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An Interpretation of the Silverwood-Lucky Valley Upper Palæozoic Succession.

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An Interpretation of the Silverwood-Lucky Valley Upper Palæozoic Succession.

By A. H. VOISEY, B.Sc.

(One Text Figure.)

(*Communicated by Dr. W. H. Bryan to the Royal Society of Queensland, 27th August,* 1934.)

INTRODUCTION.

The whole Silverwood area was first thought to be Permo-Carboniferous on the evidence of fossils found in various places. Professor H. C. Richards and Dr. W. H. Bryan[1] in 1924 explained the area as a number of isolated fault blocks of Permo-Carboniferous material within an older series of Middle Devonian Age. They attempted to place the individual blocks of Permo-Carboniferous material into their proper relative stratigraphical positions as follows:—

Volcanic Series
Condamine Beds
Wallaby Beds
Eurydesma Beds.

An endeavour was then made to correlate the suite thus assembled with the Kamilaroi sequence in N.S.W. The Eurydesma Beds were considered Lower Marine, the fresh water Wallaby Beds Greta, and the rest Upper Marine.

In 1930 J. H. Reid (p. 48) disagreed with Richards and Bryan's interpretation on two points:—(1) the correlation of the Permo-Carboniferous, and in particular the position of the Condamine Beds which he regarded as certainly on the lowest stratigraphical horizon of those described from Silverwood and to be of the transition series which he advocated for the beds of Gympie, Silverspur, Drake, and Kempsey; (2) the evidence of an important folding movement later than the Silverwood Series (Devonian) and earlier than the Fault Block Series (Permo-Carboniferous).

During February last I paid a visit to the Silverwood district with a view to comparing the sequence of Upper Palæozoic rocks there with that found in the Macleay and Hunter River districts of New South Wales.

Being in agreement with Reid as to the position of *Monilopora* low in the sequence, after finding it at Kempsey, I looked for it in the Eurydesma Block below the Eurydesma horizon and the search was successful. This discovery made it imperative that the Condamine Beds be placed below the Eurydesma beds as proposed by Reid from evidence elsewhere. As to Reid's suggestion that the Condamine Beds belong to a transitional marine series in place of the fresh-water Kuttung Beds of New South Wales, I disagree on the grounds that the Kempsey Monilopora beds, which may be correlated with those at Silverwood, overlie fresh-water Kuttung rocks including tillite, varves, and *Aneimites.* Detailed correlation of the Carboniferous and Permian rocks of New South Wales and Queensland will be attempted later.

The other alterations in the Fault Block sequence seem desirable on account of the evidence presented below. The position of the volcanic series is more in accord with Reid's suggestion (p. 50) that it can be correlated with the Stanwell Lower Bowen Volcanics even to the *Glossopteris* horizon.

My thanks are due to Dr. W. H. Bryan for his valuable advice and directions with regard to the field work. The hospitality of Mr. and Mrs. H. W. Scott, of Stanthorpe, and Mr. and Mrs. R. Hamilton, of Warwick, enabled me to carry out my observations. Without the help of Mr. Hamilton, who was my guide in the field, it would have been impossible for me to have become acquainted with the whole sequence.

THE RELATIONSHIP BETWEEN THE CONDAMINE BEDS AND THE EURYDESMA BEDS.

As Reid pointed out, the correlation of the Condamine Beds with the Upper Marine Series of the Hunter Valley (N.S.W.) because of the abundance of *Trachypora wilkinsoni* has been invalidated since 1924. Richards and Bryan described the upper strata of the Condamine Beds as rhyolitic tuffs and very tuffaceous grits, lighter in colour and coarser in grain than the underlying beds (R. and B., p. 66). The highest bed is a "tuffaceous grit containing marine fossils" (*Martiniopsis* cf *subradiata, Monilopora,* and a zaphrentoid coral were collected by me from the top of the series).

Now the lowest beds of the Eurydesma Block are "conglomerates and grits containing numbers of marine fossils, the most typical genera of which are *Fenestella, Dielasma,* and small Palæopectens" (R. and B., p. 60). These are distinctly tuffaceous in places and some might be better described as dark green tuffs. In fact, they resemble strongly the uppermost beds of the Condamine Block. This resemblance is such that it indicates little, if any, break in the sequence between the two sets of strata.

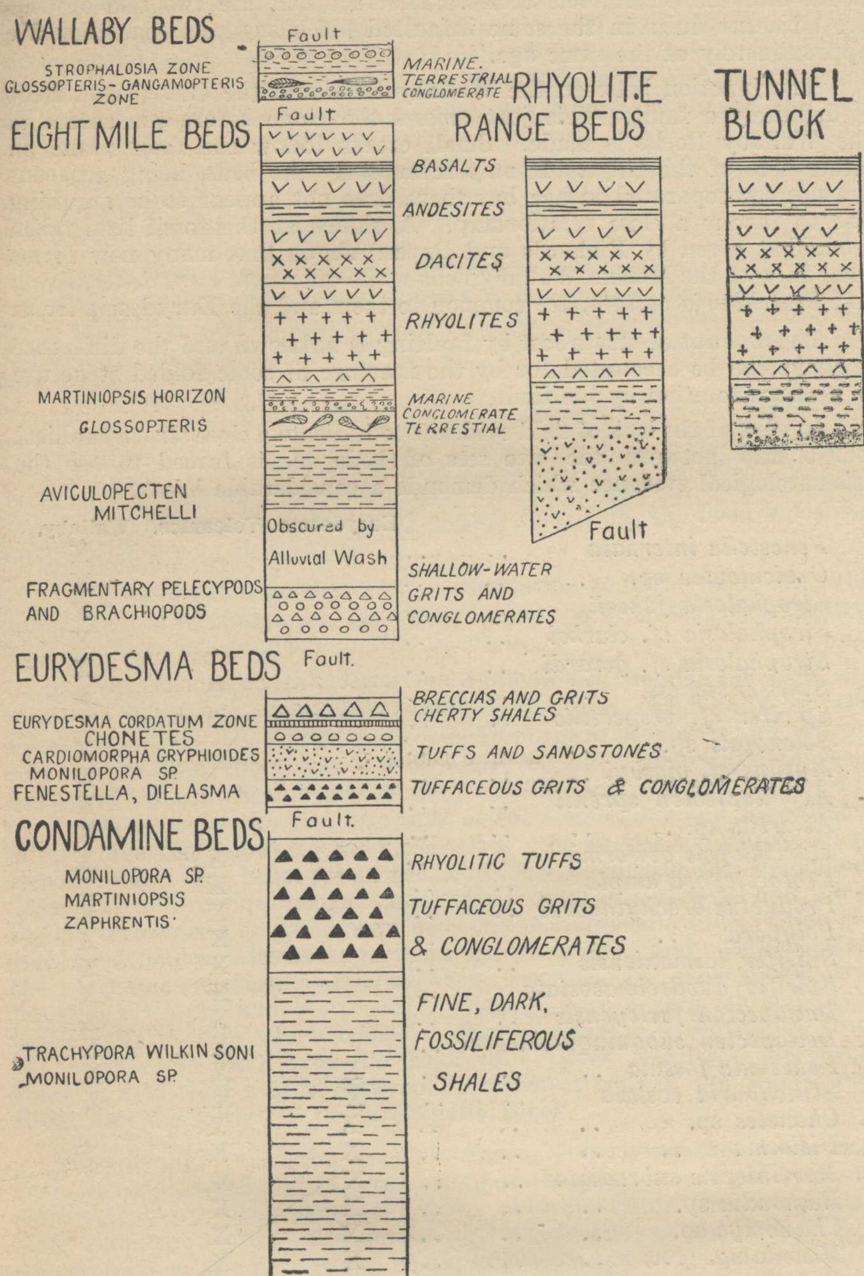
Just above the grits and tuffs of the Eurydesma Block are "brown and grey sandstones some 270 feet in thickness, for the most part, poorly fossiliferous, but containing in the upper part *Cardiomorpha gryphioides*" (R. and B., p. 69). It was in the lower section of this unit, just above the grits, that a number of specimens of *Monilopora* were found. Small Palæopectens are associated with the coral.

In view of the presence of the *Monilopora* and tuffaceous grits at the top of the Condamine beds and also at the base of the Eurydesma Beds it seems that the Condamine beds immediately underlie the Eurydesma Beds. Moreover, this is based solely upon the field evidence. Apart from this Richards and Bryan[1] and Reid[3] agree that it is unlikely that the typically Carboniferous corals, *Monilopora* and *Cladochonus,* would be present high up in the Permian.

The lowest beds of the Condamine Block are covered by Mesozoic sediments.

THE RELATIONSHIP BETWEEN THE EURYDESMA BEDS AND THE WALLABY BEDS.

Richards and Bryan[1] wrote of the Eurydesma and Wallaby Beds:— "The marked divergence in strike may represent a time gap of some importance, but on the other hand it may represent a dislocation brought


WALLABY BEDS
Fault
STROPHALOSIA ZONE
GLOSSOPTERIS-GANGAMOPTERIS ZONE
MARINE.
TERRESTRIAL
CONGLOMERATE
RHYOLITE RANGE BEDS
TUNNEL BLOCK
Fault
EIGHT MILE BEDS
BASALTS
ANDESITES
DACITES
RHYOLITES
MARTINIOPSIS HORIZON
GLOSSOPTERIS
MARINE
CONGLOMERATE
TERRESTIAL
AVICULOPECTEN MITCHELLI
Fault
Obscured by Alluvial Wash
FRAGMENTARY PELECYPODS AND BRACHIOPODS
SHALLOW-WATER GRITS AND CONGLOMERATES
EURYDESMA BEDS
Fault.
BRECCIAS AND GRITS
CHERTY SHALES
EURYDESMA CORDATUM ZONE
CHONETES
CARDIOMORPHA GRYPHIOIDES
MONILOPORA SP.
FENESTELLA, DIELASMA
TUFFS AND SANDSTONES
TUFFACEOUS GRITS & CONGLOMERATES
Fault.
CONDAMINE BEDS
MONILOPORA SP.
MARTINIOPSIS
ZAPHRENTIS
RHYOLITIC TUFFS
TUFFACEOUS GRITS
& CONGLOMERATES
TRACHYPORA WILKINSONI
MONILOPORA SP.
FINE, DARK, FOSSILIFEROUS SHALES

about by the heavy faulting which dropped the whole Stanthorpe Road Block into the Silverwood Series. The fact that the two sets of beds are adjacent units in the same infaulted block suggests that they are approximately of the same age.''

The junction between the Wallaby Beds and the Eurydesma Beds is definitely a fault. This just crosses the ridge before the ascent to the Wallaby Rocks is made. Small creeks follow the fault plane on either side of the ridge. It may seem likely the beds, being adjacent are not far separated in age but there does not appear to be anything else to favour a close relationship. A glance at the fossil lists taken from that given by Richards and Bryan[1] shows that many new forms came in with the Marine Wallaby beds while only two, *Fenestella fossula* and *Stutchburia costata,* are common to them and the Eurydesma Beds.

The amount of strata lost by faulting is unknown and the difference in strike can be accounted for by the fracture of some folded structure or perhaps rotation by the fault.

In view of the lack of field evidence to indicate a close stratigraphical relationship between the two sets of beds one is forced to use the palæontological evidence which demands a considerable break.

	Eurydesma.	**Volcanics.**	**Wallaby.**
Fenestella internata			X
Orbiculoidea sp.			X
Strophalosia jukesii			X
Strophalosia cf. clarkei			X
Strophalosia cf. gerardi			X
Spirifer stokesii			X
Spirifer cf. vespertilio			X
Solenopsis sp.			X
Mytilus cf. bigsbyi			X
Aviculoptecten sprenti			X
Astartila sp.			X
Martiniopsis oviformis		X?	X
Protoretepora ampla		X	X
Productus brachythaerus		X	X
Polypora		X	X
Spirifer tasmaniensis		X	X
Spirifer duodecimacostata ..		X	X
Deltopecten farleyensis		X	X
Deltopecten subquinquelineatus ..		X	X
Fenestella fossula	X	X	X
Stutchburia costata	X	X?	X
Chonetes sp.	X	X	
Dielasma	X	X	
Martiniopsis subradiata	X?	X	
Edmondia sp.	X	X	
Chænomya sp.	X	X	
Mæonia sp.	X	X	
Aviculopecten mitchelli	X?	X	
Cleobis	X	X?	
Platyschisma oculum		X	
Aviculoptecten squamuliferus ..		X	
Cardiomorpha cf. gryphiodies ..	X		
Eurydesma cordatum	X		

THE POSITION OF THE VOLCANIC SERIES.

The fauna of the volcanic series has an almost equal number of forms common to the Eurydesma Beds and the Wallaby Beds. It thus seems to bridge the gap between the two. Further collecting would no doubt alter this balance but the fossils so far obtained are all in favour of placing the Volcanic Series between the Eurydesma Beds and the Wallaby Beds.

At any rate, the Volcanic Series cannot be considered Upper Marine on faunal evidence. *Aviculoptecten mitchelli,* for instance, has not been recorded so far from Upper Marine Strata.

Apart from the palæontological aspect the volcanic rocks are an important consideration. Reid[3] thinks it improbable that there should be a thick series of volcanic flows on such a high Bowen horizon in Queensland as that allotted to the Silverwood occurrence by Richards and Bryan.

A correlation of the series with the Kiama volcanic rocks is not likely. Richards and Bryan[1] when suggesting that this might be so stated "while there is much evidence for considering the two series contemporaneous they are chemically and petrologically quite distinct, the Kiama Series being essentially potash-rich while the local volcanics are relatively poor in this base.

It is more probable that a close correlation could be made with the Lower Bowen volcanic rocks elsewhere in Queensland. Rhyolites, dacites, and andesites are common in this position.

It will be remembered that the tuffs in the Condamine beds are rhyolitic in composition, and I have noted some acid tuffs in the Eurydesma Beds below the *Cardiomorpha* horizon. Richards and Bryan[1] pointed out that there was a progressive change from acidic to basic lavas and tuffs in the volcanic section. If this generalization is true for the whole sequence the rhyolitic tuffs of the Condamine and Eurydesma Blocks must be below the volcanic series. As to the continuity, then, we note that the beds above the *Eurydesma* horizon are mudstones followed by "breccias and grits containing fragments of large and thick-shelled pelecypods." The lowest beds of the Eight-mile Block which are met in the field are described as "shallow-water grits and conglomerates, the former containing fragmentary remains of pelecypods and brachiopods" (R. and B., p. 63). There is here a very marked lithological relationship which makes it easy to imagine a continuity from the Eurydesma Beds into the Eight-mile Block Marines. Moreover, there is, less than a mile between the topmast beds of the Eurydesma Block and the lowest of the Eight-mile Block.

The possibility of the Volcanic Series underlying the Condamine Beds was considered and rejected owing to the great amount of evidence pointing to the position suggested above. Also the fauna cited is probably later than the corals, *Monilopora* and *Cladochonus*, and I feel that *Glossopteris,* at any rate, would be out of place a few thousand feet below these.

A REVIEW OF THE SEQUENCE.

I am inclined to the view that the only stratigraphical break of any magnitude in the Fault Block Series is that between the Volcanic Series and the Wallaby Beds. However, this does not seem very important because the only beds lost are probably lavas and tuffs. The conglomerate below the *Glossopteris-Gangamopteris* Beds looks like the base of the series. It appears that, after the extrusion of the lavas, there was a development of a fresh-water lake without an intervening marine stage.

If the conclusions arrived at are accepted, the whole sequence may be considered without referring to the field occurrence. On the evidence of the nature of the sediments and the fossils contained therein the Fault Block Series may be divided into five stages:—

(5) Shallow Water Marine.
(4) Fresh Water.
(3) Volcanic.
(2) Shallow Water Marine (with oscillations to fresh-water conditions in the upper part).
(1) Deep Water Marine.

It may be of some significance that, with the exception of the Wallaby Block, the rocks get younger to the west—the general dip being in this direction also.

With regard to the age of the beds the Wallaby Fresh Water horizon is taken to be of Greta or Lower Coal Measure age as Richards and Bryan[1] suggest. The Marine Wallaby Beds might then be equivalent to the Upper Marine of the Hunter Valley, New South Wales, while the Volcanic, Eurydesma and Condamine stages are Lower Marine.

GEOLOGICAL HISTORY.

The deep water calcareous shales of the Condamine Block were deposited well away from the shore line. Here the corals *Monilopora* and *Trachypora* flourished. Coincident with the outbreak of volcanic activity causing the formation of beds of rhyolitic tuff there was a gradual shoaling of the sea. Coarse conglomerates, grits and tuffs buried shallow water pelecypods and brachiopods. The thick-shelled *Eurydesmas* were very abundant at one period and form now a well-marked horizon in the coarse sediments.

Oscillations of the strand-line took place and fresh water *Glossopteris* shales became interbedded with marine sandstones. Great outbursts of volcanic activity ensued and after marine tuffs were laid down lavas poured over the land.

At the conclusion of the eruptions a freshwater lake developed and above a basal conglomerate *Glossopteris-Gangamopteris* shales were formed. A sea transgression gave rise to the deposition of sandstones containing abundant *Strophalosias* and Bryozoans. The new fauna was very unlike that of the marine period preceding the volcanic stage.

