maryvale and the Diamantina River, sections of the bone-beds have been exposed by the corrasion of the downward cutting streams.

But in spite of the wide geographical distribution and marked variation in lithology of these beds, their other, constant characters and, more particularly, their contained fossils, warrant us in bringing them together under the comprehensive name *Diprotodon* beds.

By far the most important development of the *Diprotodon* beds is that on the Darling Downs. Here the series is thick and extensive and has yielded a wealth of fossils from many localities, including Clifton, Drayton, Eton Vale, Gowrie, Kings Creek, Pilton, Warwick and Westbrook. A prolongation of this area to the north-west includes Dalby and reaches to Brigalow and Chinchilla.

The fossil bones obtained from these and other localities nearby, provide striking evidence of the existence in Queensland in Pleistocene times of an amazing collection of marsupials, birds, reptiles and other vertebrate animals. The great majority of these have been regarded as extinct, but some are identical with living species, while many others show clearly their ancestral relationships to present-day species, although some of them appear to have been animals of much greater bulk. On the other hand some of the more specialised and bizarre forms appear to have left no descendants.

The fish are represented by the dipnoid *Neoceratodus* (identical with the lung fish at present living in some of our coastal streams), *Tandanus* (the dew fish) and *Oligorus* (the Murray cod). Of the turtles the most interesting

is the giant *Meiolania* which, in addition to being of huge dimensions, was equipped with horns. Several large monitor lizards have been described, among which was *Megalania,* a giant iguana measuring 20 feet in length. The crocodiles include the extinct *Palimnarchus* (15 feet long) and smaller species still living.

Nearly thirty different species of birds have been found all of them extinct, but many belonging to living genera. Of these the emu-like forms *Dromaeus* and *Genyornis* (the latter nearly 7 feet high) are of especial interest. Other birds include *Taphaetus* (a falcon), *Pelicanus* (the pelican), *Palaeopelargus* (an ibis), *Platalea* (a spoonbill), *Anas* and *Dendrocygna* (ducks), *Lithophaps* (a pigeon), *Chosornis* (a mound builder related to the scrub turkey), *Tribonyx* (a moor hen), and the stork *Xenorhynchus.*

Australia's unique monotremes are represented by extinct species of *Echidna* and *Ornithorhynchus.* The marsupials are very strongly represented by a fauna of exceptional interest, many of the species being much larger than the present-day forms. Of these *Thylacinus* (the "Tasmanian wolf"), *Thylacoleo* (the "marsupial lion"), *Sarcophilus* (the "Tasmanian devil"), and *Dasyurus* (the "native cat") have living representatives, but the giant *Diprotodon* (bigger than the rhinoceros), the closely allied *Nototherium* and the strange *Euryzygoma* with extraordinarily wide cheek pouches, have left no direct descendants. Kangaroos were numerous, the largest being *Palorchestes* (whose skull was as large as that of a bullock), while several large species of *Macropus* have also been recorded. Wombats were plentiful and varied in size from *Phascolonus* (as large as a pony) to the small burrowing form *Phascolomys.* Animals closely allied to our opossums and native bears have also been described, among the latter being *Koalemus,* the ancestor of the koala.

Associated with this amazing collection of vertebrates is found a less spectacular invertebrate fauna, including the freshwater lamellibranch *Corbicula* and the gastropod *Melania.* The dicotyledenous wood *Mesembrioxylon* is also present.

All the above are found in the south-eastern corner of the State, but the long list can be further extended by additional finds in other parts of Queensland. Of these numerous localities (the positions of which are shown on the map) special reference may be made to Fernlees. from which many fossils have been obtained similar to those of the Darling Downs; Marmor, which, in addition to some of those already mentioned, has yielded vertebrae of a snake very like the living carpet snake associated with the remains of *Trichosurus* (a bat), *Phascogale* (a pouched mouse), and *Petrogale* (the rock wallaby): Peak Downs and Caiwarroo which have both yielded bones of *Dromornis,* a large ostrich-like bird. At Maryvale, the type area of the "*Diprotodon* Breccia," the small gastropods *Limnaea,* and *Physa* have been found intermingled with the bones of many larger animals including a freshwater species of crocodile. Another well-developed bone-bed at Riversleigh contains abundant large crocodilian and mammalian remains. Associated with this last occurrence are calcareous beds so crowded with the remains of snails that they are known as the Helicidae limestones.

Although the old alluvial soils that cover such extensive areas of western Queensland have not been explicitly included within the Diprotodon beds, it is probable that they may ultimately prove to be their less spectacular equivalents.

In the extreme south-western part of the State there occur many desert sand dunes, which are now inactive, being firmly fixed by vegetation. These old dunes probably had their origin in Pleistocene times.

At many places along the coast and on the adjacent islands dunes of wind-blown sand, which have become firmly fixed by a vegetative cover and which now carry valuable forests, are a conspicuous feature of our coastal scenery. Frequently there are found in the dunes irregular tubes of silica, known as fulgurites, which are the result of lightning striking shrubs and fusing the sand grains about their roots. These fixed dunes are clearly not of recent origin and may well have accumulated in the Pleistocene period. At Mount Tempest, on Moreton Island, these old dunes rise to a height of almost 1,000 feet, while near Tewantin borings have proved their depth to 200 feet below sea level. At the latter locality seeds of *Banksia* and woody fragments of *Casuarina* and the mangroves *Ceriops* and *Aegiceras* have been obtained. These fixed coastal dunes may perhaps be correlated with the "dead" desert dunes of the far south-west.

The very extensive coraleine reefs which extend for 1,200 miles along the eastern coast occur sporadically over a maximum breadth of 160 miles. These, which are comprehensively known as the Great Barrier Reefs, appear to have been well established in Pleistocene times and may even go back as far as the Pliocene period.

The volcanic activity which was so strong a feature of the Pliocene period is represented in the Pleistocene by outbursts that were by comparison sporadic and intermittent. The results of this activity are best seen in northern Queensland and become progressively less impressive as we proceed to the south. In keeping with this is the fact that the northernmost effusions appear to be the latest of all. These Pleistocene lavas were for the most part basaltic, and fluid streams of this material have flowed down many of the present valleys partly choking them and bringing about minor changes in the arrangement of the streams. In some cases the valleys themselves are carved out of Pliocene basalts so that the relationship of the Pleistocene volcanics to these is clearly displayed.

Numerous extinct volcanoes occur throughout the coastal regions of the State, some of which are in a remarkable state of preservation. Frequently, the craters of these are still complete and some of them contain beautiful crater lakes. Special reference may be made to Mount Quincan and Lakes Eacham and Barrine on the Atherton Tableland, and to Mount Le Brun and its twin crater lagoons, the Coalstoun Lakes near Biggenden.

