The Geological Range of the Tiaro Series.

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I. INTRODUCTION.

The area investigated by the authors lies in the County of Lennox, Queensland, to the west and south of Maryborough, principally on and in the vicinity of the railway line between Mungar Junction and Biggenden.

The earliest geological work in the area seems to have been done by W. H. Rands,[1] who in 1890 published an account of the geology of what he termed the "Tiaro district," an area embracing some 900 square miles, of which he wrote, "The greater part of this country is composed of rocks belonging to the Burrum coal measure series. It is a continuation of the Burrum coal field . . ." Rands examined and reported on coal seams met in this series near Gunalda, on Munna Creek, on Tanyalba Creek at Mount Bopple, on Tinana Creek, and at other places. These coals, he points out, are "non-caking," and differ in this and other respects from typical samples from the Burrum coal field, cited for purposes of comparison. "The coal measures of the Tiaro district are much more disturbed by faults and intrusive rocks than in the Burrum and Howard district, north of Maryborough. The direction and amount of dip is seldom the same over any large area. In many places dykes and masses of intrusive rocks come up through and disturb the coal strata." In the map which accompanied his report Rands considers the base of the coal measures to be a sandstone ("freestone") horizon, with a general N.N.W. trend. To the west of and below this are mapped "Gympie beds."

In his annual report to the Department of Mines in the same year Rands described from the Tiaro district "Granite intruded into the Gympie beds, and on which the Burrum beds rest."

The Burrum beds with which Rands sought to correlate the Tiaro coal beds were at this time, and for many years after, thought to be "On a higher horizon than the Permo-Carboniferous system and on a lower than the Ipswich formation."[2] Later work, as we shall see, has gone to prove that—

1. The Tiaro series is *not* an extension of the Burrum series, but is considerably older; and
2. The Burrum series is not older than the Ipswich series, but considerably younger.

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[1] Qld. Geol. Sur. Pub. No. 59, p. 1.

[2] Jack and Etheridge, Geol. of Qld., p. 300.

The generally accepted explanations of the relationship between the various systems then and now are as follows:—

		Old Classification.	New Classification.
Cretaceous	Upper	Maryborough Series	
	Lower		Burrum Series. Maryborough Series.
Jurassic ..	Upper		
	Lower	Ipswich Series	Walloon Series = Tiaro Series.
Triassic ..	Upper	Burrum Series = Tiaro coal beds	Bundamba Series = Landsborough Series. Ipswich Series.
	Lower		
Permo-Carb. ..		Gympie Series	Gympie Series.

The fact that the Tiaro series was not equivalent to the Burrum series but was considerably older was established by the field investigations of Richards[3] and of Dunstan,[4] who showed that the two series were separated by the Maryborough Marine series, the Burrum coal measures overlying the Marine beds and the Tiaro coal measures underlying them.

The fact that the Burrum series was not older than the Ipswich series but considerably younger was confirmed by Walkom's[5] comparison of the fossil floras of the two series. The same author concluded from the palæobotanical evidence that the Tiaro series was equivalent to the Walloon series. Although this conclusion has met with general acceptance, Jensen[6] has recently expressed the opinion that the Tiaro series is equivalent to the Ipswich series.

One of the present authors [W.H.B.] in company with the late Captain L. R. Blake, M.C., in 1914 made a hurried investigation of the area now under consideration, and found that the Tiaro series were much thicker and more extensive than shown on Plate 5 of the Queensland Mineral Index, and as mapped by Rands in the publication already cited, a considerable extent of Rands's "Permo-Carboniferous" rocks being found to be quite conformable with the overlying Tiaro coal measures and to contain plant remains of Mesozoic types. The total thickness of the Tiaro series, as estimated by Blake and Bryan after this addition, was in the neighbourhood of 12,000 feet.

Dunstan[7] in 1915 showed that at its southern extremity, in the neighbourhood of Landsborough and Caloundra, the Tiaro series is conformably underlain by the massive sandstones of the Landsborough

[3] Aus. Ass. Adv. Sci., 1913, p. 187.
[4] Qld. Govt. Min. Jrnl., 1912, p. 641.
[5] Proc. Linn. Soc. N.S.W., 1918, p. 45.
[6] Proc. Roy. Soc. Qld., 1924, p. 139.
[7] Qld. Geol. Sur. Pub. No. 252, p. 3.

series (which is regarded by him as the local equivalent of the Bundamba series), and that these in turn conformably overlie the northernmost representatives of the Ipswich series.