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THE UPPER PALAEOZOIC ROCKS AROUND BOOROOK AND DRAKE. N.S.W.

A.H.VOISEY. B.Sc.,

THE UPPER PALAEOZOIC ROCKS AROUND BOOROOK AND DRAKE.

A.H.Voisey, B.Sc.

INTRODUCTION.

The object of this paper is to describe the rocks outcropping in the Drake and Boorook Districts and to place the fossil zones in their correct relative positions in the sequence obtained.

The region is situated around the headwaters of the Clarence River in the north-eastern corner of New South Wales.

A short stay was made at Rivertree during February, 1934. Tabulam and Drake received attention during June and July of the same year. Field-work was interrupted and was not resumed until January, 1936. On this occasion the Boorook and Crooked Creek fossil beds were examined and their relationship to the Drake volcanic formations was established beyond doubt.

The sketch geological map which is submitted is not accurate in detail but serves to indicate the fossil localities and, roughly, the areas occupied by the series into which the strata have been divided. The mapping of the units within the series has necessarily been left until a later date. In this connection the remarks of Mr.E.C.Andrews (Andrews 1908) are relevant:-

"It is a difficult area to map accurately, i.e., in which to supply a connected sequence of geological events. Instead of containing several strong lines of rock junctions, whose succession in time might thus be readily grasped, it consists of a mass of insignificant and overlapping lava flows sandwiched in with which are certain fossil beds. Dense jungle growths are common which still further complicate mapping work."

Andrews, however, did map the beds around Drake and his map may be considered typical of the whole area occupied by the volcanic beds.

PREVIOUS LITERATURE.

The history of the area has been given by E.C.Andrews (1908) in his "Report on the Drake Gold and Copper Field" in 1908. He reported the discoveries of fossils and described the past mining activities. In addition he discussed the general characteristics of the ore deposits and their probable origin. This report, so far as the writer is aware, is the only record of geological field-work in the area which comes within the scope of this paper.

J.B.Jaquet (1896) reported on the Lunatic Gold-Field but did not deal with the general geology.

Many references to Drake are to be found in literature notably by Browne (1929) David (1932) Richards and Bryan (1923,1924) Sussmilch (1935) and Walkom (1913).
These writers have confined themselves to discussions based upon the work of Andrews (1908).

STRATIGRAPHY.

Summary.

The Upper Palaeozoic strata between Boorook and Tabulam are bounded by granite on the east, west and south. Both granite and sediments are overlain in places by Jurassic rocks belonging to the Clarence Series.

The older beds have been divided into two main Series, the Emu Creek Series which is, in all probability, Carboniferous in age, and the Drake Series which is probably Permian. The latter has been subdivided into a Lower and an Upper Division. The Lower consists chiefly of lavas, agglomerates and tuffs and the Upper of tuffs, mudstones, occasional lava flows, and characteristically possessing prolific fossil horizons.

Andrews (1908) observed that the Drake mudstones and tuffs (Upper Division) were younger than the volcanic beds (Lower Division) but he referred the latter to two distinct periods "an older consisting mainly of rhyolites and a younger mainly of andesites."

While no definite divisions are likely to hold throughout the area, owing to the discontinuity of most of the beds, an arbitary boundary has been fixed between the Lower and Upper Divisions. This boundary is indicated on the map and sections but it must be emphasised that it is only approximately correct. It does not mark any great change in the nature of the deposits but separates a zone which is prolific in fossil remains from one in which fossils are less numerous owing to the greater amount of volcanic material, chiefly lava, which makes up the sequence. No fossils appear to have been found in Andrews' older volcanics (lower part of Lower Division.)

The relationship between the Emu Creek Series and the Drake Series has not been established beyond doubt but the dark mudstones and tuffs belonging to the former seem to dip beneath the Drake volcanic rocks in the south-western corner of the parish of Jenny Lind and also in the northern part of the parish of Antimony. However, the outcrops are poor and insufficient time was available to determine this point important though it is. In spite of this admission of doubt, from field evidence alone, the greater age of the Emu Creek Series may be accepted with slight reservation. The palaeontology is sufficient to clinch the matter.

The northward extent of the Emu Creek Series was not investigated far beyond Emu Creek but the beds continue at least to Pretty Gully.

The following table shows the succession of beds which has been established:-

Age.	Name of Series.	Rock Types.	Estimated Thickness. In Feet	Correlation.
Recent......		Alluvium and Creek gravels.		
Jurassic....	The Clarence Series.	Conglomerates, Sandstones, and shales with fossil wood.		Walloon Series.
Permian.....	The Drake Series.			
	Upper Division.	Fossiliferous mudstones and tuffs with some lava flows in lower portion.	2000+	Silverwood Fault Block Series, and Lower Bowen Volcanics.
	Lower Division.	Lavas, Agglomerates breccias and tuffs with some fossiliferous beds.	5000+	
Carboniferous.	The Emu Creek Series.	Dark rhythmically bedded mudstones and tuffs with lighter coloured sandy beds.	Very thick but no estimate made.	Neerkol(?) Series.

CARBONIFEROUS.

The Emu Creek Series.

It must be made clear that the tuffs, sandstones, and conglomerates belonging to the Emu Creek Series are lithologically and palaeontologically quite distinct from the rocks belonging to the Drake Series and must not be confused with them. Andrews (1908) appears to have recognised this from his following remarks:-

> "The fossiliferous slates at Drake have been observed to be gently folded only. Towards Jump-Up, however, the strata possessed a vertical dip; thence to Pretty Gully the dip fell to 40°. Thus a tangential thrust from the East is suggested, unless the Drake rocks proper should be decidedly younger than the Pretty Gully Series."

The name of "Pretty Gully Series" would be retained for the Jump-Up beds only for the fact that the present writer did not visit Pretty Gully, and does not feel justified in using this name. Moreover, Andrews did not define the Pretty Gully Series further, nor did he discuss the rocks. Hence in future "Emu Series" will be the name adopted for the beds outcropping around Jump-Up Hill, and it is probable that the Pretty Gully beds could be correlated with them.

The lowest units of the series which were examined, outcrop near the junction of Kangaroo Creek and Emu Creek, and consist of dark grey indurated tuffs, fine in grain and rhythmically bedded with tuffaceous sandstones and occasional thin bands of conglomerate. All members of the series are hard and, in many places, intensely mineralised.

The fine grained tuffs grade into dark grey mudstones and all the members bear witness to the fact that they are water-sorted; the pebbles in the conglomerate bands are well rounded and water-worn. The coarser beds are generally lighter in colour than the mudstones and tuffs, and are subordinate to them.

A remarkably prolific <u>fenestellidae</u> horizon outcrops on a spur between Kangaroo Creek and Emu Creek. The whole slope is strewn with fragments of rock crammed with the polyzoans. The material is a very hard, silicified, light blue to greyish-blue mudstone, highly impregnated with pyrites throughout. Its appearance is far different from the fenestellidae mudstones of the Drake Series.

Only one specimen of <u>Spirifer striata</u> was found amongst the <u>fenestella</u> and <u>crinoid</u> stems. My attention was drawn to this horizon by Miss Dorothy Smith and Mr. Arthur Smith of Cheviot Hills Station.

Probably overlying this fenestellidae horizon by a couple of hundred feet is the Jump-Up Hill fossil horizon from which Andrews and the writer have collected a number of forms. These will be listed and discussed later.

The fossils are preserved in mudstone and fine-grained sandstone, probably somewhat tuffaceous, and are most abundant in the road cuttings ascending the hill. Many can be obtained in Jump-Up Creek. The beds are not nearly so indurated or mineralised as those in the vicinity of the fenestellidae horizon, but are nevertheless very hard. The fresh sandstone is bluish-grey in colour, but weathers to a light brown. The rocks are somewhat disturbed in the vicinity of Jump-Up Hill, but the overlying beds continue with a general westerly dip of about 60° for at least 3 miles up Emu Creek. Although faulting may have caused some duplication, there is no doubt that a great thickness of rhythmically-bedded mudstone and sandstone overlies the Jump-Up horizon.

Near the boundary of the parishes of Antimony and Callanyn, the creek exposes a peculiar agglomerate. It contains irregular fragments of fine bluish-grey tuff set in a tuffaceous matrix. This rock is inter-bedded with tuffs similar to the fragments it contains.

It is in this locality that lava flows occur and seemingly overlie the west-dipping Emu Creek beds. Although an examination was made the actual contact was not found.

PERMIAN.

- The Drake Series -

LOWER DIVISION.

The magnificent suite of volcanic rocks outcropping around Drake has been partly described by Andrews (1908). Detailed petrological work on the numerous rock types is most desirable, but the writer could not spare the large amount of time for this, so has very little to add. Andrews, in connection with this aspect of the work, writes:-

> "The lavas of the Drake District present a difficult problem as regards detailed sequence of events. They are studies in minutiae. Frequently within the limits of a ten or twenty-acre block as many as a dozen rock sub-types may be found."

He has divided the volcanic beds into two groups:

> "(a) one productive of whitish to grey felsites, purple and green lavas, tuffs and breccias and
>
> (b) a younger one, productive of blue and purple agglomerates, breccias, lavas and tuffs deposited on a sinking sea floor."

This division is upheld from a descriptive point of view, but there seems to be no need to make the break very significant. Andrews, himself, suggests that his older series may represent (1) the actual sites of small vents or (2) masses thrown out of neighbouring small vents. No evidence contributing to the problem was collected, but the detailed map given by Andrews is sufficient to show that his opinions are backed by much field-work and are worthy of consideration.

No records of fossils from the older volcanic beds have been found and this is hardly surprising, owing to their being made up of so much lava and agglomerate. Stratification is much more marked in the younger volcanic beds than in the older, and the marine fossils found in the tuffs and mudstones between lava flows and agglomerates show that most were laid down under water.

Andrews submits the following list of fossils from Drake:-

<u>Martiniopsis sub-radiata var. deltoidea</u> Eth. fil.
<u>Fenestella</u> sp.
<u>Strophalesia jukesii</u> Eth. fil.
<u>Productus undatus</u> ?
<u>Spirifer stokesi</u> Konig.
<u>Zaphrentis</u> sp.
<u>Stenopora</u> dendroid form
<u>Trachypora wilkinsoni</u> Eth. fil.
<u>Hyalostelia</u>

Entolium
Modiola
Aviculopecten sp. nov.
Orthoceras.

Knowing that most of the beds around Drake belong to the Lower Division of the Drake Series, one feels justified in considering that these fossils may be referred to as the younger volcanic portion of the sequence.

Fragmental fossil remains including *Monilopora*, *Trachypora*, *Fenestellidae*, (Crinoid Ossicles), and *Spiriferaceae* were found in the tuffs and mudstones outcropping in Girard Creek about three miles west of Cheviot Hills Station. These sediments are interbedded with most spectacular agglomerates containing angular to sub-angular blocks, chiefly of felsite lava, up to nearly two feet across.

Several thousand feet of these tuffs and agglomerates with occasional lava flows are exposed between Cheviot Hills and Crooked Creek. At the top of this succession is a unit, about 200 feet thick, which, though an agglomerate at the base, passes upwards into a green tuff resembling an andesitic lava. The gradual change in texture from fragments over a foot across to minute particles in the top-most portion may be traced.

Overlying this horizon is a mudstone bed full of *Trachypora Wilkinsoni.* This has been taken as the base of the Upper Division of the Drake Series in this locality.

Andrew's description of the Girard Creek beds is worthy of repetition:-

> "In many cases a conglomerate bed will contain numerous angular and sub-angular blocks; or again, a conglomerate mass will pass gradually into an agglomerate. Here co-mingling of two processes is evidenced - in shallow water agglomerates have been primarily thrown out, where probably the sea reduced the mass to a conglomerate; oftentimes, however, the imposition of fresh agglomerate deluges checked the process of pebble formation. Redistribution, with partial to complete rounding by waves of breccias and agglomerates intermittently discharged from volcanoes is most probably the origin of the great majority of such rock masses."

Another section of the younger volcanic beds was measured at Boorook as one ascended the hill between the ruins of the treatment plant on the Cataract River and the old Boorook township site.

(In descending order)	Approx. thickness in feet.
Trachyte and trachytic tuff	100
Agglomerate	50
Trachyte	40
Felsite and felsite breccia	100
Grey felsite	30
Felsite breccia	30
Pink felsite	40
Agglomerate	20
Green trachyte	100
Volcanic breccias and Agglomerates	200
Grey trachyte	100
	810

These are overlain by the Upper Division of the Drake Series. The Cataract River has only cut down as far as the grey trachyte so that the underlying beds are not exposed in this locality. According to Andrews, however, the Cataract flows through felsite breccias and lavas for miles downstream and the banks are high and almost impassable.

It is not possible to give a reliable figure for the thickness of the volcanic beds. A most conservative estimate, based on the section from Crooked Creek down Girard Creek to a point about two miles north-east of Cheviot Hills Station, is about 5,000 feet. The lower members of the Series have not been located definitely, though the lavas in the north-east of the parish of Antimony must be among them. It is a point of importance to determine whether the volcanic rocks are underlain by marine fossil beds and also a Glossopteris horizon as is the case at Silverwood.

PERMIAN.

The Drake Series.

The Upper Division.

Fossiliferous, mudstones, tuffs and quartzites interbedded with breccias, agglomerates and occasional lava flows follow conformably upon the main volcanic beds of the Lower Division of the Drake Series. The diminution in the amount of volcanic material and the greater development of the fossiliferous marine sediments are the characteristic features of this portion of the sequence. Eventually the volcanic beds pass into mudstones which have a thickness exceeding 1,000 feet. As the rocks overlying the mudstones were not examined, it is not known whether the vulcanism continued after the deposition of these beds.

A specimen section measured down a spur leading into Sawpit Gully, Boorook is as follows:-

(Descending Order)	Approx. thickness in Feet.
Massive dark-grey mudstones	1,000
Fossiliferous mudstones (Zone "D")	200
Felsite lava	20
Coarse tuffs and breccias	100
Mudstones and cherts (Zone "C")	100
Felsite breccias and coarse tuffs	100
Coarse breccia	10
Coarse tuffs with quartzite bands (Zone "B")	100
Fenestellidae mudstone (Zone "A")	30
Agglomerate	10
Fenestellidae mudstone (Zone "A")	50
Breccias and coarse tuffs	100
	1,820

The above thicknesses are approximate only and the units vary greatly throughout the district. The fossils collected from each bed will be given, but it is probable that most of the forms range throughout the above thickness. Collecting could only be carried on for a very short time, and numerous additions will be made to the lists given when further work is done.

Immediately overlying the breccias and tuffs which form the basal unit of the above section is a band of calcareous mudstone crammed with fossils chiefly fenestellidae and crinoids. This is Zone "A", and contains Zaphrentis sp., Martiniopsis subradiata and Spirifer sp., (F36370-1 Australian Museum Collection) Trachypora wilkinsoni and Morilopora cf. nicholsoni appear to occur low down in the Upper Division in the Crooked Creek locality, but the sequence was not examined in any detail there.

The fenestellidae mudstone is bluish-grey in colour when fresh, and is very tough. During decomposition it becomes buff-coloured and friable. The rock is made up of layers of fossils alternating with sediment. Weathering gives a concertina-like appearance to the outcropping blocks.

An Agglomerate with included rock fragments up to two inches across, splits the Fenestellidae mudstone and the overlying bed is similar to that below, (Zone "A").

Fossils are present, even in the coarse tuffs which follow, but, in the main, are fragmental, except in the quartzite and mudstone bands which are interbedded with them. They are mainly pectens and these are so numerous that, in places, the quartzite is entirely made up of shells which have been replaced by silica. They include Deltopecten subquinquelineatus McCoy sp., Aviculopecten, Sprenti, Johnston, and Aviculopecten englehardti, Etheridge and Dun. Fenestella sp., Protoretepora ampla, Lonsdale ? and crinoid stems are also present in Zone "B". (Specimens F36367-9, Australian Museum Collection).

Felsite breccias and tuffs overlie the pecten horizon and then comes a most prolific fossil bed which is a calcareous mudstone (Zone "C").

The fauna from here are as follows:-

Aviculopecten englehardti Eth. and Dun
Aviculopecten cf.flexicostatus. Mitchell
Aviculopecten sp.
Productus (?) brachythaerus
Taeniothyris subquadrata
Crinoid Stems
Zaphrentis sp.
Fenestella sp.
Stenopora tasmaniensis Lonsd. (?)
Myonia carinata Morris
Myonia (?) corrugata Fletcher.
Martiniopsis subradiata
Strophalosia cf. gerardi King ?
Strophalosia cf. jukesi Eth.

(Specimens F36344 - F36366 Australian Museum Collection).

Strophalosia is one of the most common fossils in this zone and certain sections of the beds are made up almost entirely of this shell. In some parts the dendroid Stenopora is dominant and in others, Fenestella.

Coarse tuffs with fragmental fossils follow, and above these a felsite lava flow outcrops.

On top of the felsite is a calcareous mudstone band (Zone "D") containing:-

Monilopora cf. nicholsoni Eth.
Trachypora wilkinsoni Eth. fil.
Crinoid stems
Fenestella sp.
Astartila sp.
Calyx plate of crinoid (Cyathocrinus ?)
Strophalosia gerardi

(Specimens F. 36329-31, F.36335-43 Australian Museum Collection).