The group of seven giant submarine volcanoes—the Tasmantides—that rise steeply for 14,000 feet above the sea floor, about 100 miles east of Southport, may belong here, although it is possible that these amazing peaks may have been erupted at an earlier period.

At the other, most northerly, end of the State, the volcanoes of the Murray Islands are also of great interest, for the history of their development is interwoven with that of the Great Barrier Reefs at that point. These volcanoes were clearly brought into being by explosions that penetrated and shattered the old coral reefs, great fragments of which are found in the tuffs and agglomerates far above sea level. On the other hand, since the volcanoes became extinct very extensive modern reefs have developed on their submarine flanks. This strange alternation of coralline and volcanic dominance is well seen also on the nearby Darnley Island and further south at Bramble Cay.

RECENT.

It is often difficult to distinguish between Pleistocene and Recent deposits in Queensland. This difficulty is particularly pronounced in the interior of the State, where the fluviatile deposits of the one period grade into those of the other. In the coastal regions, however, use may be made of the fact that at, or soon after, the close of the Pleistocene period the shorelines of Queensland, in common with those of New South Wales, were submerged to a depth of about 200 feet. In the absence of any better criterion, this submergence may be used as a datum, the coastal deposits laid down immediately before that event (and "drowned" as a result of it) being relegated to the Pleistocene, while those laid down during and since are regarded as Recent.

The deeper and older of these Recent coastal and estuarine deposits brought about by the submergence lie well beneath the present sea level and can only be investigated by bores driven through them, but the uppermost and newest have been exposed to our view through an opposite movement of emergence which has, more recently, re-elevated the coastline about 10 feet.*

Our knowledge of the deeper of these deposits, based as it is on the interpretation of a few bore records, is very scanty. Bores sunk through the Great Barrier Reefs at Michaelmas Cay in the north, and at Heron Island in the south, both show thicknesses of over 400 feet of coralline and related material. While it is probable that the lower portions date back to Pleistocene, or even Pliocene, times, much of it may be regarded as Recent.

Bores sunk at five different bridge sites spread along 12 miles of the Brisbane River have all of them shown that the rock bed of the river in that part of its course lies at about 100 feet below sea level. Thus, the original river bottom, is covered by extensive deposits of river gravel up to 90 feet in thickness. The same gravels near the mouth of the river have been dredged to considerable depths and have yielded the fossilised remains of the crustaceans *Galene* and *Thalassina*. These deep river deposits were accumulated during and after the submergence and may thus also be considered Recent.

Bores through the bedded sands, silts and clays that form the "Townsville Deep Drifts" tell a similar story, for they too have been accumulated on a rock bed that now lies approximately 100 feet below sea level.

The more superficial and more recent coastal deposits that have been brought to view through the small, very recent emergence are of course more open to investigation. They are, as might have been expected, usually quite similar to deposits now forming along the adjacent shore lines.

At many places along the mainland beaches and those of the larger coastal islands lying between Point Danger and the northern end of Fraser Island, there may be seen above the present tidal limits, examples of a formation to which the name coastal sand-rock has been given. This consists of a coherent, but not very strongly cemented, fine, even-grained aggregation of colourless quartz sand grains with a variable content of intermixed organic

* Although these movements are usually referred to as submergence and emergence of the land, it is more probable that the changes in sea level were eustatic, that the land remained stationary while the sea level first rose 200 feet and then sank 10 feet.

matter. This latter constituent supplies the binding material and controls the colour of the rock, which ranges from a strongly coherent black sandstone to a friable pale aggregate. Most commonly the rock is brown in colour and tolerably coherent. The series appears to have formed in stagnant water containing much organic material in a very sandy terrain. Such conditions are often found at present in the swamps within and immediately behind the area of sand dunes.

In addition to, but quite distinct from, the coastal sandrock, are very extensive areas, especially on the southern coast, where immense quantities of sand have accumulated along and behind the present beaches. The upper surface of these deposits is well above sea level, but they extend to considerable depths beneath it. Their organic content is almost negligible, but they contain appreciable percentages of various heavy and stable minerals, several of them of economic value. These are in many places concentrated into conspicuous black streaks and lenses. There is every evidence that these sands have been naturally sorted by the action of vigorous swirling waters, in an environment essentially similar to that between the tidal limits of the present beaches.

Turning to the northern coasts we find at many points extensive developments of "coral conglomerate" and "coquina" made up of variable proportions of coral and shelly fragments cemented into a compact, almost solid rock. It occurs most commonly just above the present beaches, but in some places this series extends for as much as half-a-mile inland. Although composed largely of material identical with that on the present beaches, these old beach rocks contain in addition very notable quantities of pumice.

Other raised beaches of various kinds occur commonly along the whole Queensland coast and some of them as, for example, that at Nudgee, near Brisbane, are found more than a mile from the present shore-line. This and the occurrence at Ross Island, near Townsville, have been studied in some detail, but numerous others, such as the "agglutinate of corals and shells" on St. Helena Island, in Moreton Bay, have been only cursorily examined.

Closely related to the raised beaches and brought about by the same movement of emergence are the many coral reefs now well above sea level which have died from exposure, and are now undergoing destruction as a result of the combined attack of the ocean and the weather. Many examples could be given, but those of Raine Island, near Cape Grenville, and Holbourne Island, near Bowen, are well known and typical examples.

The extraordinarily rich fauna associated with these elevated beaches and reefs has received little attention but it is clear that it consists predominantly, if not entirely, of species now existing in Queensland's coastal waters. This appears to be equally true of the corals, the molluscs and such vertebrates as have been found. Of the genera actually recorded may be mentioned *Ostrea, Anomalocardia, Corbicula, Cytheria, Melania, Potamides* and *Natica* from Nudgee and Ascot, and *Thalassina* from Townsville. In the fossil reefs of Bird, Goat and Mud Islands in Moreton Bay the following corals are common: *Pocillopora, Lobophyllia, Cyphastraea, Favia, Favites, Acanthastraea, Goniopora* and *Acropora.* On Luggage Point at the mouth of the Brisbane River an "exceedingly large" fossil whale was reported many years ago well above high tide mark.

Caves are known in many parts of the State. In the Chillagoe district at least thirty have been found, while others have been reported from the Broken River and elsewhere in northern Queensland. In the Rockhampton

district, those of Raglan and Mount Etna are well known. On the floors of these caves irregular deposits of varying thickness of cave earth occur. Such deposits are recent accumulations and consist largely of bat guano. They often contain the bones of many animals specifically identical with those living at the present day, including the kangaroo rat, opossum, padymelon, bandicoot and rock wallaby.