As a result of their recent field work in the type-district, the present authors now claim that the Tiaro series, as at present defined, is there naturally divisible into four series, three of which are the equivalents of the Ipswich, Bundamba, and Walloon series respectively, and that consequently the Tiaro series is considerably less thick and the Ipswich and Bundamba series more widespread than was formerly realised.

A short statement to this effect by one of the authors [W.H.B.] has been included in a publication recently issued.[8]

II. The Natural Divisions of the Tiaro Series.

The Tiaro series as at present defined extends over an area of many hundreds of square miles, is approximately 12,000 feet thick, and is made up of varied rock types, but several traverses across the area have convinced the authors that the series so-called falls naturally into four divisions. One of these is composed of productive and non-productive coal measures; one lies above the coal measures and thus separates them from the overlying Maryborough (Marine) series, while two lie beneath the coal measures.

The authors suggest that in the light of this natural division the term "Tiaro series" be restricted to the coal measures and that the other series be given the following names, suggested by the localities in or near which they are found typically developed:—

Tiaro series (in old sense) = { Graham's Creek series / Tiaro series / Myrtle Creek series / Brooweena series.

The Brooweena Series.—This series is typically developed between Brooweena and Aramara on the Gayndah railway. It is made up of shales, sandy shales, sandstones, and conglomerates. Immediately to the east of Brooweena railway station is a remarkable bed of massive purple conglomerates containing red jasperoid and quartzite pebbles. Purple shales are frequently met with in the western (older) portion of the series, but in the eastern portion the shales are much lighter in colour. Although many of the shales on various horizons show fragmentary plant remains, prolonged search only secured one determinate fossil, namely, *Thinnfeldia* sp. Numerous observations of strike and dip were made in the railway cuttings between Lakeside and Hunter's Hut. These showed that the strike is somewhat variable and that it is obviously much influenced by the presence of great granitic intrusions in the western part of the area, and to a less extent by smaller intrusions in the eastern

[8] Proc. Roy. Soc. Qld., 1925, p. 72.

portion. To the west of Boompa and Brooweena it approximates to a north-westerly direction and a north-easterly dip. In the neighbourhood of and to east of the latter place the strike veers still further to the west-north-west, but as Aramara is approached it returns to a north-south direction with a gentle easterly dip which remains the general direction for the remainder of the traverse. An average of fifty-three observations of strike taken in this traverse across the Brooweena series gives a N. 23° W. direction for the general trend of the series. Although steep dips, flattenings, and reverse dips are met with, the series as a whole can be regarded as dipping gently to the east-north-east.

With regard to the relationship of the Brooweena series to the Permo-Carboniferous Gympie series, definite evidence such as would be provided by actual contact was lacking. Marine fossils of Permo-Carboniferous age have been found near Lakeside and Glenbar, and these places lie to the west of the easterly dipping Brooweena series and are thus presumably below it.

Rands[9] regarded the Gympie series as unconformably underlying the Tiaro series, relying upon a section near Curra, where steeply dipping Gympie beds are separated from horizontal "Burrum [Tiaro] beds" by a large porphyritic intrusion. This section is far from conclusive and does not harmonise with Rands's own statement that he has traced a fossiliferous limestone bed of the Gympie series through Gigoomgan for a distance of fourteen miles in a north-north-west direction, *i.e.*, parallel with the Brooweena series, and that further north in the Burrum coal field at Agnes Vale the coal measures pass down conformably into a series of altered rocks which Rands suggests, in order to reconcile this with the Curra section, are younger than the Gympie series and of Permian age.

Although the most westerly outcrop of the Brooweena series occurs to the west of Boompa, where massive white sandstones, fissile shales and mudstones containing numerous indeterminate plant remains are found surrounded by granite, it is improbable that this outcrop marks the lowest horizon of the series. This position is more probably occupied by the purple conglomerates found at Brooweena some three miles further to the east. Hence the old-looking, strongly jointed, very compact, steeply dipping and heavily faulted cherty rocks and andesites found to the west of the Brooweena purple conglomerates may be representatives of the Gympie series and not very metamorphosed examples of the Brooweena series, which is the alternative explanation.