The two corals are most numerous and they were used for tracing the bed along the ridge for about a mile as they could be seen from a distance in the fragments of rock which strewed the surface. The lowest 200 feet of the mudstone, which makes up the rest of the section, contain numerous fossils, mainly the corals, but the higher beds are practically devoid of them - only a few crinoid ossicles being found. The mudstone becomes less calcareous and more massive and compact. It is a dull black in colour and very fine grained, for the most part, but is slightly more sandy in its lower portions. This sandy rock is lighter in colour, but has a blotchy appearance owing to the presence of dark irregularly shaped inclusions. After several hundred feet, through which there is some variety in texture and colour, the mudstone becomes more uniform and devoid of lamination and bedding planes. It is rather cherty and some harder parts give rise to falls in the creeks running west from the hills, but generally outcrops are poor. The beds are easily traced because they decompose to a characteristic yellow soil containing fragments of the crumbling rock.

This mudstone represents a complete change in the nature of the sedimentation. All through the underlying beds volcanic material is the main component right to the lowest part of the Drake Series that was examined. There is no important structural break, however, as the tuffs may be seen to pass upwards into the mudstone and fossils similar to those in the tuffs ascend well into the unit.

Fossils have been obtained in the hills bordering the granite for several miles north of Boorook. They also occur on the eastern side of the Cataract River and at Red Rock where Mr. E. C. Andrews collected Aviculopecten englehardti. Between Crooked Creek and the Stock-route, the following forms were obtained:-

Crinoid stems (Phialocrinus (?))
Trachypora Wilkinsoni Eth. fil.
Zaphrentis gregoriana De Kon
Monilopora cf. nicholsoni Eth.
Cladochorus cf. tenuicollis McCoy
Aviculopecten englehardti Eth. and Dun.
Fenestella sp.
Spirifer sp.

(Specimens F36324-8 Australian Museum Collection).

These come from similar beds to those at Boorook as described above. Andrews (1908) records these additional types from somewhere along Crooked Creek:-

Internal and external casts of:-

Stenopora (small dendroid form).
Fenestella fossula.
Fenestella internata
Fenestella sp.
Protoretepora n.sp.
Penniretepora grandis.
Hyalostelia.
Productus subquadratus.
Martiniopsis sub-radiata.
Spirifer vespertilio.
Aviculopecten squamuliferous Morris.
Aviculopecten elongatus McCoy. De Kon.
Stutchburia compressa Morris?

These fossiliferous beds undoubtedly continue for many miles to the north into the Rivertree District. It will be interesting to see whether the Eurydesma cordata recorded by Andrews from that locality comes from strata which can be correlated with some part of them.

PLUMBAGO CREEK SERIES.

Limestone, interbedded with hard slates and cherts, outcrops beside Plumbago Creek just north of the point where the main road between Tabulam and Drake crosses the stream.

The general strike of the series is north-north-west and the dip is west-south-west at about 60°. The invading granite cuts obliquely across the strike.

The limestone has been marmorised by the adjacent granite and no fossil remains were identified from it. The other sediments have been converted to hornfelses in places and are hardened elsewhere. Black slates contain fossils resembling *Pachydomus* but these could not be definitely determined. Breccias and tuffs related to those found around Drake are present, so it is probable that the Plumbago Creek Series will be related in some way to the Drake Series. It has been kept separate because no limestone was found anywhere else and the northward extensions of it and the associated rocks were not followed far enough to connect them with any known beds.

JURASSIC.

THE CLARENCE SERIES (WALLOON ?)

The Clarence Series between Tabulam and Casino consists of conglomerates, grits, sandstones and shales with plant remains. A basal conglomerate is well exposed by the road cuttings just west of Tabulam Bridge. The water-worn pebbles are arranged in lenticular bands in sandstones and grits. Much of the material may be identified as it has been derived from the Upper Palaeozoic rocks.

The beds appear to be estuarine in origin. This belief is strengthened by the fact that numerous fossil tree trunks were found in the overlying sandstones and grits to the east of Tabulam. Their occurrence is reminiscent of those at Warwick, Queensland, and it is possible that both are on the same horizon.

The age of the series is probably Jurassic and equivalent to the Walloon Series of Queensland. There has been an overlap of these beds on the lower members of the Mesozoic suite. (David 1932).

Intrusive Rocks.

THE GRANITES.

The accompanying map shows that the Upper Palaeozoic rocks have granite intruding them both to the east and west of Drake. The eastern mass is overlain by the Clarence Series, but the western forms the high plateaus of New England.

The granite makes poor outcrops around Boorook station and only the aplitic dykes which traverse the main rock were examined. One such dyke is found near the station yards.

Over twenty different phases of the granite were collected from the Stanthorpe and Rivertree Districts (D.R. 3339 to D.R. 3358).

Further details with regard to the New England Granites see Andrews (1903).

PALAEONTOLOGY.

Emu Creek Series.

Andrews (1908) records the following fossils from Jump Up Hill:

Strophalosia sp. ind.
Productus subquadratus.
+ Spirifer cf. lata McCoy.
Spirifer sp. nov.
Spirifer cf. strzlecki.
+ Reticularia cf. lineata.
+ Fenestellidae.
Aviculopecten cf. mitchelli Eth. fil. and Dun.

(+ Carboniferous type).

The above were considered by Mr. W. S. Dun to be a mixture of Upper and Lower Marine forms.

The writer collected two sets of fossils one being given to the Australian Museum and the other to Sydney University. From the first Mr. Fletcher has identified the following forms:-

Cladochonus tenuicollis McCoy?
Strophalosia gerardi King (?)
Spirifer striata.
Spirifer pinguis ?
Spirifer vespertilio.
Reticularia lineata.
Fenestella sp.
Stutchburia cf. compressa.
Aviculopecten ptychotis McCoy sp.
Aviculopecten cf. pincombei Mitchell.
Aviculopecten sp.
Phillipsia collinsi Mitchell.
Crinoid stems.

(Specimens registered F 36372 - F 36379 Australian Museum Collection).

Mr. Fletcher adds the following note:

"In the Jump Up Hill beds, two pygidia and a thorax of Phillipsia cf. collinsi, Mitchell, were identified, with Spirifer striata and Spirifer pinguis. These are Carboniferous forms and when taken with the Carboniferous types recorded by Mr. E. C. Andrews, it would appear that the facies of the Jump Up Hill beds would be rather Carboniferous than Permian. In the same beds Stutchburia compressa is found, but this genus probably extends into the Carboniferous. Aviculopecten ptychotis is also a Carboniferous species."

From the second collection Dr. Ida Brown recognised the Phillipsia and Cladochonus tenuicollis as Carboniferous forms and showed the collection to Dr. F. W. Whitehouse who has kindly supplied this information:-

The fossils belong to "a fauna equivalent to that found in the Neerkol Series of Queensland. From that fauna few species have been described. The types of spiriferids productids and fenestellidae agree well with the Queensland types.

"In the collection the following genera are represented:-

Cladochonus, Fenestella, Pustula, Spiriferina "Spirifer" (spp. nult.), Schizophoria, Retzia (?), Modiomorpha, Aviculopecten and Phillipsia.

"The Neerkol Series is known in Queensland at Stanwell, Cannindah and Mt. Barney."

He is also of the opinion that the fauna is newer than the Amygdalophyllum horizon.

It is generally agreed, therefore, that the Jump Up Hill horizon is of Carboniferous age. Mr. Dun's view that the beds were Permo-Carboniferous was probably influenced by the collections from adjacent areas occupied by the Drake Series.

Exact correlation of the Emu Creek Series with other areas will have to be made later by those acquainted with the Queensland Carboniferous beds. The writer has held the view that it might be Neerkol and this has been strengthened considerably by Dr. Whitehouse's remarks.

J. H. Reid (1930) advocated an Upper Carboniferous age for the Jump Up Hill beds on the evidence of the fossils collected by Andrews. It is hoped that the additional forms which have been collected will be of assistance in the determination of the exact age of the Series.

Though fenestellidae zones are not uncommon in Carboniferous and Permian areas the presence of the prolific band near Jump Up Hill further strengthens the case for a correlation with the Neerkol beds.

The writer is still opposed to the inclusion of any part of the Kempsey or Silverwood beds in the Neerkol and consequently cannot agree to placing any of the beds belonging to the Drake Series there. (Voisey (1934a, 1935))

- D R A K E   S E R I E S -

Taken as a whole the fossil fauna of the Drake Series is as follows:-

Cladochonus cf. tenuicollis McCoy.
Trachypora wilkinsoni Eth. fil.
Monilopora cf. nicholsoni Eth.
Zaphrentis gregoriana De Kon.
Cyathocrinus (?)
Phialocrinus (?)
Protoretepora ampla Lonsdale ?
Fenestella sp.
Stenopora tasmaniensis Lonsdale ?
Strophalosia gerardi.
Strophalosia cf. jukesi King?
Martiniopsis sub-radiata var. deltoidea Eth. fil.
Spirifer spp. mult.
Spirifer stokesi Konig.
Productus undatus ?
Taenothaeris subquadrata.
Productus brachythaerus.
Myonia carinata Morris.
Myonia (?) corrugata Fletcher.
Astartila sp.
Deltopecten subquinquelineatus McCoy sp.
Aviculopecten sprenti Johnston.
" englehardti Eth. and Dun.
Aviculopecten cf. flexicostatus Mitchell.
Hyalostelia.
Entolium.
Modiola.
Orthoceras.

All these forms were found in or above the volcanic rocks so must be above the Glossopteris horizon which occurs below the Volcanic Beds at Silverwood if correlation between the lavas is accepted.

Conclusive proof of the existence of prolific Monilopora cf. nicholsoni and Trachypora wilkinsoni beds at the top of the Series definitely overlying the volcanic beds. ~~This~~ has an important bearing on the relative order of arrangement of the Silverwood fault-blocks. (Richards and Bryan 1924, Reid 1930, Voisey 1935).

It is unfortunate that a Eurydesma cordata horizon was not found in the Boorook-Drake Districts, but if the views of the writer are correct this should be discovered below the Volcanic Series (Voisey 1935).

In a broad sense the Silverwood Fault Block Series, the Drake Series and the Macleay Series are correlated with one another and all are considered to be Lower Permain in age.

STRUCTURAL GEOLOGY.

The Upper Palaeozoic strata are generally horizontally disposed or slightly undulating between the western granite and Drake, but between Drake and Tabulam, they have been folded and faulted. In the case of the Drake Series near Tea-Tree Creek, a vertical position has been attained. At the bridge where the road crosses the Creek, the unconformable junction of an outlier of the Clarence Series with the volcanic beds may be seen.

The folding has been roughly in a north-north-west, south-south-east axis.

The old Boorook township site is in the core of a syncline which pitches towards the north. This is a very gentle fold. The beds on the limbs of the syncline dip into the hill at angles generally about 5°. The northward pitch is demonstrated by the outcrop of the mudstones. This is roughly V-shaped, widening to the north.

Everywhere that rocks belonging to the Emu Creek Series have been seen they are steeply folded but this may be because the disturbed zone happens to include them. Nevertheless the conformity of the Emu Creek Series, and Drake Series is open to doubt.

Going westward from Jump-Up Hill along Emu Creek the beds dip west at angles between 40° and 60°, but here and there they are badly faulted.

A parallel might be drawn between the Drake and Kempsey Districts. In both cases there are areas of intense folding of Upper Palaeozoic beds to the east and gently folded beds to the west. It seems that pressure came from an easterly direction. The marginal beds yielded to the force, and, by collpasing, allowed it to expend itself on them, thus protecting the strata to the west.

The New England granite was intruded into the Drake rocks after the folding had taken place. It is seen to cut across the strike of the beds. This was some time before the Jurassic sediments were deposited, for these rest upon planed down granite surfaces. That the diastrophism occurred between Middle Permian and Jurassic times is thus proved, but in all probability, it marked the close of the Palaeozoic Era. (David 1932). || Richards and Bryan (1924) offered the suggestion that the "Permo-Carboniferous" fossils collected in the Drake District might have been obtained from isolated fault blocks let down into Devonian strata, the structures then resembling those at Silverwood. However, no rocks remotely related to the Silverwood Series (Devonian) were found in the area examined and the volcanic units were found to be continuous for many miles.

N.P.

The sediments belonging to the Clarence Series used to cover a much greater area west of their present boundary, but they have been removed by erosion. An outlier at Kettle's Lift remains, and this is being worn away rapidly.

The beds dip easterly at a very low angle and form the western rim of the Clarence Basin.

PHYSIOGRAPHY.

Boorook and Drake are situated on the eastern fall of the New England Tableland near the head waters of the Clarence River.

The Cataract River collects Boorook Creek, Crooked Creek, and numerous tributaries as it flows northward from Sandy Hills to Rivertree where it joins the main stream. The Clarence turns southward and eventually reaches Tabulam where it collects the drainage from Drake by means of Plumbago Creek and the Timbarra River.

The dissection which has occurred may be judged by the steep fall of the country from Tenterfield just west of the Main Divide to Tabulam. The heights are as follows:-

Tenterfield	2831 feet.
Drake	1650 " .
Tabulam	410 " .

Between Tenterfield and Boorook high granite hills rise to over 3,000 feet and continue northwards as the Boonoo Boonoo Heights. East of Boorook Station the creek falls into the Cataract which flows through narrow gorges carved out of the resistant lavas of the Drake Series. Both this river and its tributary, Crooked Creek are aptly named. Travelling is slow through this region, but access may be had by means of tracks which follow the more gentle spurs.

The response of the sub-horizontal rocks to rapid erosion is the main feature of the physiography as both the Clarence Series and the Drake Series, (in part) may be studied in this connection. The Clarence Series occupies the lower regions and cliffs are formed where the hard sandstone beds alternate with softer slates. These are common on all sides, but the east, as the dip of the units in this direction is sufficient to give rise to a dip-slope. As a great deal of the country has been cleared, these sandstone bluffs make conspicuous features as they rise above the undulating grassy areas and usually have a number of trees remaining on them. Sometimes two bands may be seen in the one hill.

The big differences in resistance to erosion between the lavas and sediments of the Drake Series has led to the development of benches round the hills.

As the streams have cut down into the Lower Division, the fossiliferous beds of the Upper Division occupy the ridges between the valleys. The natural contouring of the highlands by means of these resistant bands is somewhat obscured by the thick vegetation. Along the stock-route between Sandy Hills and Drake, one goes from terrace to terrace. On some of these terraces, outliers of the overlying bed form small hills. One unit in particular, an agglomerate from the top of the Lower Division of the Drake Series gives rise to such outliers as it is underlain by a resistant tuff band.

Between Cheviot Hills and Emu Creek the topography is neither so interesting nor its evolution so clear. Outcrops are poor and in the north the rocks are similar in type and dip steeply. Here deep gullies, tending to conform with the strike, lead into the main creek and the spurs fall steeply, but uniformly, into them.

In the south-eastern corner of the area the old granite surface upon which the Clarence Series was laid down has been re-exposed during recent times and the streams are at work cutting downwards into it.

The sequence of events leading up to the formation of the present topography is similar to that of the whole coastal region and the matter has been discussed elsewhere. (Craft 1933, etc., Andrews, 1903, Voisey, 1934).

GEOLOGICAL HISTORY.

Marine mudstones, sandstones and conglomerates were deposited, during Carboniferous times, in a sea which had its location in the position now described as north-eastern New South Wales. Rhythmic deposition was a characteristic feature of this thick series of rocks.

With the beginning of Permian times, vulcanism broke out and volcanoes were situated in the region about Drake and poured lavas over the sea floor. Tuffs and mudstones were laid down between the lava flows and in these sediments the remains of sea animals were preserved. Eventually the activity of the volcanoes declined and a thick deposit of mudstone was spread over the sea floor.

Pressure from the east affected the sediments some of which yielded under the strain, fracturing and folding taking place in some areas; but the western portions were protected and remained practically horizontal. The invasion of the rocks by granite followed with metamorphism of them and the introduction of the auriferous, cupriferous and argentiferous quartz reefs. Uplift and subsequent erosion led to the exposure of the granite and the reduction of the area to comparatively level country over which the sea transgressed during Jurassic times. Fresh-water conglomerates, sandstones and shales were laid down and among them were preserved the logs and plant remains washed in by the rivers.

Eventually the sea receded and uplift brought the Clarence Series under the influence of erosive forces which reduced Eastern Australia practically to sea level, leaving only a low divide. Basalts were poured out over this surface. Uplift occurred at the end of the Tertiary Era and subsequent erosion has led to the development of the present day topography.

CONCLUSION.

The most outstanding results obtained from the field-work in the Drake and Boorook districts are as follows:-

(1) The Drake volcanic beds were separated from the Jump Up Hill beds and the basis for such separation has been given.

(2) Suites of fossils were collected from each series and arranged in their correct stratigraphical positions.

(3) The relationship between the Boorook and Drake rocks was determined beyond doubt.

(4) An extraordinarily rich zone of Trachypora wilkinsoni and Monilopora cf. nicholsoni was proved definitely to overlie the volcanic beds of the Drake Series. This has an important bearing upon Queensland stratigraphy.

It is hoped that the data collected will be useful to palaeontologists and to future workers in a most fascinating locality.