Along many of the coastal streams are found well defined river terraces. The position of these, well above the reach of the highest floods, sometimes as much as 75 feet, clearly indicates that they are older than the present flood plains, to which material is being added each year. Consistent with this is the fact that the soils which top them show a maturity which can only have resulted from the free play of the soil-forming processes for a very considerable time. Unfortunately, in many cases these old soils of the river terraces have attained maturity only at the cost of losing much of their fertility.

In western Queensland, where the waters of the Great Artesian Basin are under great pressure and where the confining cover is relatively thin, the artesian waters in many places have burst through to the surface, carrying with them silt and clay in suspension and various salts in solution. These materials are deposited about the mouth of the spring and gradually a mound of mud mixed with chemical precipitates is formed. These mound springs or "mud volcanoes," which usually occur in groups of a dozen or more, appear to have been very active in geologically recent times, although, usually, only one or two of any one group are at present in operation. Essentially similar "springs" associated with small artesian structures have also been found in the coastal regions as at Aspley and near Sandgate. Of a different kind are the hot springs of Northern Queensland which, however, have also been responsible for the local accumulation of recent deposits. At Innot's Springs extensive areas of siliceous sinter were precipitated from the waters; whereas the springs in the Einasleigh River valley have brought up considerable quantities of calcium carbonate which have been deposited as a calcareous sinter, loose and spongy on the surface but comparatively solid at depth. These latter springs, as they occur in the valley of a river down which Pleistocene (or even Recent) basalt has flowed, may well represent the last feeble manifestation of volcanic activity in Northern Queensland.

Only in geologically very recent times is there clear evidence of the existence of man in Queensland, and there is little to indicate when the aboriginal inhabitants of our State actually arrived. Neither human bones nor artifacts have been found directly associated with the fossiliferous Pleistocene deposits, or in the deep gravels and drifts of the drowned valleys or even in the raised beaches. It is true that at Talgai Station, on the Darling Downs, there was found about sixty years ago an aboriginal skull, suggestive of considerable antiquity, but although it has sometimes been referred to the Pleistocene, the evidence for this is far from satisfactory.

The most impressive evidence of man's existence is that supplied by the numerous, and sometimes very large, kitchen-middens found along the present beaches. These mounds are formed essentially of the shells of oysters, and other edible shell fish together with occasional bones of dugong and fish. They represent the refuse heaps of aboriginal tribes which periodically visited and camped at these particular spots for many generations. Sometimes small artifacts, such as might be used for the opening of the shell fish, are found, as is other evidence of human occupation.

At the present time the various geological processes of the Recent period are actively in operation. Along the coast off-shore marine deposits are accumulating, coral reefs are extending, beaches are being built up and dunes are growing, while in the interior, floods annually contribute their quota to the extensive fluviatile deposits.

In one respect only do the present activities differ from those of the immediate past, and that is in the modifications of natural conditions deliberately or accidentally introduced by the hand of man. Many of his works are trivial in this respect, but some have wide and far-reaching effects. Of the smaller of these, deliberately produced, may be mentioned the dredging and straightening of river channels and the consequent increases of tidal scour and change in locus of deposition of the river-borne sediments. Of the larger effects, incidental to man's activities, are those due to accelerated soil erosion. In this case a relatively small change produced in the balance of natural forces may have a trigger effect which ultimately has far-reaching and often, from the human point of view, detrimental effects on the geological processes of erosion and deposition.

ECONOMIC ASPECT.

INTRODUCTORY.

The economic aspects of stratigraphy are important, not only for commercial reasons, but as illustrating a particularly interesting facet of geological history. Indeed stratigraphy and economic geology are so closely interwoven that strictly stratigraphical surveys frequently result in the discovery of deposits of economic value, while on the other hand the study of these deposits themselves often leads to a better knowledge of the geological history of the area, in which they are found.

In the case of interbedded materials such as coal and oil-shale, certain iron-ores and rock-salt, the relationship to stratigraphy is of a direct and simple kind, but where most ore-bodies are concerned the connection is less obvious, for the strata in which the ores are found must be older, often much older, than the igneous intrusions, which are usually responsible for the introduction of these ores. In the following account the ores are recorded under the same periods as those in which we have placed the containing strata, except in those instances where the ore occurs within the igneous body itself, in which case it has been placed in the period to which we have assigned the intrusion.

Unfortunately, in many cases the containing strata cannot yet be definitely assigned to any particular period while, in an even greater number, the age of the intrusion cannot be fixed except within wide limits.

The placing of the alluvial deposits in their proper stratigraphical positions also entails some difficulty, for while some of these are found in the present streams courses, others occur at higher or lower levels within the valleys, and still others, the "deep leads," lie below basalt flows of various ages. Again, in some cases the original alluvial deposits have been redistributed, sometimes more than once, to produce, in one and the same area, alluvial deposits ranging over many geological periods.

PRE-CAMBRIAN.

The rocks of this period contain ore deposits which include some of the most important worked in the State.

The silver-lead-zinc-copper deposits of Mount Isa, together with the copper ores of Mount Oxide, were deposited in the rocks of the Mount Isa Series, and the copper and the gold deposits of the Cloncurry deposits are contained in the rocks either of the Soldier's Cap Series or Mount Isa Series.

At the "Top Camp," near Cloncurry, gold associated with native bismuth and coated with limonite is known as "black gold."

Near Selwyn and at other places in the Cloncurry district, high grade deposits of cobaltite and beautiful crystals of cobalt bloom (erythrite) were formed at or near the contact of amphibolites and rocks of the Soldier's Cap Series. These are the most important deposits and the biggest producers of cobalt known in the State.

All these are probably related to the granitic intrusions which took place about the end of the Proterozoic, although the connection is not always obvious.

At the Mount Elliott copper mine, near Cloncurry, crystals of selenite up to 6 inches in diameter and several feet in length are common and have been used to make high grade plaster of Paris.

Mount Leviathan and Mount Philp, both near Cloncurry, are mountains of ironstone (very largely haematite), the former lying within the limits of the Mount Isa Series and the latter in the Kalkadoon-Argylla Series. In both localities the ore is rather high in silica, but large quantities are available—probable and possible reserves being each in excess of 20,000,000 tons.

The silver-lead-zinc ores of Lawn Hill are in rocks which are probably the equivalent of the Mount Isa Series, but the mineralisation extends somewhat into the overlying Middle Cambrian limestone. At Croydon, graphitic granites, probably of Pre-Cambrian age, are associated with gold ores which were probably precipitated by the graphite. These ores have been extensively worked, and somewhat to the south in the Stanhills area, granites brought in tin ores, which pass in depth into lead, zinc and copper.