The Myrtle Creek Series.—Lying to the east-north-east of the Brooweena series and exposed in numerous railway cuttings between Hunter's Hut and Thinoomba is a series of rocks which in lithological character form a striking contrast with the shales and sandy shales which it conformably succeeds. This series is made up of very massive siliceous sandstones showing marked current bedding. It is presumably

[9] Op. cit., p. 59.

the massive character and lack of regular bedding planes which are responsible for the fact that in the geological map accompanying the Queensland Mineral Index these rocks are mapped as "granites."

The series is so faulted and disturbed by numerous intrusions of porphyrites that it is difficult to generalise with regard to strike and dip. However, the general direction of the outcrops of this easily recognised horizon as seen at intervals over a distance of ten miles is approximately north-north-west, and hence conformable with the underlying Brooweena series. Almost identical massive white sandstones have been noted by one or other of the authors on the southerly prolongation of this line to the east of Curra railway station and on Widgee Creek and on the northerly prolongation on Duckinwilla Creek and to the south-west of Childers. No fossils of any description have been found in the Myrtle Creek series.

The Tiaro Series.—In the restricted sense suggested earlier in this paper, the Tiaro series outcrops on the Gayndah railway between a point 1½ miles west of Thinoomba, where it conformably succeeds the Myrtle Creek series, to a point about one-half mile to the east of Yerra. The series is composed of soft friable shales, often carbonaceous and sometimes containing coal seams, sandy shales and soft micaceous sandstones. The shales are frequently fossiliferous, the most typical fossil being *Cladophlebis australis.* The general strike is to the north-north-west, although in the more easterly part of the series north-north-easterly strikes are met with. The general dip is a gentle easterly one. The series can be discontinuously followed in a south-south-east direction as far as the northern end of Moreton Island, and has been traced to the north-north-west as far as the Isis River.

The Graham's Creek Series.—To the east-north-east of the Tiaro series, as typically developed and separating it from the overlying Maryborough (Marine) series, is a very considerable thickness of tuffaceous sediments.

Several figures published by Dunstan and by Walkom show tuffaceous rocks as forming the basal part of the Maryborough series, but in view of the wide areal development, considerable thickness and significant nature of these beds, the authors are of the opinion that they should be ranked as a separate series, and have suggested the name Graham's Creek series, owing to their typical development along the stream of that name. The series is made up of trachytic and andesitic tuffs and tuffaceous sandstones, buff, green, and purple in colour, and containing rounded fragments of porphyritic trachytes and andesites. As is often the case with tuffs, it is frequently impossible to decide definitely on the directions of strike and dip, but in all those cases where reliable observations could be made both strike and dip were in conformity with the underlying coal beds of the Tiaro series and the overlying Marine beds of the Maryborough series. The areal extent of the series is considerable, for it is well developed as far north as Delan on the Wallaville branch railway, where Mr. Morton has found a great thickness of volcanics underlying the Maryborough series.

III. Correlation with Other Series.

If for the moment the Graham's Creek series be neglected as forming passage beds between the Tiaro series and the Maryborough series, the remaining series of the group under discussion form a triad which, composed as it is of two sets of fossiliferous shales separated by one of massive barren sandstones, is frequently met with in the developments of Lower Mesozoic rocks, both in Queensland and New South Wales. Thus in both the Sydney and Clarence basins in the latter State, and in the Ipswich, Brisbane Valley, Wide Bay, and Carnarvon areas in Queensland, the same threefold lithological development is met with. Such uniformity of development strongly suggests contemporaneity of deposition, the change from fossiliferous shales to barren sandstones and back again to shales apparently indicating widespread changes of some geographic or climatic controlling factor. Such a conclusion is supported by other facts. Thus in Sydney, Carnarvon Range, and the Wide Bay areas there is general conformity between the lowest shales of the Mesozoic sediments and the underlying Permo-Carboniferous series, although of course the different junctions may represent disconformities of different values.