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I desire to thank Dr. Ida Brown of Sydney University, Mr. Fletcher of the Australian Museum and Dr. F. W. Whitehouse of Queensland for their notes upon the fossils. I am indebted also to Messrs. Hodge-Smith and Chalmers for their capable work in cataloguing the material which I have given to the Australian Museum.

Geological work at Drake, Boorook and Tabulam has always been a pleasure - largely because of the help and hospitality given to me by numerous residents. My grateful thanks are due to them and especially to the following:- Mr. and Mrs. Arthur Smith of Cheviot Hills, Mr. and Mrs. Clarence Smith of Boorook, Mr. and Mrs. Hunter Smith of Drake, Mr. G. Purvis Smith of Sandy Hills, Rev. Schmitzer and Mr. and Mrs. Fergusson of Tabulam.

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THE NEW SOUTH WALES

UPPER PALAEOZOIC SUCCESSION.

A.H.Voisey, B.Sc.

T H E

NEW SOUTH WALES

- UPPER PALAEOZOIC SUCCESSION.-

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INTRODUCTION.

The Upper Palaeozoic Succession in New South Wales is generally very well known, but there are certain aspects which have given rise to a great deal of discussion for many years. This paper has been inspired by one written by J.H. Reid entitled, "The Queensland Upper Palaeozoic Succession" (1930b)*. It will refer in detail only to the controversial points.

Field-work has been carried out intermittently by the author since 1928, chiefly on the North Coast of New South Wales, between the Hastings River and the Queensland border. His acquaintance with the Hunter Valley rocks was ~~had~~ gained mainly through participation in field excursions held by the Department of Geology of the University of Sydney. This was supplemented later by field-work around Maitland and Greta.

Under the able guidance of Mr. S. W. Carey, a tour of the Tamworth-Currabubula Districts was made during 1934, and the principal geological features were examined.

Early in 1934, field-work was done at Silverwood and in the Stanthorpe District with a view to correlating the New South Wales and Queensland Carboniferous and Permian beds.

It is regretted that investigations could not be carried out in the Manning River District and at Vegetable Creek, N.S.W. These areas remain comparatively unknown, although it is believed that some of the deposits will be connected up with the known beds in the Macleay River and Drake respectively.

The results of the investigations carried out by the writer in North-eastern New South Wales make it necessary to discuss some of the statements of Mr. J.H. Reid (1930b), who, in his compilation, was forced to draw upon work of an admittedly preliminary nature. It is not surprising that more detailed work has led to the need for some adjustments in the relative positions of the beds. The writer is indebted to Mr. Reid for his stimulating treatment of a most interesting problem.

GENERAL.

Following Reid, (1930b), the Upper Palaeozoic rocks are defined as those between Middle Devonian and the end of Permian times.

Within that period in N.S.W., David (1932), recognised the following Series:-

Upper Permian.	Upper Coal Measures.
Middle Permian.	Upper Marine Series.
Lower Permian. -	(Lower Coal measures. (Lower Marine Series (in part)
Upper Carboniferous -	(Lower Marine Series (in part) (Kuttung Series (upper part).
Lower Carboniferous -	(Kuttung Series (lower part) (Burindi Series. (Barraba Series (upper part).
Upper Devonian. -	(Barraba Series (lower part). (Baldwin Agglomerates.

He included all the Drake and Kempsey beds in the Lower Marine and considered them to be Upper Carboniferous. He was followed by Sussmilch (1935) in this regard although it was admitted in an addenda to David's book (1932), that the slender evidence used for putting the beds into the carboniferous had been invalidated by the discovery that the so-called, Paralegoceras of Western Australia was really Metalogoceras "a genus not known outside the Permian."

David placed the Neerkol Series of Queensland as late Lower Carboniferous and possibly contemporaneous with the oldest part of the Kuttung Series of New South Wales. Reid (1930b) had correlated the Drake, Vegetable Creek, and Kempsey beds (in part) with the Neerkol which would on David's time scale make them the equivalents of the Kuttung Series in part at all events. This could not be upheld in the case of the Kempsey beds for the writer found them overlying the equivalents of the Kuttung Series at Yessabah. Subsequent work (Voisey 1936), led to the division of the Drake and Boorook rocks into two parts, the Drake series and the Emu Creek Series. Correlation of the Fault-Block Series (Silverwood Qld.); the Drake Series, and the Macleay Series, with the Lower Marine of the Hunter River District became desirable.

The Emu Creek Series, which takes in the locality, Jump Up Hill, where Andrews (1908) collected his Carboniferous fossils, is older than Lower Marine and underlies the Drake Series. The Kuttung Series is absent here as in Southern Queensland. Although the fauna contains some Lower Carboniferous representatives many typical Burindi forms are absent. It must therefore be considered Middle to Upper Carboniferous and as such is comparable to the Neerkol Series of Queensland. Dr. Whitehouse (verbal communication), considers the faunas to be identical.

In the Hunter River District, the Kuttung Series conformably overlies the marine Burindi Series. Beneath the Burindi in the Tamworth-Werris Creek area comes the Barraba. Carey (1934), remarks that no disconformity could be recognised between these two series; in fact the zone of passage had been only arbitarily fixed. The similarity between them makes separation a matter of slight importance for the presence of a long time break which could have such far-reaching possibilities as that between the Kuttung and the Kamilaroi Series is unlikely.

It is proposed for the purposes of this paper to assign the respective series of Queensland and New South Wales to the geological periods as follows:-

	New South Wales.		Queensland.
Upper Permian.	Upper Coal Measures.		Upper Bowen Series.
Middle Permian.	Upper Marine Series. and Lower Coal Measures.		Middle Bowen Series.
Lower Permian.	Lower Marine Series.		Lower Bowen Series.
	Hunter River	Drake.	
Upper Carboniferous.	Time Break and Kuttung Series (in part).		Dinner Creek Series.
Middle Carboniferous.	Kuttung Series.	Emu Creek Series.	Neerkol Series
Lower Carboniferous.	Burindi Series.		Rockhampton Series.

The above arrangement brings up two important questions - (a) What is the extent of the break between the Kuttung Series and the Lower Marine Series? and (b) What is the exact age of the Emu Creek Series?

If the time break between the Kuttung and Lower Marine is small, then either the Kuttung Series is Upper Carboniferous, in spite of the views of palaeontologists or the Lower Marine Series extends downwards into the Carboniferous as proposed by David. Neither of those alternatives is ~~very~~ readily acceptable so that the best procedure appears to be to accept the time break. Some of the Lower Marine beds are definitely unconformable with the Kuttung in the Hunter Valley (Sussmilch and David 1920) and the possibility of a time break in the Macleay District exists though no apparent unconformity was found. In the Currabubula District the Lower Coal Measures rest conformably upon the Kuttung beds (Carey 1934). In this case there is no evidence to indicate a big time break yet we know the Lower Marine Series is missing. Whether this time break is represented by marine beds in Queensland the writer is unable to say but he cannot agree to putting any members of the Silverwood Fault-Block Series, Drake Series or Macleay Series into this position. The Emu Creek Series may belong there but as its fauna seems to be more related to the Neerkol Series than the Drake Series it cannot be so placed with safety.

ie between L. marine + Kuttung?

The Hunter River District.

This is by far the best known of the Carboniferous and Permian areas in Australia and is one in which a great deal of work has been done. Owing to the efforts of David (1907,1920) Walkom (1911,1913a, 1913b), Browne (1911, 1924) Sussmilch (1920,1921), Dun (1924), and Osborne (1921 etc.) the sequence has been determined beyond doubt and the fossils have been zoned.

Nevertheless this district has given rise to a great deal of controversy. The differences in opinion which have arisen over one critical point have been outlined by Sussmilch (1935).

This question will now be discussed more fully.

The freshwater Kuttung Series, the age of which is considered to be Middle to Upper Carboniferous is overlain by marine beds belonging to what has been termed the Lower Marine Series. (David 1907; Walkom 1913). The question arises as to whether the Lower Series is wholly Permian in age or partly Upper Carboniferous.

The lowest beds of the Lower Marine Series are the Lochinvar Shales which contain glacially striated pebbles. Walkom (1913, P. 116) states that in places, they are distinctly unconformable with the underlying beds. Browne and Dun (1924, P.203) consider that "there is no warrant for affirming or denying the existence of such an unconformity." They add, however, "but, in any case, the absence of an angular unconformity is surely of little stratigraphical moment, seeing that there is evidence of a change from freshwater to marine conditions and a very marked life-break in passing upwards from the Kuttung to the Permo Carboniferous strata."

The Lochinvar shales only form the base of the Lower Marine Series in certain places notably between Gosforth and Lochinvar, but, at Eelah, they are overlapped by the higher members and coarse conglomerates and sandstones are the basal beds. (Walkom 1913, P.117).

Further overlap has brought the Harper's Hill Horizon into contact with the Kuttung volcanic beds at Mount Bright near Pokolbin and it is stated that there is a strong angular unconformity between these two horizons at the above locality (Sussmilch and David 1920). The strata between the Harper's Hill horizon which contains Eurydesma cordata and the Lochinvar Shales were considered to be Upper Carboniferous in age by Sussmilch and David (1920).

The reasons for such a belief are given by Sussmilch (1935) P.104 but none of these seem to carry much weight. In the first place, the Eurydesma horizon (Harper's Hill) though found in many places outside the Hunter River District, is nowhere else the basal bed. In the second place, the possible palaeontological break indicated by the absence of Strophalosia Clarkei is surely not comparable with the break from fresh-water to marine conditions such as occurs betwee the Lochinvar Shales and the Kuttung beds.

David (1932, P.61) limits the Carboniferous to the main horizon of the coral Monilopora nicholsoni and Cladschonus, a horizon which is associated with a cephalopod which was alleged to be Paralegocera jacksoni was really Metalegoceras, " a genus not known outside the Permian." This favoured the placing of the whole of the Kamilaroi

Series in the Permian.

The writer is opposed to correlation between Western Australian and Eastern Australian beds especially on a single form (Monilopora cf. nicholsoni) which has a number of variations and whose range is not known. Moreover this coral has not been found in the Hunter River District. In addition to these objections the value of the Eurydesma cordata bed as a datum horizon has yet to be proved. An examination of the sequences at Kempsey (Voisey 1934,1936), Springsure (Reid 1930a) shows that, in the first case, Monilopora and Trachypora are best developed above the Eurydesma cordatum and in the second the coral zone is well above and also below. At Drake and Silverwood it is probable that there is even more variation in the relative positions. It means that no reliance can be placed on the coral zone or perhaps none on the Eurydesma zone while the possibility exists that neither is restricted to one position throughout Eastern Australia. It is believed by the writer that both the Eurydesma cordatum zone and the main developments of the associated corals are restricted to the Lower Marine, but that the relative positions may vary.

Indeed the evidence for dividing the Lower Marine Series into a Permian Section and an Upper Carboniferous Section is not supported either by evidence supplied either by the Hunter River District nor any other that the writer has examined. The comparison of the fauna with that of areas outside Australia has been inconclusive, and has not favoured an Upper Carboniferous Age for any part of the beds under examination.

As the Hunter River District is the only one in which a detailed sequence of rocks and the fossils contained has been available, it has always been used for the purposes of comparison with other areas. It will be so used in this paper but will be considered to be Permian throughout.

B. Macleay River District.

The history of geological work in the Macleay District has been given elsewhere (Voisey 1934). Marine fossils were described by L.G.De Koninck (1898) and W.S.Dun (1898) but the main field-work done before 1928 was that by W.G.Woolnough (1911). The presence of the purple Tait's Creek Glacial Beds which Woolnough correlated with the Lochinvar Shales and the fact that these were overlain by limestone containing Eurydesma cordata and Monilopora became known but details of the underlying and overlying beds remained obscure. So little was known that J.H.Reid (1930b) suggested that the bedded tuffs below the Tait's Creek Glacial Beds might belong to an Upper Carboniferous marine sequence. These have since been found to be the equivalents of the Kuttung Series. (Voisey 1934).

On the strength of the Eurydesma horizon and the glacials the rocks were accepted by Sir. T.W.E.David as belonging to the Lower Marine Series and some were placed in the Upper Carboniferous. (David 1932).

In a preliminary paper published in 1934 the writer gave an account of the geology of the Middle North Coast District (Voisey 1934) and showed that there was present a sequence ranging at least from Lower Carboniferous to Middle Permian and corresponding to the Burindi, Kuttung and Lower Marine Series of the Hunter River. Devonian rocks occur to the south but were not examined in detail. A fuller treatment of the Yessabah District has just been prepared. (Voisey 1936a)

C.A.Sussmilch (1935) has given a summary of the Carboniferous rocks and includes Springsure, Silverwood, Vegetable Creek, Macleay River and Lochinvar. The correlation, with the possible exception of Vegetable Creek, is endorsed but as mentioned previously all these beds are considered to be Permian.

An examination of the nature of the succession in the Macleay District will show how impossible it is to separate any two adjacent beds between the Eurydesma horizon and the Tait's Creek glacial beds. Each unit is intimately related to its neighbour and there is no marked faunal division as a glance at the accompanying fossil lists will show. Yet, in order to place the beds below the Eurydesma horizon in the Upper Carboniferous and effect a correlation with the Harper's Hill horizon which overlaps the other beds Sussmilch is forced to make such a division.

To carry this idea further one must place all the beds ~~below~~ belonging to the Dilly stage at Springsure in the Carboniferous or else just take those below the Lower Monilopora horizon in the coral stage. (see Reid 1930a). Indeed the attempt to separate any of the sequences which have been correlated with the Lower Marine Series of the Hunter Valley, becomes ridiculous.

C. Silverwood - Lucky Valley Area, Qld.

Richards and Bryan (1923 and 1924) have been the principal investigators of the Silverwood-Lucky Valley Area near Warwick, Qld. and had the difficult task of arranging the members belonging to a number of isolated fault blocks in their stratigraphical positions They placed a series of volcanic rocks with interbedded fossiliferous marine sediments above fresh-water beds containing Glossopteris and Gangamopteris which were overlain by marine beds containing Strophalosia and a number of other forms. A third block containing marine sediments among which was a zone containing Monilopora cf nicholsoni and Trachypora wilkinsoni was correlated with the volcanic beds. All the beds were considered to be of Upper Marine age with the exception of the gangamopteris-glossopteris beds which were regarded as Greta.

The strata occupying another block were placed in the Lower Marine ~~on the strength~~ because of a prolific Eurydesma cordatum horizon.

Richards and Bryan (1923) on the strength of their correlations refused to correlate the Silverwood volcanic suite with that at Drake in spite of the resemblance because Andrews' fossils indicated a Lower Marine age.

Reid (1930b. P.40) pointed out that the assumptions upon which Richards and Bryan had relied could not be upheld and suggested that the volcanic beds might be correlated with those of the Lower Bowen areas elsewhere. He also considered that the coral zone (Condamine Block) should underlie them.

The writer (Voisey 1935) visited Silverwood and suggested a re-arrangement of the blocks largely on account of the discovery of Monilopora in the Eurydesma Block. This seemed to be confirmation of Reid's ideas.

During the discussion (Bryan 1935) which followed the presentation of this paper to the Royal Society of Queensland, Dr. Whitehouse said he did not favour a correlation of any of the beds with horizons in the Hunter Valley where the Silverwood forms such as Trachypora did not occur. He believed them rather "to represent a "Middle Marine Stage" of considerable thickness between the Lower and Upper Marine Series where a cessation of marine conditions is indicated by the Greta Coal Measures".

J.H.Reid at the same meeting disagreed with the correlation of any portion of the Wallaby Beds with the Greta Coal Measures and pointed out that Monilopora has a range above the Eurydesma beds at Springsure. W.H.Bryan objected to the presence of two distinct volcanic epochs separated by normal marine sediments as was implied by the re-arrangement.

Realizing that finality could only be reached by comparison with an adjacent area, where an unbroken sequence could be obtained, the writer carried out field-work in the Drake and Boorook Districts, with the result that he is forced to admit that the evidence favours the removal of the Condamine beds containing the corals, from the bottom to the top of the Silverwood sequence.

D. The Drake District.

Until recently the only recorded field-work in the Drake District was that of E.C.Andrews (1908). His work has been quoted by many writers, but the fact that he failed to emphasise ~~the fact~~ that the fossils from Jump-Up Hill came from a different series of beds from that at Drake and Boorook, led to the idea that the Drake rocks were older than Lower Marine.

J.H.Reid (1930b) states "The first possibility of a marine transition series and corresponding fauna would seem to come from N.S.W. Andrews, in 1908, expressed, or at least, implied this for the Drake and Warwick areas in part". The fossils from Jump-Up Hill were quoted.

Recent field-work (Voisey 1936b) has shown that the Jump-Up Hill fossil beds belong to the Emu Creek Series containing rocks which differ greatly from those of the Drake Series. The Emu Creek Series may be Neerkol in age and does not contain Monilopora or Trachypora but has Cladochonus tenuicollis. The Drake Series has been divided into two parts. The Lower Division contains chiefly lavas tuffs and conglomerates with only a few fossil horizons. The Upper Division has a number of prolific fossil beds and above these and marking the end of the volcanic rocks is a big thickness of black mudstones at the base of which is a zone which yields numerous Monilopora cf. nicholsoni and Trachypora wilkinsoni.