To the east, the gold deposits of the Cape River, Charters Towers, Coen, Einasleigh, Etheridge, Gilbert, Hamilton, Normanby and Woolgar fields are contained in rocks very probably of Pre-Cambrian age and genetically connected with granites also probably of that age. Associated with them are limited quantities of tin, molybdenum and bismuth ores. Copper ores, also, occur at Cardross and Einasleigh.

CAMBRIAN.

The Cambrian beds of north-western Queensland are of economic interest inasmuch as the limestones of the Barkly Tableland have proved to be important natural reservoirs of water.

A bore in Cambrian limestones, 37 miles from Camooweal on the Camooweal-Mount Isa road, intersected several beds, varying from 1 to 8 feet in thickness, of oil-shale. The grade of this shale is low, the yield being only 15 gallons per ton from one bed and traces from others.

For the most part the Cambrian rocks are completely lacking in minerals of economic value, but at Tott's Creek, limestones of the Templeton Series are known to carry silver-lead deposits, while at Lawn Hill the mineralisation, although mainly in Pre-Cambrian rocks, extends up into limestones of Middle Cambrian age.

To the east, schists, slates and greywackes of the Herberton, Irvinebank, Stannary Hills and Koorboora districts, containing important deposits of tin and also silver, lead, tungsten, and copper may be of this age (though the mineralisation was post-Cambrian).

ORDOVICIAN.

Rocks proved to be of this age have contributed little to the mineral wealth of the State, but small quantities of gold are widely distributed in silicified zones of the Bunya Series; at Indooroopilly a small but rich deposit of silver-lead ore in the same series has been mined. Small quantities of turquoise for use as gems, have been mined near Dayboro. Apatite has been recorded from many localities in the Emu Park Series but has not as yet been worked.

In addition the rocks containing the tin, copper, &c., deposits mentioned under the Cambrian are possibly Ordovician in age.

SILURIAN.

The rocks of this period are rich in deposits of silver, lead and copper (with minor amounts of gold), especially in the Chillagoe-Redcap-Mungana area. The copper deposits are of unusual interest in that they occur at the contact of granite and limestones and as infillings of irregular solution cavities in the limestones. Further north also, near O.K., copper deposits are important.

To the south, at Kangaroo Hills, tin and silver-lead-copper lodes are associated and have yielded considerable quantities of ore. These lodes are also the result of contact metamorphism.

The manganiferous zones of the Brisbane schists belong mainly to the Fernvale Series, though in part to the Neranleigh. Many deposits are known, but only those at Mount Millar and Auckland Hill, both near Gladstone, have been worked at all extensively. Other deposits occur to the west of Brisbane and to the south of Gympie. At Mount Coora and Mount Cobalt, about 8 miles south of Kilkivan, cobalt-bearing manganese ore is interlaminated with jasperoid slates as a result of selective replacement of the latter. The deposits are of considerable size and have been worked at Mount Coora.

DEVONIAN.

Marmorised portions of the Devonian limestone deposits are quarried for marble, notably at Ulam and near Silverwood, and the limestone at many places is burnt for lime for agricultural purposes and the building trade. Limestone, possibly belonging to this period, has been quarried at Gore for the making of cement at Darra, near Brisbane. A further use of limestones of this age is as a flux in the smelting of ores; in particular the deposit at Marmor has been used for that purpose by the Mount Morgan Company.

Lenticular beds of high grade magnetite and haematite ore on Iron Island have been mined in the past. These lenses represent metasomatic replacements of Middle Devonian limestones and shales.

The extensive serpentine instrusions, which probably took place in the latter part of this period, contain a number of deposits of economic importance. Chromite occurs as small irregular deposits throughout the whole serpentine belt, but especially near Rockhampton, Kilkivan and Pine Mountain. The most important area is the Cawarral-Canoona region where the Elgalla lode, for example, is formed of lenses and irregular masses separated by serpentine.

Other ores, associated with the serpentine are: cobalt with manganese ores near Kilkivan; cobalt, manganese and nickel at Mount Coora; asbestos near Princhester (54 miles from Rockhampton), and at the same place magnesite, occurring in a broad belt associated with minor basic intrusions. Further north at Mount Pring, near Bowen, a remarkably pure deposit of magnesite in serpentinised dolerite is known.

The first payable gold discovery in Queensland was that at Canoona, where the ore occurs finely disseminated in belts or zones in serpentine. Several gold mines at Cawarral are also associated with this serpentine.

On the Cania and Kroombit goldfield reefs occur in Devonian sandstones, shales and limestones.

The gold ores of Charters Towers, once one of our richest fields, were probably introduced near the end of this period by igneous intrusions into metamorphosed rocks of Pre-Devonian age.

While most of the gold won on the Palmer field came from alluvial deposits, a certain amount has been obtained from reefs which are within rocks, probably of Devonian age.

CARBONIFEROUS.

In spite of the name Carboniferous being based on the great development of coal during this period in Europe, there are no coal seams of this age in Queensland, or indeed in Australia.

Ore deposits, however, although not numerous, are important, for they include the gold-copper deposit of Mount Morgan, probably the richest single goldmine the world has known, though now worked mainly for copper. The ore was formed as a result of the intrusion into the Carboniferous sediments of hornblende-granite and doleritic dykes.

About Texas the sediments include a number of limestone lenses, three of which have yielded Carboniferous corals. Fossils have not as yet been found in the others and they may be either Devonian or Carboniferous in age. Two of these latter lenses are quarried for marble.

PERMIAN.

Our Permian rocks are of very great economic importance because they contain not only many valuable metalliferous deposits but also extensive fields of high grade coal. Although none of the coal deposits is yet developed to its maximum extent, the Bowen River and Dawson-Mackenzie basins are known to contain great reserves, while there are, in addition, many smaller fields, such as Blair Athol and Mount Mulligan, with high grade deposits. The coals rank from sub-bituminous at Blantyre to semi-anthracite in the Dawson River district, and both low-and medium-volatile bituminous coals are common. Most of the coals are highly suited for steam-raising purposes and some are particularly suited for the production of metallurgical coke for smelting.

At Blair Athol occurs the thickest known seam of black coal in the world—15 to 93 feet in thickness with an average of 75 feet of clean coal. Actual and probable reserves are in excess of 1,300,000 tons.

Details of the fields, seams, quality, &c., are set out in Table U and Map 13.

Small deposits of low grade torbanite are known in the Upper Bowen Series both in the Carnarvon Ranges and on the Bowen Coalfield, while a small high grade deposit occurs at Alpha in rocks which may belong to the Lower Bowen Series.