In the light of these facts it is natural that the older geologists should have regarded the Lower Mesozoic rocks of the two States as being confined to three series, a lower and an upper series of fossiliferous shales, and a middle series of barren sandstones.

Some years ago Dr. A. B. Walkom made a series of detailed palæontological investigations into the several developments of Lower Mesozoic sediments in the eastern States of Australia, as a result of which he concluded that the lithologically similar threefold divisions of the Sydney, Clarence, and Ipswich areas occupied quite different positions in the geological time scale, the middle sandstones, for instance, being assigned to three distinct horizons. The palæobotanical evidence thus appears to be directly opposed to the simple generalisation of the earlier geologists which so nicely and effectively correlated our Lower Mesozoic deposits.

Although Dr. Walkom's conclusions have met with general acceptance, Jensen[10] supports the old classificatory scheme in that he correlates what he terms the "Ipswich series" of the Carnarvon Range area with the Narrabeen shales of the Sydney basin. The Chief Government Geologist of this State, basing his opinion on both lithological grounds and on field mapping, still adheres to the view that the threefold divisions of the Clarence series are respectively equivalent to the Ipswich, Bundamba, and Walloon series,[11] while the authors have been privileged to see the manuscript of a paper by Mr. J. H. Reid, in which he has arrived at the same conclusion as a result of a comparative study of coal analyses from the two areas.

[10] Qld. Govt. Mining Jour., 1921, p. 405.

[11] Verbal communication.

In correlating the lacustrine sediments of the Wide Bay area, there is no room for such perplexing doubts, for the palæobotanical and lithological evidence both point to a correlation of the Brooweena, Myrtle Creek, and Tiaro series with the Ipswich, Bundamba, and Walloon series respectively, and this conclusion is strongly supported by the facts of geographical distribution.

The detailed evidence for this correlation is as follows:—

Palæobotanical Evidence.—Fossil plants were collected from four points, A, B, C, D, three of which, A, B, C, were within the Tiaro series in the restricted sense, the fourth, D, being in typical beds of the Brooweena series. These specimens were kindly examined by Dr. A. B. Walkom, who has forwarded the following determinations and comments:—

"Locality A.—

Equisetites rotiferum Tenison-Woods.

Taeniopteris spatulata McClelland.

Elatocladus cf. *plana.*

? *Sphenolepidium* sp.

Equisetites rotiferum is a typical Walloon fossil. The examples of *Taeniopteris spatulata* are similar to that originally described by McCoy as *T. Daintreei,* and also to specimens described from the Burrum series (Qland. Geol. Survey, Pub. 263, p. 36, Pl. 1, fig. 9). The coniferous fragments referred to *Elatocladus* may be compared with specimens of *E. plana* described from the Walloon series and also from the Burrum series. The specimens named *Sphenolepidium* sp. are similar to that previously figured from the Burrum series (loc. cit., Pl. 2, fig. 3).

Locality B.—

Cladophlebis australis.

Locality C.—

Equisetaceous stems (probably *E. rotiferum*), similar to those from Locality A.

Locality D.—

? *Thinnfeldia* sp. (apical portion of a frond).

? Insect wing.

It is to be noted that all the species from localities A, B, and C are species occurring in the Walloon series in other areas, and also that the only recognizable plant from locality D is a *Thinnfeldia,* which genus is, so far as we know at present, confined to the Ipswich series in Queensland. This confirms the suggestion that the Tiaro series includes representatives of both Ipswich and Walloon series."

The following key shows details of the localities from which the specimens were obtained:—

A. In gully, near road, S.E. corner of Portion 37v, Parish of Gutchy, County of Lennox (4 miles north of Theebine).

B. On road between Portions 24F and 25F, Parish of St. Mary, County of Lennox (2½ miles west of Owanyilla railway station).

C. Railway cutting immediately west of Thinoomba railway station.

D. Railway cutting 2 miles west of Aramara railway station.

Lithological Evidence.—The thin-bedded micaceous and carbonaceous shales and sandy shales which make up the Tiaro series (in the restricted sense) can be correlated only in a very general way with the Walloon coal measures as developed in the type area. They resemble them in their weak resistance to weathering and consequent lack of outcrops, but some lithological types which are well developed in the Walloon-Rosewood area, such as the red and brown fossiliferous clay ironstones, appear to be absent from the Tiaro series. On the other hand, the curious cone in cone limestones described by Reid[12] from the Walloon series are well developed in certain portions of the Tiaro series, as in the S.E. corner of Portion 37, Parish of Gutchy, four miles north of Theebine.