It is considered that there is little doubt that the volcanic beds with their interbedded marine sediments can be correlated with those at Silverwood only a short distance away. The acceptance of this correlation means that the Monilopora -Trachypora zone at Boorook is stratigraphically above the Silverwood volcanics. As the main reason for the writer's placing of the Condamine Beds below the Eurydesma Beds, i.e., the presence of Monilopora in the Eurydesma Block, cannot be refuted the range of Monilopora must be from some distance above the Volcanic suite at Silverwood and Drake to below the position assigned to the Eurydesma horizon. This being the case there is no longer any palaeontological excuse for placing the Condamine sequence above or below either the volcanic or the Eurydesma section.

CORRELATIONS.

Owing to the lack of an established palaeontological standard with which collections of fossils might be compared it is unsafe for anyone to attempt detailed correlations of the Upper Palaeozoic beds in Eastern Australia. This standard can be built up after a great deal of field-work has been carried out. During the last seven years, the writer has made every effort to obtain material which could be used in such a compilation.

The greatest obstacle has been the difficulty of correlation between areas on other than palaeontological grounds. Two main connecting links have been used. The Macleay and Hunter Districts have been correlated because of basal glacial beds, (Woolnough 1911, Voisey 1934), and the fact that each overlies a fresh-water Series composed of comparable stages (i.e., glacial beds, Rhacopteris - Aniemites beds, and volcanic beds). Drake, Silverwood and the Lower Bowen Series of Queensland have been correlated by means of a volcanic stage which exhibits unusual and distinctive characteristics in each case. Support for this correlation is to be found in the statements of Richards and Bryan (1923, 1924) and Reid (1930). The interbedded marine sediments and the occasional plant beds, to say nothing of the petrological features of the volcanic suite, lend weight to this argument.

To connect the Macleay and Drake Districts on lithological grounds is possible only in a very general way as the sediments are similar only because they belong to what is regarded as the "Permian" type as opposed to the "Carboniferous" type. The change in the nature of the Lower Marine sediments from those in the Carboniferous has been noted elsewhere - Reid (1930b, p.50) states that, "Geological Survey work in Queensland seems to indicate a marked, wide-spread, and apparently almost constant difference in the marine sediments of the Carboniferous transition, ('Carboniferous type') as opposed to those of the 'Bowen Series' ('Permian type'). The former are prevailingly fine-grained, usually dark to black densely consolidated muds; the latter normally are light-coloured, coarser grained sandstones, etc., and weathering with exceeding rapidity.

"These types are constant for both the Lower and Middle Bowen Marine Sediments in the Great Syncline over a distance of about 400 miles from Collinsville to Springsure."

These generalisations, with regard to the Queensland Permian beds, hold good for New South Wales. This is strikingly shown in a comparison between the Drake Series and the Emu Creek Series.

Resort to palaeontology indicates that the Macleay Series and the Drake Series may be correlated in a general way and for the present this is all that is desired. With regard to more specific correlations on faunal evidence, it is of interest to note the correlation made by J.H. Reid between the Dilly Stage and the New South Wales Lower Marine (Reid, 1932, p.62). He states also:

> "Considering the association of <u>Linoproductus springsurensis</u>, <u>Productus</u> (?) <u>subquadratus</u>, <u>Aviculopecten mitchelli</u> and <u>Eurydesma</u> as strongly indicative of Dilly age, with the reservation that the evidence cannot yet be considered conclusive that they.

> individually or collectively, may not range below that stage, we may consider the occurrence of these forms in combination on the eastern side of the Great Syncline together with other species occurring in that stage or known to be co-zonal ...."

Of the four forms quoted by Reid, at least three are characteristic of parts of the Hunter Valley, Macleay District, and Silverwood areas. Monilopora and Trachypora have been found in all except the Hunter Valley. These corals are present at Drake with many forms characteristic of the other places.

Further, Reid remarks, (1932, p.63):

> "At Dilly the abundant development of Strophalosia gerardi and the presence in its lower beds of the Permian Upper Marine Species, Stenopora crinita will make it additionally difficult to maintain an earlier age than Lower Permian for the stage."

The evidence produced by the writer since 1930, indicates that the Lower Marine of New South Wales and Lower Bowens of Queensland are linked through Kempsey, Drake and Silverwood, and that there is no reason to suppose that any part of them could be transitional between Neerkol and Lochinvar.

Fossil lists from a number of areas are appended. Where possible the forms from the Eurydesma cordatum horizon are in separate columns from those above and below. In the case of Silverwood, those occurring in the various blocks are shown. Using the volcanic stage as a fundamental link, the list should assist in the elucidation of Queensland stratigraphy. The faunal links with New South Wales Lower Marines appear to be strong.

The failure of the writer to definitely place the Eurydesma cordatum horizon with relation to the volcanic stage is unfortunate. When this is done - and it should be possible as the lamellibranch was recorded by Andrews from Rivertree (Andrews, 1908) - the Silverwood problems will be solved and correlations will be more secure.

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Of the four forms quoted by Reid, at least three are characteristic of parts of each of the areas examined by the writer, (i.e., Hunter Valley, Macleay District, Drake, Boorook and Silverwood), Monilopora and Trachypora have been found in all except the Hunter Valley.

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"At Dilly the abundant development of Strophalosia gerardi and the presence in its lower beds of the Permian Upper Marine Species, Stenopora crinita will make it additionally difficult to maintain an earlier age than Lower Permian for the stage."

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The forms from the Eurydesma horizon are in separate columns from those above and below. In the case of Silverwood, those occurring in the various blocks are shown. Using the volcanic stage as a fundamental link, the list should assist in the elucidation of Queensland stratigraphy. The faunal links with New South Wales Lower Marines appear to be strong.

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FOSSIL LISTS FROM AREAS CORRELATED WITH THE

LOWER MARINE OF THE PERMIAN.

HUNTER VALLEY.

1.	Lochinvar Stage -	Lower Marine.
11.	Eurydesma Horizon - Harper's Hill. -	" "
111.	Between Eurydesma Horizon and Greta Coal -	" "

MACLEAY DISTRICT.

1V. Below Eurydesma Limestone
V. Eurydesma Horizon and above.

DRAKE.

Vl. Drake Series.

SILVERWOOD. Qld.

V11. Eurydesma Block.
V111. Volcanic Beds.
lX. Wallaby Beds.
X. Condamine Beds.

DILLY AND SPRINGSURE.

Xl. Lower Bowen Series.

	1.	11.	111.	1V.	V.	V1.	V11.	V111.	1X.	X.	X1.
Tribrachiocrinus.	X				X	?					X
Cladochonus tenuicollis.						X				sp.	
Monilopora cf.nicholsoni.				X	X	X	X			X	X
Trachypora wilkinsoni.				X	X	X				X	X
Zaphrentis sp.				X	X					X	
Z - gregoriana.					X	X				X	
Fenestella fossula.	X	X	X	X	X	sp.	X		X		X
" internata.	X		X	?	X	sp.			X		X
" propinqua.					X	sp.					
Protoretepora ampla.			X	X	X	X			X	X	X
Polypora sp.	X								X	X	X
Stenopora tasmaniensis.	X	X			X	X			X		
" cf. ovata.		X							X		X
Phyllopora cf. Retepora.					X						
Dielasma amygdala.			X					X			
Dielasma cymbeformis.			X		sp.		X				
Dielasma hastata.		X	X								
Dielasma sacculus.		X	X								
Chonetes sp.	X		X		X						X
Strophalosia sp.			X	X	X						
" jukesi.	X					X?			X		X
" gerardi.				X	X	X			X		
" clarkei.			X						X		X
Productus brachythaerus.				X	X	X		X	X		X
" semireticulatus.					X						
" cora.	X		X								
" undatus.					X	X?					
Taeniothyris subquadratus.					X	X					X
Linoproductus springsurensis.				X							X
Martiniopsis subradiata.	X	X	X	X	X	X	X	X		X	X
" oviformis.					X			X	X		X
" darwini.									X		X

	1.	11.	111.	1V.	V.	V1.	V11.	V111.	1X.	X.	X1.
Spirifer sp.		X		X	X	X					X
" tasmaniensis.		X	X					X	X		X?
" vespertilio.	X	X	X	X	X				X		
" stokesii.	X	X	X			X			X		X
" duodecimacostata.	X		X					X	X		X
Syringothyris.				X							
Aviculopecten mitchelli.	X	X	X	X	X	?		X			X?
" squamuliferus.			X		X			X			
" sprenti.	X	X	X	X		X			X	X	
" englehardti.	X		X			X					
" tenuicollis.	X	X	X	X							
" cf.flexicostatus.						X					
Deltopecten subquinquelineatus.	X					X		X	X		
" illawarrensis.		X			X						
" farleyensis.	X		X					X	X		
Eurydesma cordatum.		X	X		X	?	X				X
Eurydesma hobartense.	X										X
Cordiomorpha cf.gryphoides.	X		X	X			X				
Cleobis sp.							X	?			
Merismopteria macroptera.		X			X						
Merismopteria sp.	X										
Chaenomya sp.		X	X				X	X			
Maeonia sp.	X		X								
Maeonia Corrugata.						X?					
" carinata.			X			X	X				
" elongata.							X	X			
Astartila sp.			X	X		X			X		X
Pleurophorus sp.	X	X	X				X				
Stutchburia costata.			sp.				X	sp.	X		
Modiola.		X				X					
Pachydomus.	X	X	X								
Mytilus cf.bigsbii.			X						X		
Edmondia.	X	X	X				X	X			

	1.	11.	111.	1V.	V.V1.	V11.	V111.	1X.	X.	X1.
Entolium.					X					
Hyalostelia.					X					
Solenopsis.		X	X					X		
Naticopsis sp.									X	
Pleurotomaria sp.									X	
Platyschisma sp.	X	X	X	X			X			X
Keenia.	X	X						X		
Ptychomphalina.	X	X	X	X				X	X	X
Conularia.	X	X	X	X						
Orthoceras.	X		X		X					

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(With three text-figures.)

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INTRODUCTION.

General geological investigations have been carried out in the Middle North Coast District of New South Wales since 1928, and it is thought that the physiographic observations made during that time merit some record.

The quantitative side of this work was limited to the measurement of the most significant heights with the aid of an aneroid barometer and an Abney level. The bases of gravel- and shell-deposits were determined, as well as the heights of river-terraces, and gravel and alluvial areas were mapped in connection with the geological structures. The boundary between the recent plain deposits and the older rock practically coincides with the 20 feet contour-line on account of the abrupt change in slope. This level has been mapped, otherwise no detailed contouring has been attempted. The accompanying relief-map (Fig. 1) shows the chief topographical points, and will be useful for reference.

The essential physiographic features to be noted are :—

(1) The deeply dissected New England Tableland to the west;
(2) an intermediate area with broad valleys, in which the rivers have been entrenched;
(3) horizontal coastal plains of accumulation with inliers of older rock; and
(4) a coast-line consisting of long, curving beaches between rocky headlands.

There are two definite breaks in slope. The first is from the main plateau level at about 2,000 feet on to the broad valley-floor level between 50 and 300 feet, and the second from this on to the low-lying sandy coastal plains.

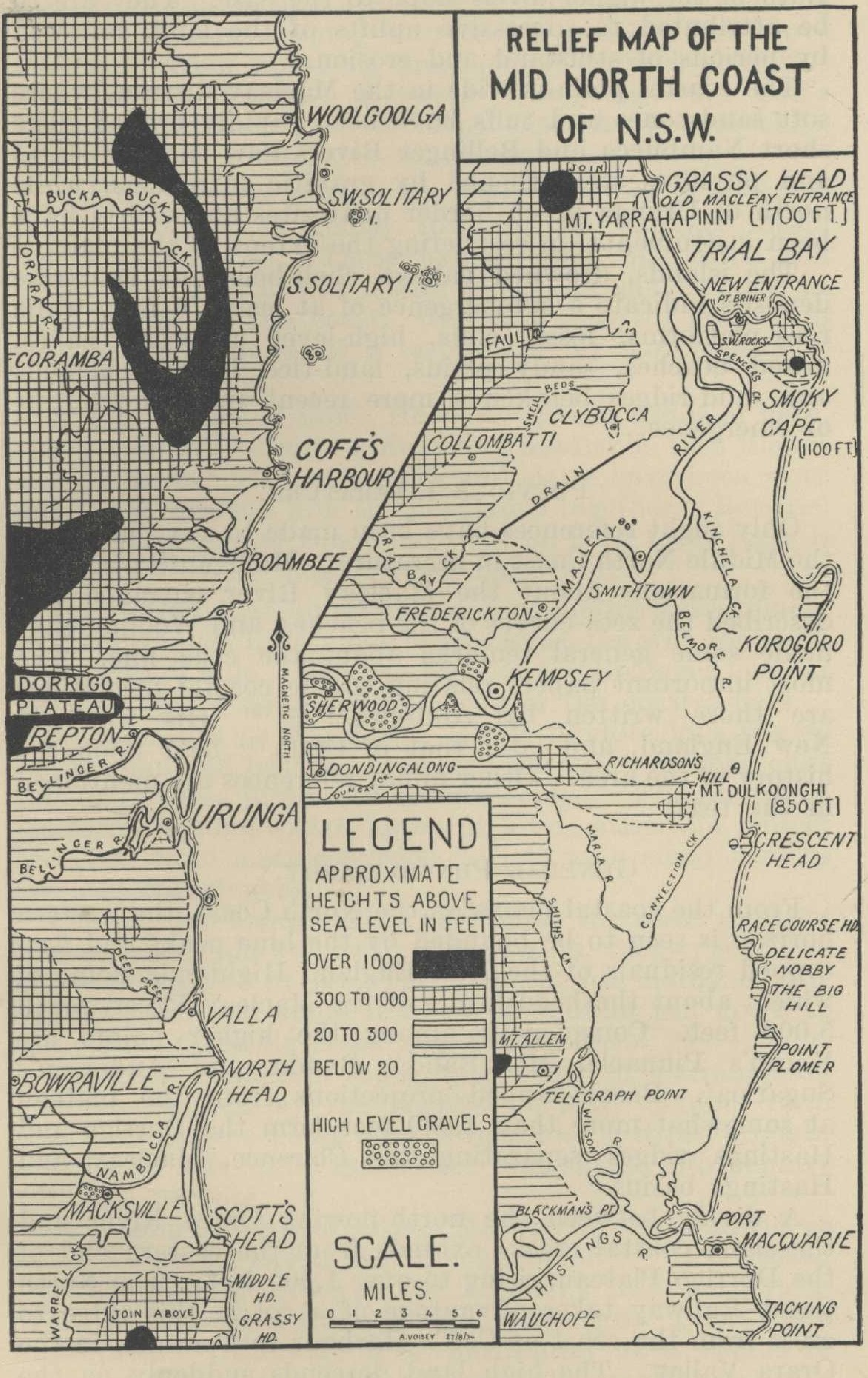

Fig. 1.—Relief Map of the Mid-North Coast of N.S.W.

Both of the higher levels slope to the east. They are to be attributed to successive uplifts of the land, followed by periods of stillstand and erosion.

The coastal plain is wide in the Macleay district, where soft sandstones and tuffs have been rapidly eroded. The short Nambucca and Bellinger Rivers flow through slates and phyllites strengthened by granitic intrusions, while north of Urunga much harder quartzites and cherts have been instrumental in restricting the extent of the plain.

The islands, drowned valleys, shell-beds and estuarine deposits indicate a submergence of at least 70 feet, while rock-platforms, fossil cliffs, high-level sea-worn caves, raised beaches, sandy plains, land-tied islands, lagoons and sand-ridges betoken a more recent small movement of emergence.

Previous Literature.

Only slight references have been made to any portion of the Middle North Coast in literature. Halligan[6] discussed the formations about the Macleay River entrance and described the zeta-curves of the beaches, and Woolnough[7] made some general remarks about the coast-line. The most important papers relating to the coastal formations are those written by Andrews.[1] [2] [3] His work in New England, and later that of Craft,[4] bear upon the history of the area. Other minor references are mentioned in the text.

General Physiography.

From the coastal plains on the North Coast, the western horizon is seen to be bounded by the blue peaks and flat-topped residuals of the New England Highlands, some of which, about the headwaters of the Macleay River, reach 5,000 feet. Conspicuous among the higher points are Kemp's Pinnacle, Mt. Banda Banda and Anderson's Sugarloaf. Basalt-capped projections from the plateau at somewhat more than 2,000 feet form the Dorrigo and Hastings ridges separating the Clarence, Macleay and Hastings basins.

A divide between the north-flowing Orara River and the short coastal creeks extends from the eastern end of the Dorrigo Plateau, rising to over 1,000 feet. The North Coast Railway takes advantage of a col in this ridge to cross from the coast at Coff's Harbour to Coramba in the Orara Valley. The high land descends suddenly on the east to an undulating area several miles wide, extending to the coast, and keeping between 150 and 300 feet above sea-level; from this cliffs drop steeply to rock-platforms and fringing beaches. Between Woolgoolga and Coff's Harbour small sandy flats break into the line of cliffs, becoming more extensive to the south.