The rocks of this period are also important for their past and present production of gold. The Gympie goldfield was the first of Queensland's major goldfields to be found, although it is now almost worked out. The gold there was found in close association with several graphitic or carbonaceous beds of shale, known as "beds of slate." This field produced many museum specimens of gold ore, including a number of wire-gold. Small amounts of platinum were associated with the gold in the Lady Mary and the Alma reefs.

The most recently found of Queensland gold fields—Cracow, is also situated in Permian rocks—volcanics, shales, sandstones and limestones of the Lower Bowen Series, but the mineralisation may have been prolonged into the Triassic.

Near Biggenden, the very interesting Mount Shamrock mine (apparently a breccia filled pipe) produced much gold, partly in the form of gold tellurides associated with bismuth sulphides and tellurides. The Mount Biggenden mine has yielded iron, gold and bismuth and is still worked intermittently.

At Clermont were found the richest and most extensive of our many alluvial gold deposits. Leads of several different ages are present, but the oldest include shales with the fossil plant *Glossopteris* indicating a Permian age. Such form the oldest alluvial drifts known in Queensland. The leads are, in many cases capped by basalts.

At the Neerdie mines, 14 miles north of Gympie, gold and silver is associated with the chief product, antimony, in brecciated lodes and quartz veins.

Silver lodes occur associated with altered dolerites at Ukalunda, on the Sellheim Mineral Field.

At Silverspur, near Texas, complex lodes introduced by late Permian granites into fossiliferous Permian rocks have yielded considerable quantities of silver, lead, zinc, copper and gold.

Similar granites are responsible for both the copper ores and the arsenic-tin deposits of Sundown, while the extensive arsenic ores which have been mined at Jibbinbar were formed at the same time. At Stanthorpe, however, most of the tin-bearing lodes have been removed by erosion, but this process has given rise to widespread alluvial tin deposits of Recent age.

In the far north the tin bearing lodes of the Cooktown field are associated with granite possibly of Permian age.

Also in the far north tungsten, molybdenum and bismuth have been extensively worked around Wolfram, Bamford and Mount Carbine. The lodes, frequently pipe-like in form, occur in granite at the two former and in slates of unknown age at the latter locality. Such lodes were formed as one result of the intrusion of granite, possibly during this period. Some lodes, as near Petford, have also yielded fluorspar for use as a flux.

Most of the intake beds which fringe the eastern margin of the Great Artesian Basin are of Mesozoic age, but, in the north-westerly projection shown on the Permian map, beds assigned to this period are probably of importance both as intake beds and as aquifers (water bearing horizons).

TRIASSIC.

As with the Permian rocks, the main economic interest of the Triassic lies in the coal deposits. Although neither as extensive nor of as high quality as those of the Permian, the Triassic coals have been exploited to a greater degree, mainly because of the proximity of the main field, Ipswich, to the most thickly populated and most highly industrialised portion of the State. The many workable seams include bituminous coals of high and medium volatility and other of sub-bituminous rank. They are suited both for steaming purposes and the production of coke. Actual and probable reserves amount to at least 234,000,000 tons. Details of the fields, seams, &c., are set out in Table U.

To the north of Ipswich, within the Tivoli stage of the Ipswich Series, retinite, a fossil resin, has been found in the Tivoli mine.

The Callide Coal Measures are restricted to a small basin but two seams of good coal are known and the overburden is sufficiently thin, at least in places, for open-cut mining to be feasible.

At Kilkivan are found small deposits of mercury ores, the only workable ones known in the State. The sulphide and, rarely, the liquid native mercury, occur in rocks of the Neara Series and older metamorphics and intrusives. The ores were, however formed at a later, probably considerably later, date than any of the containing rocks.

Some of the sandstones of the Ipswich Series, for example, that at Petrie's Quarry, Albion, have in the past been used as building stones and the Helidon sandstone, probably of Bundamba age, is much used as a building stone and also for grindstones. Clays are common in the Ipswich Series, as at Kalinga, and although little used at present may be of greater value in the future.

At Mount Morgan a considerable deposit of high quality fire-clay, probably of this age, was worked for some years.

The Dooloogarah Series along the eastern margin of the Great Artesian Basin consists largely of coarse porous sandstones, and thus forms important intake beds.

JURASSIC.

Once again the main economic interest lies in the coal measures, which are very extensive, but as yet not fully developed. The coal of the Rosewood coalfield and that of the Darling Downs is particularly valuable for the production of gas and is also suited for the raising of steam. Other fields include the most westerly at Orallo and the most northerly at Laura. Actual and probable reserves of Jurassic coal total at least 170,000,000 tons.

At Mount Bopple near Maryborough graphite formed by the metamorphism of Jurassic coals as the result of the intrusion of syenite has been worked to a considerable extent.

At North Arm gold with a high silver content is found in reefs associated with volcanics which may be of this age. Silver lead selenide, rare elsewhere, is a common constituent.

At several places in the Roma district, and at Orallo, high gravity oil in small quantities and petroliferous gas have been met in several bores at depths ranging from 250 to 3,700 feet. The gas from the Roma bores yielded 1.2 pints of petrol per 1,000 cubic feet of gas; the petrol was extracted for a short period until the flow of gas was lost.

At Longreach a bore, started in Cretaceous marine strata, penetrated an oil sand, 14 feet thick, in Jurassic shales and sandstones, close to the granite bed-rock which was reached at 3,258 feet. It yielded a thick oil at the rate of half-a-gallon an hour, which solidified on exposure to a dark-brown wax.

Thin lenses of low to medium grade oil-shale are known in Jurassic strata at many localities: in the Rosewood-Laidley district, at the foot of the main range near Toowoomba, at Sugarloaf near Oakey (associated with cannel coal), and at Kingsthorpe, Orallo and Miles. Unfortunately none of these deposits is of sufficient size or rich enough to be of economic importance, although the Orallo seam is 2 feet thick and tests show a yield of 45 gallons per ton. Most of the Queensland oil-shales of this period yield less than 30 gallons per ton.

The Attica Series and the Blythesdale Series (in part Cretaceous), which fringe the eastern margin of the Great Artesian Basin and extend westward below later rocks, consist largely of sandstones; and since they are even more porous than the underlying Triassic beds they form important intakes and aquifers.

Jurassic sandstones from the Warwick area have been used as building stones.

CRETACEOUS.

As in the other Mesozoic periods, the chief economic interest of the Cretaceous lies in the coal deposits. Developed fields are the Burrum-Howard, where there are eleven seams of medium-volatile bituminous coal, suitable both for steaming and for metallurgical coke, and Styx River, with five seams of high volatile bituminous coal, suitable for steam raising and for gas making. Actual and probable reserves on these fields amount to over 130,000,000 tons.

The Stanwell field is undeveloped, as are the small seams at Winton.