The evidence furnished by the several analyses of coal seams from the Tiaro series is at first sight distinctly against a correlation of that series with the Walloon series, the nature of the coal being much more like that of the Ipswich coals than the Walloon coals, as the following average analyses taken from the Queensland Mineral Index show:—

	Tiaro.	Walloon.	Ipswich.
Moisture	4·4	6·0	1·5
Volatile matter ..	20·0	39·0	27·0
Fixed carbon	61·8	44·0	58·5
Ash	13·8	11·0	14·0

However, it should be borne in mind that a feature of the Tiaro coal field which has been emphasized by Rands,[13] by Dunstan,[14] and by Jensen,[15] and which is indeed obvious to anyone traversing the area, is the great number of faults and of intrusions and their effect upon the coal seams. In the neighbourhood of Mount Bopple this alteration in the coal seams has been so intense as to produce anthracite and graphite. This is very different from the Walloon coal field where, as Reid[16] has pointed out, in the type area there is "entire absence of intrusive rocks . . . and freedom from disturbance by faulting." From the neighbourhood of Mount Alford, however, Reid[17] has described a coal seam undoubtedly of the Walloon series which is associated with sills

[12] Qld. Geol. Sur. Pub. 272, p. 16.
[13] Qld. Geol. Sur. Pub. 59, p. 2.
[14] Qld. Min. Index, p. 761.
[15] Proc. Roy. Soc. Qld., 1924, p. 139.
[16] Qld. Geol. Sur. Pub. 272, p. 18.
[17] Qld. Gov. Min. Jour., 1922, p. 470.

of trachyte. The analysis of this coal is more like that of the typical Ipswich coal than that of the typical Walloon, and is very similar to that of the typical Tiaro coal. The analysis is as follows:—

Moisture	6·4
Volatile matter	18·5
Fixed carbon	63·2
Ash	11·9

The differences in the chemical analyses of the Walloon and Tiaro coals may thus be reconciled, if it be granted that the comparatively low values for the volatile constituents of the latter coals are the result of the numerous intrusions and the movements to which they have been subjected. It should be noted, however, that Jensen, while realising this possibility, retains the opinion that the Tiaro series is of Ipswich age, as the following quotation will show:—"The Tiaro coal measures are, in the writer's opinion, of Ipswich age, the same as the Esk beds. They are intruded by dykes of acid igneous rocks, and as a result of the intrusions they are much folded and the coals are high in fixed carbon."[18]

The lithological evidence in favour of a correlation of the Myrtle Creek series with the Bundamba series is strong. The siliceous nature, massive character, current bedding, mode of weathering, and consequent nature of outcrops of the two series as typically developed are practically identical.

The shales, sandy shales, sandstones, and conglomerates of the Brooweena are lithologically similar to those of the Ipswich series, and this is especially true of those shales containing numerous plant fragments which occur to the west of Aramara.

The Brooweena series is, however, conspicuously different from the Ipswich series in that it lacks those coal seams which have made the latter series of so much economic importance.

Geographical Distribution.—Dunstan[19] has shown how the Tiaro series can be followed to the south and east continuously down the Queensland coast to Caloundra, and that to the west of and below the series is a development of massive sandstones of the Bundamba type which he has named the Landsborough series. These reach from the Obi Obi Creek to Toorbul Point. The position and trend of this belt of sandstones is well shown by Walkom,[20] whose map also shows how the series (there called the Bundamba series) is cut off to the north by a development of Palæozoic rocks. The field work of the authors shows that the outcrop of the Myrtle Creek series forms a belt of approximately the same width as, trends in the same direction as, and is in alignment with, the Landsborough series. To the west of this and occupying the same relative position to the Myrtle Creek series as the Ipswich

[18] Proc. Roy. Soc. Qld., 1924, p. 139.
[19] Qld. Geol. Sur. Pub. 252, p. 3.
[20] Proc. Linn. Soc. N.S.W., 1918, Pl. II.

series to the Landsborough series is the Brooweena series. The evidence of field mapping and geographical distribution is thus strongly in favour of correlating the Tiaro, Myrtle Creek, and Brooweena series with the Walloon, Bundamba, and Ipswich series respectively (see map).