Part of the ridge close to the coast is formed of Mesozoic sandstones dipping gently towards the Clarence Basin to the north-west. These overlie hard quartzites and cherts interbedded with slates and tuffs and striking at right angles to the coast. The resistance to erosion of this metamorphic series is responsible for the presence of high land.

In the vicinity of Coff's Harbour vertical bands of hard, siliceous rock give rise to projecting headlands with islands east of them. The softer tuffs and slates have been worn away, and beaches link the headlands together. Between Coff's Harbour and Boambee, both on hard rock, there is a plain four miles long and two miles wide.

The Dorrigo Plateau presents a steep southern escarpment to the Bellinger River, and breaks away towards the coast in a series of hills. The two arms of the Bellinger meet at Urunga, where river alluvium covers the coastal flats.

As far south as Nambucca Heads phyllite hills rise to several hundred feet and approach the coast, forming cliffs similar to those just south of Woolgoolga. Fringing rock-platforms abound a little above high-tide mark and protect the cliffs from marine erosion. Flats with small lagoons are also conspicuous.

The phyllite series strikes parallel to the coast south of Urunga, and shows little variation in rock-type. The intrusive granite at Mt. Yarrahapinni has hardened the contact-rock, and spurs from the mountain run down to the coast at Middle Head and Grassy Head.

The great change in topography south of Yarrahapinni has been caused by the Kempsey Fault, running from Grassy Head to a point west of Bellbrook; it has brought a series of soft tuffs, sandstones and shales into contact with the phyllite.

The plain about the Lower Macleay extends inland as far as Kempsey, and covers 250 square miles. It is broken by older rocks at Smoky Cape, Rudder's Hill near South-West Rocks, Richardson's Hill, Korogoro Point, and Smithtown. Otherwise it is horizontal, at a height of about 10 feet above sea-level, over the whole area, save for the levées of the Macleay and the sand-ridges near the coast. The landward limit of the plain is marked by a very definite break of slope, and low cliffs, generally about 50 feet high, may be traced from Grassy Head in a rough semicircle to Crescent Head.

In the north the land of the intermediate area is gently undulating, but it gives way to hills near Mt. Yarrahapinni, while masses of hard rock stand well above it in the south. Mt. Dulkoonghi (850 feet) is the most prominent of these, and forms the eastern extremity of the divide between the Macleay and Hastings Rivers. At Kempsey the Macleay emerges from a broad valley in which it has become entrenched, and flows across a low plain. The level represented by the floor of the older valley forms the crest-plane of the 50-feet scarp. On either side of the valley hills run up towards the plateau. Those to the south are composed of hard conglomerate, sandstone, and tuff. Secomb's Mount at Yessabah is 1,300 feet high, and many such residuals exceeding 1,500 feet occur in the much-dissected country on both sides of Dungay Creek.

A soft sandstone series forming part of a northward-plunging anticlinal structure has an arcuate outcrop between Bellbrook and Kempsey ; this accounts for the course of the Macleay and for its broad valley.

The watershed between the Macleay and Hastings Rivers is very low to the south of Kempsey, and the railway-line runs through the gap. The Cooperabung Mountains and Mount Allen near Telegraph Point scarcely reach 1,000 feet, but represent the highest points in this district. The Wilson River has cut quite a broad valley to the west. This rather broken country gives way towards the sea to another large sandy plain comparable in size to that about the Macleay, and stretching from Crescent Head to the Hastings River.

The Lower Macleay Plain.

To an observer looking east from Gowing's Mountain at Dondingalong the Lower Macleay plain seems to be quite flat. The prominent hills, Smoky Cape and Korogoro Point, stand up from it like islands in a calm sea. A thin golden line between them marks a fourteen-mile beach, beyond which lie the blue waters of the Pacific. The low chain of hills to the south-east ends in Mt. Dulkoonghi, while on the north-east Mt. Yarrahapinni, rising to 1,700 feet, marks the northern boundary of the plain. In the foreground

Dungay Creek winds towards the Macleay, both streams entrenched in the wide valley, which can be seen to better advantage if one looks north-west. Through a gap in the hills near Anderson's Sugarloaf the flat-topped Dorrigo Plateau stands out to the north.

The Macleay leaves the rocky country at Kempsey and meanders through the level plain, collecting Christmas Creek, Belmore River and Kinchela Creek. Lines of farmhouses mark the levées on either side of the streams. During floods most of the plain is inundated, an indication of its uniformity of level. For a mile or more on either side of the river there is a veneer of alluvium, which thins out away from the river and passes into swamp-deposits of fine clay and black mud. Peaty material from reeds and grasses is slowly accumulating and aiding in the building up of the swamps into dry land. Much of the plain might be described as the lagoon marsh-meadow of Andrews.[(1)] The once extensive swampy areas have been drained and are now covered only after heavy rains. The swamp and lagoon water is fresh, but coloured brown by oils from the tea-trees which characterise the marshy country.

A special type of swamp is the crescentic lagoon occurring behind curving sand-dunes which follow the beach and prevent the water, which is generally a few feet above high tide, from draining seawards. During storms and specially high tides waves break through the sandhills and allow some of the water to escape, while salt water may mingle with the fresh. At Crescent Head the lagoon connects up with the sea only during exceptionally high tide periods. In January, 1934, seaweed was washed a mile from the entrance into the lagoon. The water here is generally quite salt or brackish, owing to the influx of sea-water, though after heavy rains it is fresh and flows into the sea.

Some of the plain is covered by wind-blown sand, which is freely mixed with the black swamp-muds. The sandhills have been formed through the combined action of wind and tide, and are held in place by abundant vegetation. They curve sympathetically with the beaches, and rise behind them to a height of more than 30 feet, but are piled up to hundreds of feet against the headlands. The dunes in the vicinity of Smoky Cape are particularly large. Between Smoky Cape and Korogoro Point there is a second line of sandhills at a distance, in places, of as much as sea at Kempsey, and Smoky Cape, Korogoro Point, *etc.*, would be islands.

The shells, where exposed by the drain, are at about the level of high tide, but they are several feet above this near Mr. Plummer's house at Clybucca. Their presence above sea-level seems to demand an emergence of small magnitude following the deposition of the estuarine sediments.

The Old Macleay Gravels.

The gravels at Willawarrin and Sherwood were first noted by W. G. Woolnough,[(8)] who thought that they

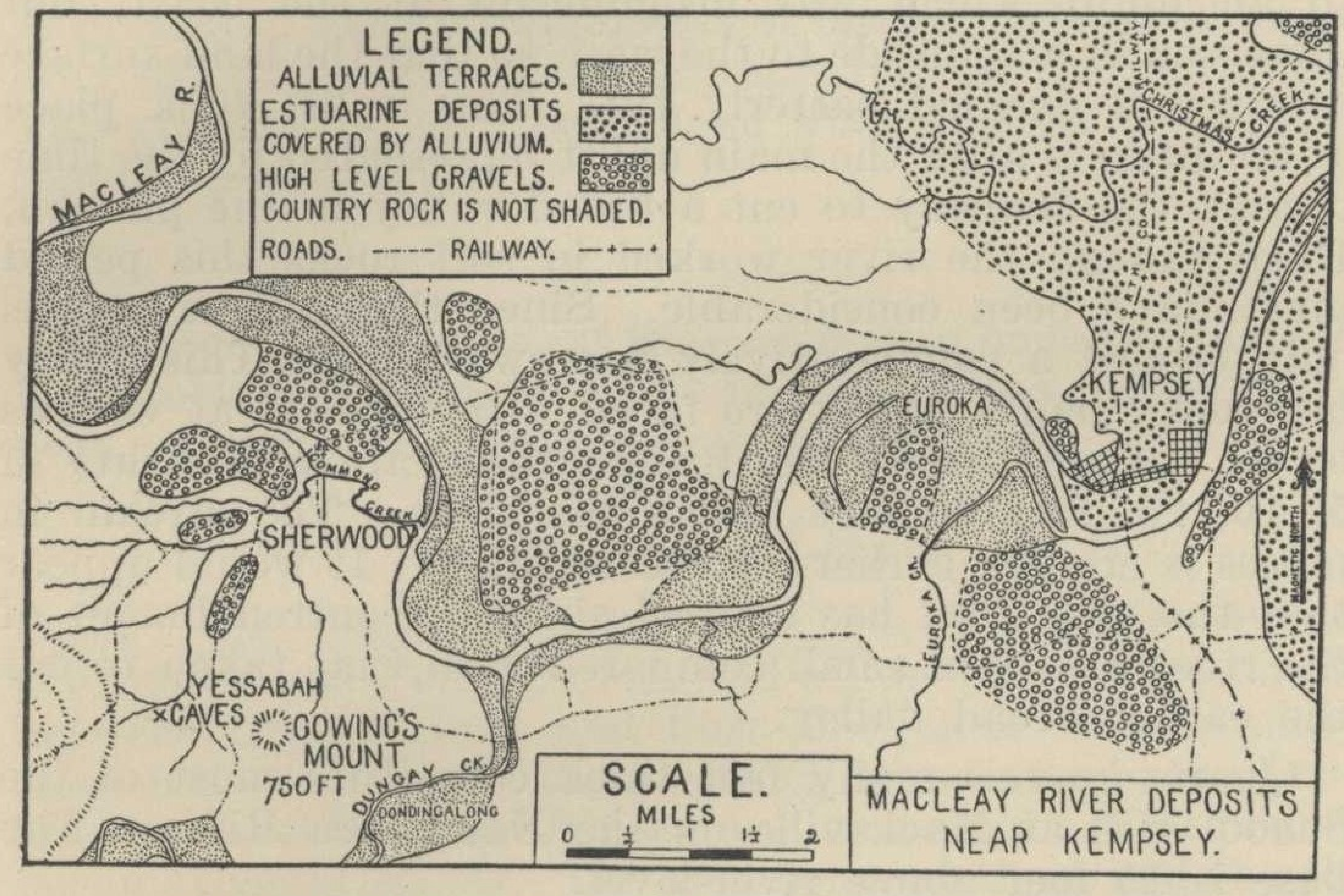

Fig. 2.—Macleay River Deposits near Kempsey.

were of Permo-Carboniferous age, probably because they have been cemented into a hard conglomerate and are associated with a Permo-Carboniferous limestone at the latter locality. These deposits, locally known as "ridge gravels," are very extensive around Sherwood, and they cap most of the hills between it and Bellbrook (Fig. 2). They consist generally of rounded pebbles of quartz, jasper, chert, slate and quartzite set in a sandy matrix. The level of the base of the gravel varies from 140 to 180 feet at Yessabah, but is only 80 feet near the Sherwood Bridge, where the Macleay River is 30 feet above sea-level. At Temagog boulders up to two feet across cover the hills at heights of over 100 feet above river-level, and at

Willawarrin they are about 200 feet above. Fine quartz-gravel is common about Kempsey, and is mixed with river-silts containing much iron oxide. The height of the base of the gravel varies greatly here, from about 30 feet in some localities to 100 feet in others.

These gravels are close to the present coast, but the coast-line was certainly further east when they were laid down, though exactly how much further we cannot say. The gravels are spread out over the floor of a broad valley in which the river has become entrenched. They have been cut into by Commong Creek.

The elevated position of these river-deposits is attributed to an uplift which was insignificant at the coast, but increased in magnitude to the west, so that the land-surface received a decided easterly tilt. This uplift took place at an interval after the main uplift represented by the time it took the Macleay to cut a broad valley in the plateau. Even though the river worked in soft rocks this period must have been considerable. Since then the river has only eroded a comparatively narrow valley. This valley has rocky banks which are faced with terraces at various levels. About Sherwood Bridge these are at heights of 5, 10, 25, and 50 feet above the river. The stream in places is eroding earlier-formed terraces. It would appear that the time that has elapsed since the entrenchment of the river has been small compared with that taken to cut the earlier broad valley.

Quartz-gravels many feet thick constitute most of the School Hill at Macksville on the Nambucca River. The base is 15 feet above river-level.

The Coast-Line.

(i) *Fossil Cliffs and Rock-Platforms.*

Where cliffs border the coast south of Woolgoolga they are fringed by rock-platforms just above high-tide mark. These have been worn away in places by the waves, and sand has covered the remnants, which are thus still influential in protecting the cliffs behind from attack. The shape of the cliffs indicates that they were formerly more exposed to the attack of the sea than they are at present. Old caves at the base are sand-filled, and the face of the slope is covered by vegetation.

The broad rock-platform at Nambucca Heads is cut out of strongly-folded phyllites, and the surface is almost independent of the structures, showing that the explanation offered for the formation of some platforms in horizontal rocks is not applicable here. Furrows are at present being cut into the platform, indicating that the sea is at a lower level than it was when the platform was formed.

(ii) *Pulpit-Rocks.*

Masses of rock are found standing up from the rock-platforms or beaches along the shore. Wellington Rock at Nambucca Heads is one of these. It owes its fantastic shape to interlacing quartz-veins in phyllite. These pulpit-rocks do not seem to be undergoing much erosion at present. They are remnants of former cliffs which have been cut off by waves and left standing on the platforms. This could only have been done when the sea stood at a slightly higher level.

(iii) *Islands.*

The Solitary Islands off the coast were once residuals of hard rock on a coastal plain of denudation; they have been converted into islands by submergence.

(iv) *Land-Tied Islands.*

Like the Solitaries, Smoky Cape, Korogoro Point, Crescent Head, Point Plomer and all the coastal headlands between Grassy Head and Port Macquarie were formerly residuals standing on the plains of denudation around the Macleay and Hastings Rivers, and as a result of drowning became coastal islands. The area between them and the old coast, however, was never far below sea-level. In fact, during the drowning of the land, the accumulation of silts kept pace with the submergence, and sand-spits forming from the islands kept them in intermittent connection with the coast. It may also be that recent emergence helped to complete the work of currents and to tie the islands definitely on to the mainland.

(v) *Beaches.*

The land-tied islands are linked to each other by beaches which take on a characteristic zeta-curve, as described by Halligan.[6] He considers that the fourteen-mile beach between Smoky Cape and Korogoro Point is perhaps as good an example of the zeta-curve beach as there is on the coast. Halligan also states that the current impinging upon the headland of Laggers' Point has scooped out sufficient land to form Trial Bay. Although the shapes of beaches are dependent on the currents, Trial Bay is accounted for by the fortuitous position of the former islands, Smoky Cape and Point Briner. These were linked together by sand-bars, thus giving rise to the projection of the coast which enfolds the bay.

The Lower Courses of the Rivers.

All the North Coast rivers flow through the flats representing their silted estuaries for some distance before entering the sea. As they have reached base-level and the modern estuaries are tidal, their entrances are dominated by ocean-currents and winds. All of them pass through salt-water lagoons before they reach the sea. These lagoons owe their existence in the first place to the formation of sand-banks isolating bodies of salt water, and their maintenance is due to their incorporation into the courses of rivers. The extra flow of water accomplishes what the lagoons could not do alone, and keeps a permanent connection with the ocean.

However, the scour of the river, already reduced through following a winding course across the plain, is not strong enough to keep a deep channel through the beach, and a wide, shallow entrance results, with some of the water flooding back into the lagoon. The Hastings River at Port Macquarie furnishes a good example. Its entrance has extended in recent years to about a mile across, with consequent shallowing, and salt-water lagoons stretch out to the north.

The Macleay River once had such an entrance near Grassy Head, after flowing behind the sandhills through an old lagoon area for several miles. During 1895 flood-waters broke through the southern end of the lagoon, and the main river cut across one of its own tributaries, Spencer's Creek, and formed a new mouth. The construction of two breakwaters to restrict the opening has been a successful project. The flow of the river and the tidal scour keep the channel deep enough for coastal steamers to enter.

Halligan's conclusions with regard to currents and the formation of sand-bars are very relevant when applied to the North Coast, but it does not seem that currents are directly responsible for all the curves of the rivers near the coast. He supposes that the Macleay, for instance, first entered the sea near South West Rocks, but was forced to move northward by coastal currents, its mouth taking up successive positions until Grassy Head was reached. It may be suggested, however, that the Macleay first entered a lagoon, this being formed through the building of a sand-bank by coastal currents. The river happened to choose the site of the northern end of the lagoon for its entrance. The Hastings in a somewhat similar position chose the southern, influenced no doubt by the currents and the headland of Port Macquarie.

Warrell Creek should enter the sea near Scott's Head, but turns north, probably through a lagoon tract, to meet the Nambucca near its mouth. The main river is certainly being forced north. It cut into the phyllite headland as its southern bank advanced until the advance was checked by a breakwater. Now the entrance has become so shallow with the accumulation of sand that ships of any size cannot pass.

The Macleay and Nambucca have north-east trends as they flow through the plains. This is in all probability due to the operation of currents during the time when the strand-line was rising and the bay was silting up. The river entrances were continually being pushed towards the north. The present courses are probably very much the same as they were before the recent small uplift entrenched the rivers in the older silts.

Physiographic History.