The argillaceous and calcareous rocks of the Roma and Tambo Series, form the impervious cover essential for the retention of the water of the Great Artesian Basin.

The Roma, Tambo and Winton Series all contain an abundance of clays, and while these are not as yet utilised to any extent they may prove of importance in the future.

Within the deep soils overlying the Cretaceous rocks of the west occur layers and discontinuous masses of gypsum. These have not as yet proved of economic value.

Globules of mineral oil have been detected in the marine beds of the Tambo Series near Longreach.

The famous opal fields of Queensland are located in a belt, 550 miles long and 250 wide, stretching from the Kynuna district in a south-south-westerly direction through the Opalton, Jundah, Eromanga and Cunnamulla fields to Hungerford on the southern border. In these districts precious opal is widespread and considerable quantities have been mined at over one hundred localities. The opal, which is in strong demand as a gemstone, is in many cases of superb quality; it displays an endless variety of colours and has frequently been found in large pieces—in pieces of good quality as large as a man's hand.

At the close of the period and within a coastal strip about 60 miles wide, extending from Bundaberg south to Yandina, there appear to have been injected many major intrusions of granitic and allied rocks. These had important effects in mineralizing the palaeozoic and (in some cases) the mesozoic sediments in the vicinity. The metals introduced include antimony, and possibly mercury. In addition these granites carry within themselves, as at Culgoa and Teebar, workable copper ore.

EOCENE.

The Redbank Plains Series contains a wealth of clays which are utilised for many different purposes. The clays about Darra are used as an ingredient in the manufacture of cement and for making bricks and ornamental tiles. Near Dinmore, a clay of sufficiently good colour for making porcelain ware is found, and other clays around Dinmore and Ebbw Vale are used in the manufacture of pipes, pottery, &c.

A small low-grade deposit of oil-shale is known at Redbank Plains. At Lowmead and Baffle Creek much more extensive deposits of oil-shale occur but these, too, are of low grade.

At Nagoorin and Ubobo a seam of hydrous black coal is known, but its extent and value has not been investigated. Associated with the coal is a small deposit of oil-shale.

OLIGOCENE.

In the Petrie Series a bed of oil-shale is known at Strathpine and on the South Pine River, but it is disturbed by overthrust faulting and is of low grade. A seam of brown coal also outcrops nearby.

To the north the extensive area of shales at The Narrows and the smaller area at Plevna contain considerable thicknesses of low grade oil shale. Inland, too, fairly extensive deposits of oil-shales are known at Duaringa, but there again the grade is low.

The limestones of the Silkstone Series were the first to be worked in the State, at "Limestone," afterwards known as Ipswich. They were soon abandoned owing to their low quality.

A little to the south, at Flinders and at Anthony, dolomite associated with basalt and occurring over an area of about 5 square miles, is worked. It probably belongs to this period.

At Waterpark, near Rockhampton, six seams of brown coal are known. These total over 80 feet in thickness and although not worked as yet have possibilities for briquetting and the production of electric power.

MIOCENE.

Economically the period is lacking in interest but certain of the laterites of this age may prove to be a source of aluminium.

PLIOCENE.

Tripolite (Diatomaceous earth) is of frequent occurrence, usually as thin beds of restricted area in association with the basalts of this period. They are best known in south-eastern Queensland, especially in the MacPherson Range, as at the head of Nerang Creek, where beds up to 10 feet thick occur. One of the more important deposits is that worked at Black Duck, near Gatton, which has a maximum thickness of 20 feet. That diatomaceous earths are not restricted to the south-eastern part of the State is shown, for example, by the occurrence of one, 30 feet thick, near Spring Creek Station, on the Etheridge goldfield.

At Tambourine Mountain weathering processes have produced from basalts of this age fairly extensive areas of bauxite. These have been tested for their aluminium content but have not yet been developed.

Near Yarraman an extensive area of a high quality bentonitic clay has recently been found and is being worked on a small scale.

At Anakie alluvial deposits, usually well above the present streams, have produced large quantities of high quality sapphires. These are most commonly blue, but purple, red, green and the rare yellow varieties are also found. Many sapphires too poor in quality for use as gems are of value for small bearings and pivots. Occasional diamonds and rubies are associated with the sapphires.

Certain drifts containing alluvial gold and stream tin occurring immediately beneath the Pliocene basalts, as for example those on the Russel River south of Mount Bartle Frere and on the Beatrice River, probably belong to this period.

At Clermont the extensive auriferous alluvial drifts range in age from Permian to Post-Tertiary, but many, capped with basalt and containing boulders of basalt, are probably Pliocene in age.

At Wycarbah fire clay, probably a decomposition of an acid volcanic tuff, is worked.

PLEISTOCENE.

A number of deep leads, found at various levels within the present valleys may be placed in this period. Such deep leads may be auriferous as, for example, that on the Kroombit goldfield, or stanniferous as is the Herberton deep lead. Besides yielding considerable quantities of stream tin the latter also produced limited quantities of beryl of gem quality.

The Great Barrier Reef, which was probably in existence during this period, is a potential and almost inexhaustible source of lime for agricultural and other purposes.

RECENT.

A certain amount of gold was associated with the Recent alluvial deposits of most of our goldfields, and an appreciable amount of the total gold recovered in the State has come from this source. But the only major goldfields, predominantly alluvial in character are those of Clermont (already dealt with) and the Palmer. On the latter, in addition to the Recent deposits, which have contributed the bulk of the gold, there are other ancient auriferous alluvials, the age of which is not certain.

Stanniferous alluvial leads of Recent age, are also widespread and have been a valuable source of tin.

Occasional diamonds have been found also in the tin drifts of Stanthorpe and the gold drifts of Gilberton.

Other gold and tin bearing alluvials, at higher levels, are found on many fields. These, occurring in the present stream valleys, are probably Recent, but may be somewhat older.

"Black sands" are widespread along and behind the present beaches of south-eastern Queensland and yield rutile, garnet, monazite, and small quantities of gold, platinum, stream tin, &c. Rutile, at present the most valuable product, reaches its highest percentage in the sands south of Currumbin. Monazite-bearing sands are known at the mouth of Johnstone River but have not yet been exploited.

The dredging of sand and gravel for the building trades from the thick deposits (up to 100 feet) in the bed of the Brisbane River, is a considerable industry and the white, almost iron free, sands of Moreton and Stradbroke Islands, are suitable for all but the best quality glasses. At Virginia, near Brisbane, recent sandy clays are used to make bricks.

The fossil coral at Mud Island, in Moreton Bay, is the principal ingredient in the cement which is manufactured at Darra.