Walkom[21] has commented on the great thickness of the Walloon series as determined in the Roma district (11,000 feet) and in the Tiaro district (12,000 feet) as compared with the thicknesses of the Bundamba series (3,000-5,000) and the Ipswich series (2,000–2,500 feet). Since Walkom's comment Reid[22] has estimated the thickness of the Walloon series in the type district as at 6,000 feet. Such an estimate was difficult to reconcile with that from the Roma district until Jensen[23] divided the so-called Walloon series there into the equivalents of the Ipswich (4,000 feet), Bundamba (3,000–5,000 feet), and Walloon (5,000 feet) series. The investigations of the present authors in the Tiaro area show that the 12,000 feet estimated as the thickness of the Tiaro series in the old sense may there also be split into three series, thus bringing the thicknesses of the different occurrences of our lower Mesozoic deposits into harmony. Thus we see that the work of the past few years has shown—

1. That the thickness of the Walloon series and its equivalents was neither so great nor so variable as was thought; and
2. That the equivalents of both the Ipswich and Bundamba series outcrop over much greater areas than had been previously realised.

IV. Earth Movements and Igneous Activity.

This aspect of the geology of the area has already been briefly touched on by one of the authors.[24]

The earliest event of importance in this connection within the area seems to have been the intrusion of great granitic masses. These may be studied in the railway cuttings to the east of Lakeside and of Boompa. These outcrops appear to form a neck connecting two very extensive outcrops of granitic rocks lying to the north-east and south-west respectively.

Petrologically the representatives of this great development actually examined by the authors may be described as medium-grained grey granodiorites. Micro-sections show the presence of quartz and two felspars, one of which, a basic oligoclase, predominates over orthoclase, while the ferromagnesian minerals are represented by both biotite and hornblende, the former, however, being in considerable excess.

With regard to the age of these granodiorites in the Tiaro district, Rands[25] is of the opinion that they intrude the Gympie beds and that

[21] Proc. Linn. Soc. N.S.W., 1918, p. 58.
[22] Qld. Govt. Min. Jrnl., 1922, p. 467.
[23] Proc. Linn. Soc. N.S.W., 1923, p. 157.
[24] Bryan, Proc. Roy. Soc. Qld., 1925, p. 72.
[25] Qld. Geol. Sur. Pub. 58, p. 8.

the "Burrum [Tiaro] Beds" rest upon them; but Jensen,[26] writing of the area immediately west of that examined by the authors, has stated that "the rhyolites, dacites, quartz porphyries, and granites are in the main Mesozoic." In the same paper Jensen points out that "Mr. Morton's work has vastly extended the granitic intrusions of Triassic and post-Triassic age in Queensland." There seems to be a growing recognition that the intrusion of large masses of granitic rocks played an important part in the early Mesozoic history of certain portions of Queensland, and especially in that of the Wide Bay and Burnett areas. Such a conclusion is certainly strengthened by the evidence in the Tiaro district, for, while the Tiaro series (in the restricted sense) may, as Rands avers, rest upon the granites, there can be little doubt that the underlying Myrtle Creek series has been intruded by them. This is well shown in the neighbourhood of Cabbage Tree Mountain, where the massive sandstones have been considerably disturbed and altered to quartzites in the neighbourhood of a large intrusion of granodiorite.

That the granitic intrusions of the area may be still later is indicated by Dunstan's[27] geological note describing the Mount Bopple area, in which he states, "Syenitic granite forms the top of the mountain, altered Trias-Jura [Tiaro] coal measures occurring around the base. Where the coal measures are much crumpled and intruded by dykes of andesite and syenite, the coal seams have been altered to anthracite and graphite." The same authority, in his geological note under "Tiaro," writes[28]:— "The coal measures are much disturbed and rest on the Gympie formation, both series being intruded by the granite."