The Pliocene period found Eastern Australia, and in particular the Middle North Coast District of New South Wales, at a lower altitude than at present. There was a Main Divide in somewhat the same position as today. This rose in places to a little over 3,000 feet, the main ridges and hills being composed of the most resistant rocks and solid structures. The hard rocks were mainly the New England granite massif and Lower Palæozoic schists and slates. South of the Nambucca River and east of Bellbrook on the Macleay highly folded Upper Palæozoic sediments of variable hardness had been worn down to an undulating plain. Volcanic activity ensued, thick basalt sheets covering the plains, filling in the river valleys and causing some re-organisation of the drainage. Then came the Kosciusko epoch, marking the close of the Tertiary Era and involving the slow elevation of the Main Divide some 2,000 feet with a tilt towards the coast, which was much further east than at present. The coastal rivers rapidly cut downwards in an attempt to keep pace with the rising land, thus forming deep V-shaped gorges like that of the Apsley River. Nearer the sea the Macleay River followed a series of soft sandstones and tuffs from the site of Bellbrook to the coast, widening its valley until it reached harder units in the Lower Palæozoic phyllites to the north and the Carboniferous conglomerates and tuffs to the south. In the soft rocks also it formed a broad coastal plain of denudation with residuals of the harder tuffs and intrusive rocks. Brought from the hills,

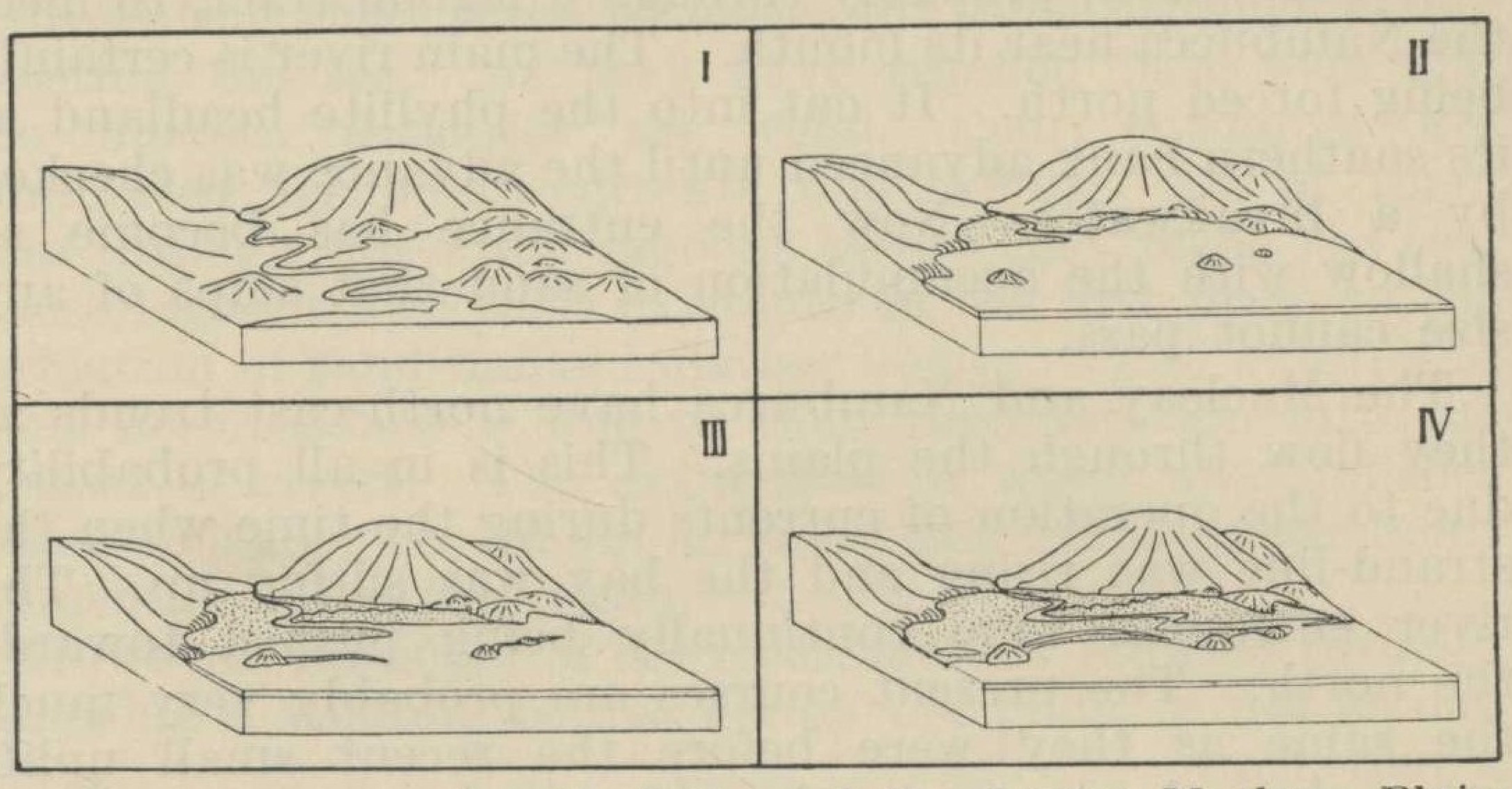

Fig. 3.—Stages in the Evolution of the Lower Macleay Plain.
I. A coastal plain of denudation with residuals.
II. Flooding of the plain by the rising sea.
III. The development of an internal delta and sandspits.
IV. Final stage, deposition being supplemented by small uplift.

boulders of jasper, quartzite, slate and sandstone were strewn out over the valley floor as the river slowed up and meandered through the broader valley. Nearer the present site of Kempsey the finer quartz-gravel and silt were deposited (See Fig. 3).

Later came a further uplift of the land, with a seaward tilt, which caused the Macleay above Kempsey to be entrenched in its older broad valley. Streams commenced to cut down into the older gravels, leaving them capping low hills, residuals of the valley floor. Much later still a submergence inundated the coastal plain and turned the residual hills upon it into islands. However, the sediment from the river, which now flowed into a shallow protected bay, built up the floor of the bay, giving rise to an internal delta. As in the case of Narrabeen Lagoon,[5] accumulation balanced subsidence. Thus the estuarine shells *Spistula trigonella* and *Arca trapezia* became buried in sand-drift and river-silts. Sand-spits extended from island to island because of the shallowing of the sea-floor, and thus bodies of salt water were isolated from the sea.

The limit of sea-transgression was in the vicinity of Kempsey, and after the cessation of the transgression, since the forces of deposition were still dominant, alluvium spread over the swampy mangrove-flats. Aborigines by this time were living on the land behind the lagoons and swamps, and obtained their food largely from the abundant shell-fish living therein. Innumerable shells accumulated round the shores where the coast was not protected by sand-bars, and the waves cut rock-platforms and caves into the cliffs. The entrance of the Macleay was now in a broad lagoon separated from the sea by low sand-banks joining Grassy Head to Point Briner and Lagger's Point. A slight uplift of the land caused further narrowing of the lagoons and draining of much of the swampy land, while the rock-platforms were brought to a higher level and accepted the attack of the waves, which had previously been expended upon the cliffs behind.

Having incorporated the lagoon into its course, the Macleay sought an outlet to the sea to the north, influenced by winds and currents, and this was maintained until the more southerly entrance was formed in 1895. The northern entrance has since become completely closed.

A somewhat similar sequence of events has taken place in the case of the Hastings, Nambucca and Bellinger Rivers. The Hastings still enters the lagoons, which have not silted up so much as those of the Macleay.

Comparisons with other Coastal Areas.

It is interesting to note the differences in effect that the two most recent movements of the sea have had upon various portions of the Eastern Australian coast.

In the Sydney district the sea flowed into V-shaped gorges, giving rise to the typical drowned valley shore-line with the deep harbours of Port Jackson and Broken Bay. The subsequent small withdrawal did not cause much change in the form, merely exposing rock-platforms and aiding in the building up of small flats.

South of Sydney the drowning of less dissected country gave rise to a less indented shore-line, but owing to the lack of large rivers, the slope of the sea-floor and the action of currents there was little deposition close to the shore. Hence, again, the effect of the emergence was to give elevated rock-platforms and small reclaimed areas and, in addition, some land-tied islands such as Red Head near Gerringong.

Next the Queensland coast between the New South Wales border and Brisbane may be considered. The drowning here is masked very successfully by the land which has been reclaimed from the sea. The inner shore-line may be considered to pass through Brisbane, but between it and the coast much low land is seen, through which project hills of older rock. Obviously the sea covered an undulating coastal plain, giving rise to a shallow island-studded bay.

Shallow Moreton Bay is little more than a great lagoon fenced off from the sea by the huge sandhills of Moreton Island. The rocky extremities of both Moreton and Stradbroke Islands have provided nuclei from which crescentic sand-bars project southwards, almost connecting with the mainland at Southport. If the emergence had been a little greater it would have caused the complete infilling of Moreton Bay, moving the outer shore-line from Sandgate to the eastern sides of Moreton and Stradbroke Islands.

The coast between the Nambucca and Hastings Rivers represents the most complete obscuring of the effects of the drowning owing to the removal of the shore-line to the outer islands produced through the drowning.

Ultimately the main factor in the evolution of the present coast-line has been the nature of the rock-material and its structures. Acting upon these the eroding agencies, notably running water, determined the degree of denudation before the drowning took place. Where soft Upper Palæozoic rocks form the coastal lands, the Nambucca–Hastings coast-type is formed, but where phyllites and schists are present the features which prevail between Woolgoolga and Nambucca Heads are met. Narooma and Tathra on the South Coast of New South Wales have much in common with North Head on the North Coast, especially in regard to cliffs, rock-platforms and stacks.

Acknowledgments.

I desire to thank the members of the geological staff of the University of Sydney for their help in many directions, also Mr. F. A. Craft for valuable advice and discussion. My thanks are also due to many residents of the Macleay district for the help which they have given me during the field-work. Especially would I mention Mr. and Mrs. J. E. Gowing, Mr. and Mrs. O. W. Newman, Mr. and Mrs. T. Snow, Mr. and Mrs. Freer, and Mr. D. McIver for kind hospitality, the Ven. Archdeacon Tress and Messrs. F. Leathley, G. Hodgson, senr., G. Christian and P. Richardson for help in the field, and the Manager of Nestlé & Anglo-Swiss Milk Coy. for making available the log of the bore-core at the Smithtown factory.

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- THE UPPER PALAEOZOIC -

ROCKS AROUND YESSABAH

NEAR

K E M P S E Y

N.S.W.

A.H. VOISEY, B.Sc.

- THE UPPER PALAEOZOIC ROCKS -

AROUND YESSABAH

NEAR KEMPSEY, N.S.W.

A.H. VOISEY, B.Sc.

(Oul.)

INTRODUCTION.

This paper deals with the Upper Palaeozoic rocks which outcrop in the parish of Kullatine, County of Dudley around the Yessabah Caves Reserve. The caves are about eleven miles east of Kempsey which is 313 miles by rail north of Sydney.

Little mention of this area had been made in literature until 1934 when the writer ~~outlined~~ described the main features in a paper entitled, "A Preliminary Account of the Geology of the Middle North Coast District of N.S.W." (Voisey, 1934a). The history of previous geological investigations in the Macleay District was outlined and recognition given to the work of Dr. W. G. Woolnough, who, in 1911, went rapidly through the Willi Willi District describing some of the beds in the northern portion of the parish of Kullatine. No other information relating to the rocks in the Yessabah region has been found.

The discovery by the writer of Aneimites (?) and Rhacopteris in Chert pebbles among the Permian Marine fossils in a branch of Commong Creek near Yessabah, and its subsequent location in situ near the head of this creek, was the first indication of the presence of Carboniferous strata.

The possibility of shedding further light upon the Carboniferous - Permian junction led to the concentration upon the rocks in the vicinity of Yessabah and later Dondingalong. By careful mapping it was hoped that details of the succession of beds would be obtained. This was the case, but structures were found to be so complicated and outcrops so scarce that it was not completely elucidated. The boundaries were mapped as well as possible, but the interpretations are offered for criticism.

Most worries have been caused by the Tait's Creek Glacial Beds which are well developed north and north-west of Yessabah, but make few outcrops and although their presence has been inferred at times, they have petered out in other places and a certain amount of doubt remains with regard to their whereabouts. Although they are looked upon as the equivalents of the Lochinvar Shales, portionsof them are difficult to separate from the underlying Kuttung beds. The calcareous nature of the material and the presence of marine fossils have assisted in the separation. The purple colour is the main criterion, but as some of the Kuttung beds weather similarly, it is not always to be relied upon.

STRATIGRAPHY. The BOONANGHI SERIES.

Lower Carboniferous.

(See Specimens Australian Museum Collection
DR 3129 to DR 3165)

The Boonanghi Series (Voisey 1934 p336) occupies the south-western corner of the parish of Kullatine and consists chiefly of water-sorted felspathic tuffs, bluish-grey sandstones, greenish-grey mudstones, dark grey shales and occasional bands of conglomerate.

The felspathic tuff is the most distinctive and also the most common rock type and is confined to this series. It is composed of felspar crystals and chloritic material, but contains very little quartz. The fossils which are abundant ~~every~~where in this rock are composed of crystalline calcite. ~~Forms which~~ have been i~~dentified~~ collected are:- crinoid ossicles, fenestellidae, Loxonema, Rhipidomella, a small gasteropod and small lamellibranchs.

Further collecting should reveal a greater variety but most of the remains are fragmental and difficult to identify. The crinoid ossicles are so excessively numerous in the rock that it may be described as a crinoidal felspathic tuff.

The unaltered tuff is greenish in colour and is speckled pink and white by reason of the larger sub-idiomorphic felspar crystals. On weathering it turns brown and becomes pitted with holes where the calcite has been removed. These holes often contain a little limonite and they are most frequently casts of crinoid ossicles or small shells.

The tuffs vary greatly in texture, and those of finer grainsize are more resistant to erosion, and their outcrops may be traced through the hills. One band of medium grain gives rise to low hills about a quarter of a mile north-west of Wittitrin post office. Going westward from here along Dungay Creek into the parish of Boonanghi wonderful exposures of the series may be seen. The creek valley widens out and generally receives a tributary creek where it crosses the broader mudstone bands, whereas the banks are precipitous in the tuff and sandstone regions.

The following section was measured along the limb of an anticline as one goes west from Wittitrin post office. All the beds dip west at angles averaging about 15°.

	Thickness in feet.
Blue Sandstones and mudstones	225
Crinoidal Felspathic Tuffs	110
Fine Conglomerate with Loxonema (?) Rhipidomella etc.	30
Blue sandstones	170
Crinoidal Felspathic Tuff	100
Blue Sandstones	185
Felspathic Tuffaceous Grit	45
Greenish-grey slates with worm tracks	100
Blue Sandstone	45
Crinoidal Tuffaceous Grits and Sandstones	140
Grey Sandstone	240
Mudstones and Sandstones	155
Crinoidal Felspathic Grit	150
	1,695

This section is typical of the series. The total thickness of strata was not ascertained, as the basal beds were not located. There must be at least 4,000 feet of sediments and, in all probability much more.

Away from Dungay Creek, in rough country thickly covered with vegetation, neither the structure nore the sequence could be followed. Pieces of crinoidal felspathic tuff found in this locality indicate that the Boonanghi Series outcrops over a large area of country west of that now being described.

Mudstone has been revealed by a creek in portion 172 and dips in a north-easterly direction at 25°. This unit, which resembles the other Boonanghi mudstones, varies somewhat in texture and shows worm tracks and other markings, possibly rain prints and sun cracks. It is hardly laminated sufficiently to be termed a shale but is banded and breaks up into small flaggy blocks. The underlying beds are crinoidal tuffs, but the overlying rocks have been cut off by a fault and Kullatine strata take their place.

The fossil content of the Boonanghi Series indicates that its age is Lower Carboniferous and it may be correlated with the Burindi Series of the Hunter Valley.

There is sufficient doubt with regard to its exact limits to justify the adoption of the new name of Booranghi after the parish in which the maximum development takes place.

MIDDLE to UPPER CARBONIFEROUS.

The Kullatine Series.

The lower beds of the Kullatine Series consist of sandstones, tuffs, sandy tuffs and breccias showing a great deal of variation in texture and composition, but possessing a general dark or light grey colour. (DR3125 and DR 3128). All are very hard and resistant to weathering, forming a conspicuous range of hills which, though dissected by streams, continues in a huge semi-circle towards Moparrabah. The steep slopes in this region and thick vegetation in the gorges make progress very slow or impossible, so that geological investigations are most difficult.

These tuffaceous rocks may be seen in portions 171, 198, 190 and 165 and in the Boonanghi State Forest. They must represent several thousands of feet of material, but no reliable estimate could be obtained.

The tuffs pass upwards into thinly bedded cherts and mudstones containing well preserved Aneimites, Rhacopteris and tree trunks. These beds bring in a marked change in the physiography as the tuff hills which form the divide between Dungay and Commong Creeks fall rapidly towards the east and north-east.

The first discovery of Aneimites in situ in this district was made in the creek near a clearing close to the centre of portion 190. A good collecting ground for the plants, doubtfully regarded as the same horizon as above, is on portion 189 on a bluff close to Dungay Creek and in the gully to the west. (DR 3096 to DR 3127). Fossil wood was found among grits, sandstones, cherts, etc. on portion ~~in~~ 177 at Dondingalong. (DR 3090 to DR 3095).

Following the plant beds we have the glacial stage of the Kullatine Series, composed largely of dark grey tuffs inter-bedded with fluvio-glacial conglomerates and grey varve shales. Volcanic activity has continued throughout the glacial period. (DR 3097 to DR 3104).