On Holbourne Island a high grade deposit of phosphate rock, 20 acres in extent, has been worked, as has a smaller deposit on Bramble Cay. The phosphate deposits of Olsen and Johansen's caves near Rockhampton have been worked intermittently.

Small masses of fossil resin (immature amber) have been reported from the Atherton Tableland. The extent and value of the deposits have not been determined.

TABLE U.

COAL SEAMS OF QUEENSLAND.

(Seams one foot and over.)

Fields shown in italics are undeveloped.

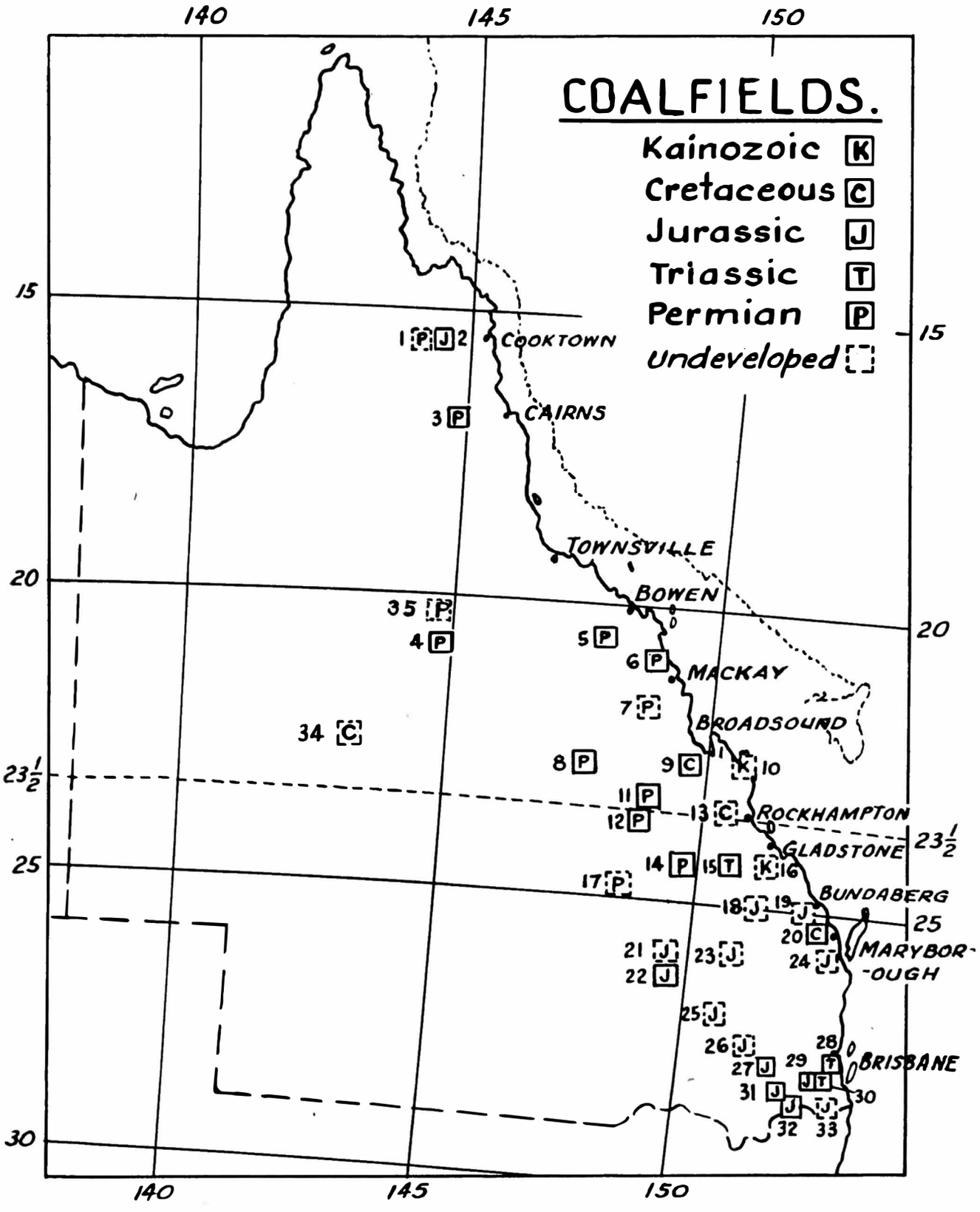
No. on Map.	Field.	Seams.	Thickness.	Rank and Type of Coal.	Most suitable for.	Reserves. A = actual P = probable
			KAINOZOIC.			
10	*Waterpark*	A B C D E F	7′ 6″ 5′ 16′ 27′ 22′ 8′	Brown coal or lignite	Briquetting	? Very large A. & P. 66,600,000
16	*Nagoorin and Ubobo*	One	Thick	Hydrous black		
			CRETACEOUS.			
20	Burrum and Howard	Eleven seams, including Bridge, Lapham, Burrum, Jervell, Watson, Hartley	Total of 24′	Medium-volatile bituminous, bright	Steams and metallurgical coke	A. & P. 120,600,000
13	*Stanwell*	One	6′	Bituminous		
9	Styx River	Five	8′ 3″	High - volatile bituminous, bright	Steam and gas	A. & P. 11,000,000
34	*Winton*	Two	2′ and 15″		Steaming and coke	
			JURASSIC.			
31	Allora Group, Allora *Clifton* *Maryvale*	One Three One	5′ 6″ 7′ 6″ 3′ 9″	Bituminous	Steam and gas	A. & P. 6,250,000
33	*Beaudesert Border*	Pitt Gould Stanfield Palen Creek Widgee Creek Mt. Lindsay	1′ 1′ 4″ 1′ 3′ 8′ 17′	Bituminous	Steam and gas	P. 14,000,000
25	*Chinchilla*	Seven	40′	Bituminous	Steam	P. 20,000,000
26	*Dalby*	Three	14′ 2″	Bituminous	Steam and gas	A. & P. 31,900,000
21	*Injune*	Many	At least 25′	Bituminous	Steam and gas	
19	Isis River	One	2′ 8″	Bituminous		P. 1,500,000
32	Killarney Group— Tannymorel *Emu Vale* *Swan Creek*	 Two One One	 5′ 5′ 5′	 Bituminous Semisplint	Steam and gas	A. & P. 8,500,000
2	Laura	One	1′ 3″	Bituminous		P. 2,800,000
	Mulgeldie	A B C D	5′ 6′ 5′ 5′	Bituminous	Steam	
27	Oakey (including Kingsthorpe)	At least five	At least 16′	Bituminous, cannel	Steam, gas, tar, etc.	A. & P. 19,000,000
22	Orallo (Cornwall-Alcurah and Yingerbay)	At least two	Over 3′ 3″	Bituminous		
29	Rosewood-Walloon (including Lanefield)	At least twelve, including— Lanefield Rosewood No. 1 Rosewood No. 2 Bruce's Caledonian Top Caledonian Bottom Walloon Upper (?)	At least 34′	High - volatile bituminous, bright	Steam and gas	A. & P. 42,000,000
23	*Taroom*	Several	13′ ?	Bituminous		
24	*Tiaro*	At least four	23′ 8″	Medium-volatile bituminous	Steam	P. 20,000,000

TABLE U—*continued.*
COAL SEAMS OF QUEENSLAND—*continued.*
(Seams one foot and over.)
Fields shown in italics are undeveloped.