One of us (W.H.B.) has stated that "the attitude of the Mesozoic strata in the neighbourhood suggests that the intrusion post-dated their folding—*i.e.*, that the intrusion took place in late Mesozoic or even early Tertiary times," but added that "in the absence of more detailed evidence the writer will not urge such a radical hypothesis."

Although no intrusions of a granitic type have been discovered by the present authors actually within the Tiaro series, there are present very numerous dykes of porphyrite and allied rocks of a hypabyssal nature. These vary from hornblende-porphyrites, in which the phenocrysts of the amphibole measure almost one inch in length, to very compact fine-grained rocks which might be best described as intrusive andesites. Microsections of typical specimens support this conclusion for the base in which the phenocrysts are set usually approaches the pilotoxitic nature characteristic of andesites.

With regard to the distribution of these porphyritic intrusions Rands[29] pointed out that while they are numerous in the Tiaro district they are not found in the Burrum district. At that time Rands regarded the Tiaro coal measures as a southerly extension of the Burrum series,

[26] Proc. Roy. Soc. Qld., 1924, p. 143.
[27] Qld. Min. Index, p. 761.
[28] Op. cit., p. 949.
[29] Qld. Geol. Sur. Pub. 59, p. 2.

and hence explained the difference as a strangely restricted *geographical* distribution of the intrusives, but the discovery that the Burrum beds are considerably younger than the Tiaro series showed that the distribution was probably a reflection of the *age* of the porphyrites. This is emphasized by the fact that the intrusives are not found in the Maryborough Marine series. Hence the age of the porphyrites must be regarded as late Jurassic or early Cretaceous. The Mount Bopple area would appear to show that the large granitic (syenitic) intrusions are also of this age. An important feature and one of economic significance is that where the intrusions are most numerous the Tiaro coal measures are also much crumpled and heavily faulted.

The Graham's Creek series of tuffaceous sediments probably for the most part post-dated the porphyritic intrusions, but it is probable that the earlier more basic tuffs were contemporaneous with the intrusions of porphyrite and andesite, while the later acidic tuffs seem to have immediately preceded the Maryborough Marine series into which they appear to pass.

The authors know of no parallel in Australia with the Graham's Creek series of tuffs, but the Upper Jurassic and Lower Cretaceous history of New Caledonia is closely comparable with that of the Tiaro area in that it was characterised by subsidence, sedimentation, and the extrusion of rhyolites and andesites.[30]

Thus the great granitic and lesser porphyritic intrusions appear to have taken place during the slow but intermittent subsidence during which the lacustrine sediments were deposited, and the eruption of the volcanics which gave rise to the Graham's Creek series coincided with the reversion from the terrestrial and lacustrine conditions which had persisted since Palæozoic times to the Marine conditions of deposition which resulted in the formation of the Maryborough series.

Although, as we have seen, the large intrusions of the granodiorites and the smaller intrusions of the porphyrites was accompanied by considerable local crumpling and faulting, the only major earth movement of which there is evidence seems to have taken place after the deposition of the Burrum series. One of the authors (W.H.B.) has described the nature of this folding in a previous publication, so that it may be dismissed with a few brief remarks. The Brooweena, Myrtle Creek, Tiaro, and Graham's Creek series, which have a general north-north-west strike and a gentle dip to the east, may be considered the comparatively flat eastern limb of a large anticline, the axis of which was in the neighbourhood of Gayndah. Immediately to the west of the Tiaro area is the steep western limb of a similar and parallel anticline. These two anticlines seem to form part of a huge denuded ge-anticline whose axis appears to have extended from the neighbourhood of Beaudesert towards Rockhampton. This ge-anticline appears to have been formed as the result of heavy thrusts from the Pacific Ocean, for the westerly dips are usually steeper than the easterly.

[30] See Benson, Transactions of the New Zealand Institute, 1924, p. 124.

EXPLANATION OF MAP.

The accompanying map of South-Eastern Queensland, showing the approximate distribution of Mesozoic formations, is in large part the result of a compilation of material from many sources, and in part the result of field investigations by the authors.

It should be noted that the large coastal islands shown in the map are, with the exception of the northern end of Moreton Island and a few small outcrops on the other islands, so covered with sand dunes that mapping of the underlying formations is impossible, although it is a reasonable assumption that these are for the most part Mesozoic.