No. on Map.	Field.	Seams.	Thickness.	Rank and Type of Coal.	Most suitable for.	Reserves. A = actual P = probable.
			TRIASSIC.			
23	Brisbane (Nundah)	One	3′	Medium-volatile bitumnous	Steam	A. & P. 10,000 000
15	Callide	At least two	18′–45′ 5′	Sub-bituminous splint with one thin bright layer	Steam	A. & P. 120,000,000
30	Bundamba — Blackstone Stage	West Moreton	2′	Bituminous	Steam	
		New Found Out	5′			
		Aberdare	15′			
		Bluff	15′			
		"Top Coal"	6′	High and medium volatile bituminous	Steam	A. & P. 78,000,000
		Four Foot	4′			
		Bergins	4′ 6″–13′			
		Striped Bacon	5′ 6″			
		Rob Roy	6′ 6″			
		Lindsay's Hard	?	Predominantly bright with some splint layers		
		At least one unnamed	?			
	Ipswich — Tivoli Stage	Garden's	7′			
		Tantivy	4′ 2″			
		Fiery	24′ Coal and stone	Medium-volatile bituminous	Steam and metallurgical coke	A. & P. 26,000.000
		Waterstown	3′			
		Unnamed	3′ 4″	Predominantly bright with high ash splint		
		Tivoli	5′			
		Eclipse	6′–11′			
		Benley's	8′			
		B'g or Waterworks	60′ Coal and stone			
			PERMIAN.			
8	Blair Athol	Top	4′	Medium-volatile bituminous Splint	Steam	(Top and Big) A. & P. 206,000,000
		Big	15′ to 93′ Ave. 75′			
		Lower	4′			
4	Blantyre	One	2′ 6″	Sub-bituminous	Steam and coke	P. 2,800,000
35	*Oxley Creek*	Two	5′ Coal and stone 7′ (Plus coal and stone)	High-volatile bituminous		
5	Bowen River Area, Collinsville, Bee Creek, etc.	Macarthur (Upper)	3′	Medium-volatile bituminous	Steam and metallurgical coke	A. & P 420,000,000
		Daintree (Upper)	17′ Coal and Stone			
		Havilah (Upper)	10′ 6″			
		Garrick (Middle)	7′			
		Scott (Middle)	5′ 3″			
		Denison (Middle)	3′ to 8′			
		Potts (Middle)	3′ to 8′			
		Vale (Middle)	6′			
		Bowen (Middle)	14′			
		Unnamed Seam (Middle)	6′			
		Blake (Middle)	6′ to 24′			
		One (Lower)	5′ of Coal and stone			
6	Calen (Mackay)	At least six	At least 50′	Semi-bituminous		
17	*Carnarvon and Consuelo*	At least four ..	At least 24′	Bituminous	(Non-coking)	

TABLE U—*continued.*
COAL SEAMS OF QUEENSLAND—*continued.*
(Seams one foot and over.)
Fields shown in italics are undeveloped.
PERMIAN—*continued.*

No. on Map.	Field.	Seams.	Thickness.	Rank and Type of Coal.	Most suitable for.	Reserves. A = actual P = probable
14	Dawson River Area Baralaba-Dawson Is.	Two	14′	Semi-anthracite bright	Steam and smelting	A. & P. 78,000,000
1	*Little River*	Numerous, thick dirty seams; three 7″ seams good	At least 78′	Very dirty low-volatile bituminous		A. & P. 2,000,000 (Good quality)
11	Mackenzie River Area— Blackwater Rangal Bluff Stanley	Mammoth Rangal Bluff Cambria One	20′ 6′ (Plus coal and stone 6′ 6′ 6′	Semi-anthracite bright	Steam and smelting	A. &. P. 562,000,000
3	Mt. Mulligan	Two	7′	Medium-volatile bituminous, splint with some bright	Steam and metallurgical coke	A. &. P. 20,000,000
7	*Nebo*	One	4′ 6″	Semi-anthracite	Steam	P. 20,000,000
12	Tolmies	Two	7′	Medium-volatile bituminous	Coking, not suitable for steam	A. & P. 3,400,000



MAP 13. COALFIELDS.

Locality Key.—1. Little River; 2. Laura; 3. Mt. Mulligan; 4. Blantyre; 5. Bowen River; 6. Calen (Mackay); 7. Nebo; 8. Blair Athol; 9. Styx River; 10. Waterpark; 11. Mackenzie River; 12. Tolmies; 13. Stanwell; 14. Dawson River; 15. Callide; 16. Nagoorin and Ubobo; 17. Consuelo and Carnarvon; 18. Mulgeldie; 19. Isis River; 20. Burrum and Howard; 21. Injune; 22. Orallo; 23. Taroom; 24. Tiaro; 25. Chinchilla; 26. Dalby; 27. Oakey; 28. Brisbane; 29. Rosewood; 30. Ipswich; 31. Allora; 32. Killarney; 33. Beaudesert-border; 34. Winton; 35. Oxley Creek.

LIST OF ABBREVIATIONS.

★

A.A.A.S.	Australasian Association for the Advancement of Science.
A.N.Z.A.A.S. ..	Australian and New Zealand Association for the Advancement of Science.
A.G.G.S.N.A. ..	Aerial Geological and Geophysical Survey of Northern Australia.
Geol. Mag. ..	Geological Magazine.
Hbk. A.A.A.S. ..	Handbook for Queensland, Australasian Association for the Advancement of Science.
Mem. Qld. Mus. ..	Memoirs of the Queensland Museum.
P.L.S.N.S.W. ..	Proceedings of the Linnean Society of New South Wales.
P.R.S.N.S.W. ..	Proceedings of the Royal Society of New South Wales.
P.R.S.Q.	Proceedings of the Royal Society of Queensland.
Q.G.M.J.	Queensland Government Mining Journal.
Q.G.S.P.	Queensland Geological Survey Publication.
Q.J.G.S.	Quarterly Journal of the Geological Society of London.
Univ. Qld. ..	University of Queensland Papers, Department of Geology.

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