The conglomerate bands contain water-worn pebbles, mostly well rounded, but intermixed with some very irregular ones. Some of the boulders are two feet in diameter and erratics of pink granite somewhat larger than this were seen. These possessed most irregular boundaries, and fragments broken from them and just hanging or slightly separated left little doubt as to their origin. Some of the conglomerates are best described as being fluvio-glacial. Typical rocks included in them are: -

Pink and grey granites;
White quartz;
Quartzite;

and many varieties of porphyries and sandstones.

The varve shales are neither as abundant nor as noticeable as in the Hunter River or Currabubula Districts and are very different in appearance, being dark grey, cherty, and, though possessing some summer and winter layers, are more typically fine-grained rocks not markedly laminated. The continual deposition of volcanic ash into the lakes in which they were being laid down probably had some influence upon them.

Excellent exposures of the glacial beds are to be seen in portions 56, 190, 196 and 192. They form the foothills of the main range, and their junction with the overlying Macleay Series is marked by a definite break in slope. At Dondingalong these conglomerates and tuffs are responsible for Gowing's Mount which attains a height of over 700 feet in portions 176 and 183. They outcrop also in portions 177, 200 and 163 just north of Dungay Creek and are associated with the underlying plant beds. All continue southwards into the parish of Wittitrin where they again form high, hilly country and swing round to join up with the Yessabah formations south of portion 56.

On the eastern fall of Gowing's Mount, a splendid outcrop of tillite occurs. It consists of numerous angular rock fragments of great variety set in a bluish-grey ground mass which weathers to a purplish colour. Because of this colouring, it was first thought to belong to the Tait's Creek glacial horizon in the Macleay Series, but has now been included in the Kullatine division. As S.W. Carey (verbal communication) suggests, it is comparable with the tillite described by him from the top of the Kuttung Series in the Currabubula District. (DR 3083 - DR 3091).

A correlation of the Kullatine Series with the Kuttung Series in the Paterson and Currabubula Districts is confidently made.

P E R M I A N.

The Macleay Series.

The tillite at Dondingalong does not appear to extend very far and the grey tuffs of the Kullatine Series at Yessabah are followed in places by the purple Tait's Creek Glacial Beds and elsewhere by fossiliferous sandstones and tuffs of the Macleay Series. The junction line is very difficult to pick up, more because of the very poor outcrops than because of any similarity in rock type.

Although the writer does not suggest that there is any unconformity between the Kullatine and Macleay Series, the removal of some of the top-most beds of the older series is indicated by the variation in the nature of the rock upon which the younger series rests.

There must have been an important time break represented by this disconformity and it involved a change over from terrestrial to marine conditions. After its junction with the Wittitrin road, the Willi Willi road follows a belt of purple calcareous shales and tuffs containing scattered pebbles which are faceted and striated. Here the beds are at the base of the Macleay Series. They were first described by Dr. W. G. Woolnough (1911) and called the Tait's Creek Glacial Beds from their occurrence to the west. He correlated them with the Lochinvar Glacial Beds in the Hunter Valley. The rocks are generally purple or red in colour, but rarely grey, green and blue. As they are soft and subject to deep weathering, it is uncertain what is the colour of the fresh rock. The only exposures seen were where road cuttings had been made or where a creek had recently been eroding its banks. Pebbles collected from the shales mainly off portions 98 and 142 included the following:-

Pink Acid Granite (coarse and fine types);
Purple Rhyolite with pink orthoclase phenocrysts and chlorite amygdales;
Orthoclase Porphyry with pink and white felspar phenocrysts up to 5mms. in diameter set in a purple groundmass;
Quartz Porphyry with rounded quartz phenocrysts;
Hornblende Andesite;
Banded purple Adnesite;
Glassy Andesite with tabular plagioclase phenocrysts;
Keratophyre, Green Dacite;
Dacite with quartz and plagioclase crystals set in a dark brown groundmass;
Grey Sandstone, Brown Quartzite, Green Quartzite, etc.

Their sporadic distribution, striations, facets and angular shapes leave no doubt that the above pebbles had a glacial origin. Some water-worn pebbles were found, but these were subordinate in quantity to the others. (See Specimens DR 3020 to DR 3028).

A microscopic section of a typical piece of the containing rock showed it to be a tuff composed of angular quartz grains up to 0.1mm. in diameter and fragments of volcanic material up to over 3mms. all set in an opaque groundmass, deep brown by reflected light. The volcanic material is ragged in outline, and consists of chlorite with tabular, somewhat decomposed felspars, and a little quartz.

The groundmass is largely haematitic. The rock reacts violently with hydrochloric acid owing to the presence of calcite derived from the marine fossils which occur plentifully in it. Among the fossils found in this unit are:- Crinoid stems, fenestellidae, Spirifer sp., Martiniopsis sub-radiata and small lamellibranchs.

The following sequence was measured along a branch of Commong Creek in portions 190 and 191:-

	Thickness in feet.
Fine grained grey tuff	130
Purple Chert with sponge spicules	15
Purple tuff with pebbles	10
Brown Tuff	20
Silicified Limestone (Zone "D")	40
Crinoidal Limestone (Zone "C")	240
Fenestellidae mudstone and Pecten Sandstones, etc. (Zone "A") with possibly some purple glacial beds	350
	805-ft.

(Australian Museum Collection DR 3011 to DR 3028).

The differences between the above sequence and this given below from Dondingalong will be readily appreciated. (Measured along creek at north end of portion 158).

	feet.
Grey Mudstone	?
Sandstone with Pectens (Zone "E")	90
Silicified Limestone (Zone "D")	70
Crinoidal Limestone (Zone "C")	100
Fenestellidae Mudstone (Zone "B")	20
Limestone	10
Fenestellidae Mudstone (Zone "B")	20
Sandstone with Pectens, etc. (Zone "A2")	40
Conglomerate with shell fragments (Zone "A1")	15
Sandstone	50
Conglomerate with shell fragments	10
Sandstone and tuff (Zone "A")	85
	510-ft.

(Australian Museum Collection DR 2985 to DR 3005).

The occurrence of the glacial beds in these two localities is somewhat doubtful, but if present they are included in the basal sandstones and tuffs.

Overlying or substituting the glacial horizon is a variable thickness of sandstones and calcareous mudstones which are crowded with marine fossils. Between portions 188 and 199, just east of the Wittitrin road, pectens are well preserved in mudstone, and are exceedingly numerous. Ptychomphalina is abundant wherever the pecten beds are found. The fossils contained in this bed are listed in the palaeontology section of this paper as Zone "A".

Good collecting grounds are at Dondingalong on the low ridges east and south-east of Gowing's Mount, and also in portion 164 near the Stock-Route.

The sandstones and mudstones peter out rapidly northwards so that when the purple glacials become well represented in portion 109 they are only a few feet thick and the crinoidal limestone rests almost directly upon the glacial beds. The fenestellidae mudstone horizon which is between the limestone and the pecten beds at Dondingalong has almost disappeared.

It is noteworthy that, south of Willi Willi the sandstone, mudstone and tuff beds between the limestone and the glacial beds are at least 750-feet thick, being even better represented than in the parish of Kullatine. (Specimens DR 3042 to DR 3082). Here the unit is more clearly divisible into separate beds. Conglomerate occurs and some of the mudstones form definite fenestellidae horizons. Other beds are full of <u>Productus brachytherus</u> (?). (Specimens DR 3042 to DR 3082).

Details of the sandstones and mudstones at Yessabah are difficult to obtain, owing to the scarcity of outcrops, but at Dondingalong two thin bands of conglomerate were mapped among the more finely grained sediments. These conglomerates contain fragments of large shells, probably pectens, among rounded and sub-angular pebbles. <u>Spirifer vespertilio</u> has been identified from it.

At Dondingalong the top-most beds of this fossil zone are calcareous mudstones crammed with fenestellidae and productids. The forms collected from here include <u>Linoproductus springsurensis</u>, and <u>Momlopora cf. nicholsoni.</u> (See Zone "B" list). The bed is best seen on portions 173 and 183 where it outcrops in the form of large flaggy boulders. When fresh it is a grey colour containing fossils composed of crystalline calcite. These are best detected on the weathered surfaces.

The mudstone contains limestone bands and passes upwards into the main horizon of crinoidal limestone. This unit may be traced from south ofthe Lime Station near Kundabung north-westward to Dondingalong and then with breaks due to faulting from Yessabah to the west and south-west of Willi Willi.

Because of the proximity of the limestone to the purple glacial beds on the Willi Willi Road, and the association of the limestone with the fossiliferous sandstones and mudstones at Yessabah and Dondingalong, the question arises as to whether the limestones are on the same horizon in each case. Although there is an impure limestone band, 50-feet thick and about 500-feet above the main limestone horizon in the parish of Warbro, no evidence was found to support the idea that there are two main limestone horizons in the sequence. The very fact that sections taken in various localities throughout the Macleay Series do not correspond in detail, is evidence enough of the discontinuity of certain of thebeds. The limestone, indeed, seems to be the only horizon upon which it is safe to rely.

The limestone band varies from 100-feet to 500-feet in thickness. It is crystalline, fairly even in texture throughout, and almost pure calcium carbonate in its composition. Its appearance is pretty and unique, the colour being usually pink, but also reddish-brown, purple, grey and white. It would make an excellent ornamental building stone-being obtainable in large blocks at numerous localities. The columns at the entrance to the Art Gallery in Sydney bear testimony to its appearance, and even better material could be obtained. (Specimens DR 2986-DR 3004).

On weathering, the surface of the limestone becomes grey. The effect of weathering is well seen in the fluted outcrops on top of the Caves Hill at Yessabah. Here, too, are a number of small caves with the stalactites and shawl formations. Similar caves are found at Moparrabah and Willi Willi.

Fossils are best detected on the weathered surfaces of the limestone which is largely made up of crinoid ossicles. Under the microscope many bryozoans were also seen. (See fossil list for Zone "A"). Eurydesma cordatum has been found in abundance in the Willi Willi District in association with large pectens.

Though massive in places the rock sometimes is seen lying in beds of variable thickness between which there is little or no sediment. Sometimes patches of pebbles are found in the limestone, and their presence suggests that they might have been dropped from ice-bergs still lingering after the passing of the main glacial epoch. That marine fossils form the limestone and that they actually occur in the purple glacial beds indicate that these forms of life were able to live under comparatively cold conditions.

Tuffaceous material is much in evidence, showing that volcanoes were still active. It would seem that much of the reddish colouring of the limestone is due to the addition of fine volcanic ash during its deposition. The crinoidal limestone is followed by silicified limestones which vary greatly in their characteristics from bed to bed. They are well exposed by the creek running through portion 158. On weathering the calcium carbonate is removed and spongy siliceous masses remain. As the silica has, for the most part, replaced the fossils, these are splendidly preserved. Monilopora of nicholsoni, is most abundant in this zone so that much of the resulting material resembles macaroni (See Zone "D" fossils).

On top of the silicified limestone is a variable thickness of tuffaceous sandstone containing pectens. It is well exposed at Dondingalong, but generally forms poor outcrops.

The beds described above are the only ones traced with any degree of certainty in the parish of Kullatine. The mudstones, tuffs and sandstones, overlying them give rise to few outcrops and attempts to map them even broadly have met with little success. Whether the sediments pass upwards into the Kempsey Series, or whether they are separated therefrom by faulting, is not known.

The mudstones are soft, crumbly and black and are exposed in places by the creek in portions 8 and 158.

P E R M I A N ?

The Kempsey Series.

This name has been given to the sandstones, slates, mudstones and tuffs which outcrop between Sherwood and Kempsey. There is little evidence to show what age the beds are, but as the writer has been unable to separate them from the Macleay Series, and as their outcrop corresponds with the general structure of the Parrabel Anticline, he has considered them to be Permian. The general criteria used for identifying the beds have been given previously (Voisey 1934a p. 340).

The rhythmically-bedded sandstones and mudstones in the Eastern portion of the parish of Kullatine are doubtfully referred to ~~as~~ the Kempsey Series. They are revealed by the road cuttings between Sherwood School ~~to~~ and a point about a mile west where they are covered by gravel deposits and here are about a mile east of the Macleay Series limestone which is dipping eastward. It would appear that these sediments, at any rate, are Permian in age and overlie the Macleay Series, but whether the same could be said truthfully about the beds further to the east is problematical.

For rocks referred to the Kempsey Series (See Australian Museum Collection DR 2908 to DR 2984).

PLEISTOCENE.

Gravel deposits cap many of the hills in the parish of Kullatine and, in fact, much of the country between Sherwood and Kempsey. They are well seen on portions 113, 120, 121, and 122 where they have been cemented into a conglomerate and unconformably overlie the Permian rocks.

Here they contain rounded jasper, quartz, chert and quartzite pebbles up to six inches in diameter.

The age of these gravels is probably Pleistocene because they appear to have been laid down by the Macleay River or its tributaries on the floor of a valley which had been ~~covered~~ carved by the River out of the plateau formed by uplifts closing the Tertiary era.

PALAEONTOLOGY.

Boonanghi Series.

The crinoidal felspathic tuffs contain Loxonema sp., Rhipidomella, Fenestellae sp., small gasteropods and lamellibranchs and numerous crinoid stems. Fragments of plant stems are common.

The above collection though small, indicates that the beds are Lower Carboniferous and can probably be correlated with the Burindi Series of the Hunter River District.

Kullatine Series.

Fossil plants collected were Rhacopteris, Aneimites (?) and probably Dadoxylon. These are typically Middle to Upper Carboniferous forms and there can be no reasonable doubt that the Kullatine Series and the Kuttung Series were contemporaneous.

Macleay Series.

From various sources including specimens found in the Mining Museum, Sydney and collected by Mr. J. E. Carne, the following list of the fauna recorded from the Macleay Series has been compiled:-

(Descending order)

Sandstone (Zone "E") Pecten sp.
Silicified Limestone horizon (Zone "D")
Fenestella cf. fossula.
Fenestella cf. internata.
Protoretepora cf. ampla.
Zaphrentis (2 species).
Trachypora wilkinsoni.
Monilopora cf. nicholsoni.
Stenopora - small dendroid form.
Tribrachiocrinus corrigatus.
Crinoid stems and plates.
Chonetes sp.
Dialasma sp.
Productus cf. subquadratus.
Productus sp.
Strophalosia gerardi.
Martiniopsis subradiata.
Spirifer (4 sps.)
Aviculopecten mitchelli.
Merismopteria macroptera.

LIMESTONE HORIZON - (Zone "C").

Sponge Spicules possibly Lasiocladia and Hyalostelia.
Monilopora cf. nicholsoni.
Trachypora wilkinsoni.
Zaphrentis gregoriana De Kon.
Zaphrentis sp.
Fenestella internata Lonsdale
Fenestella fossula Lonsdale.
Fenestella propinqua McCoy?
Protoretepora ampla De Koninck.
Phyllopora cf. Retepora? De Koninck.
Stenopora sp.

Martiniopsis subradiata G. Sby.
Martiniopsis Oviformis McCoy.
Spirifera tasmaniensis G. Sby.
Spirifera vespertilio G. Sby.
Spirifera sps.
Productus semireticulatus Martin (?)
Productus brachythaerus G. Sby.
Productus cf. undatus Defrance.
Strophalosia sp.
Eurydesma cordata Morris.
Deltopecten illawarrensis Morris.
Aviculopecten squamuliferus Morris.
Aviculopecten mitchelli.

Crinoid stems make up the greater part of the limestone in which the above forms occur.

FENESTELLIDAE MUDSTONE (Zone "B").

This bed is made up of masses of fenestellidae, but as well as these the following were collected:-

Monilopora cf. nicholsoni.
Zaphrentis cf. arundinaceus.
Fenestella sp.
Protoretepora sp.
Crinoid stems.
Strophalosia sp.
Strophalosia gerardi.
Productus sp.
Pustula.
Linoproductus springsurensis.
Syringothyris sp.
Spirifer vespertilio.
Spirifer sp.
Martiniopsis subradiata.
Conularia.

PECTEN SANDSTONE AND MUDSTONE (Zone "A") (including AI and A2).

Fenestella sp.
Crinoid stems.
Martiniopsis subradiata.
Spirifer mult. spp.
Syringothyris.
Aviculopecten sprenti.
Aviculopecten tenuicollis.
Aviculopecten mitchelli.
Cardiomorpha (?).
Astartila sp.
Ptychomphalina.
Platyschisma sp.

From the Macleay District De Koninck (1898) described certain fossils which he identified as :-

Favosites polymorpha	Goldf.
Chonetes hardrensis	Phillips.
Chonetes coronata	Conrad.
Atrypa reticularis.	
Aviculopecten etheridgei	De Koninck.
Aviculopecten mcleayi	De Koninck.

He had been led to believe that these were Devonian in age but his description of the material in which they were preserved leaves little doubt as to the horizon.

From the above list of forms it seems that the Macleay Series may be correlated with the Lower Marine beds of the Kamilaroi Series in the Hunter Valley, and an attempt will be made later to show that the Drake Series of Boorook and Drake and the Fault-Block Series of Silverwood, Queensland, also belong there. The writer prefers to call all these beds Permian owing to the lack of any convincing evidence to the contrary.

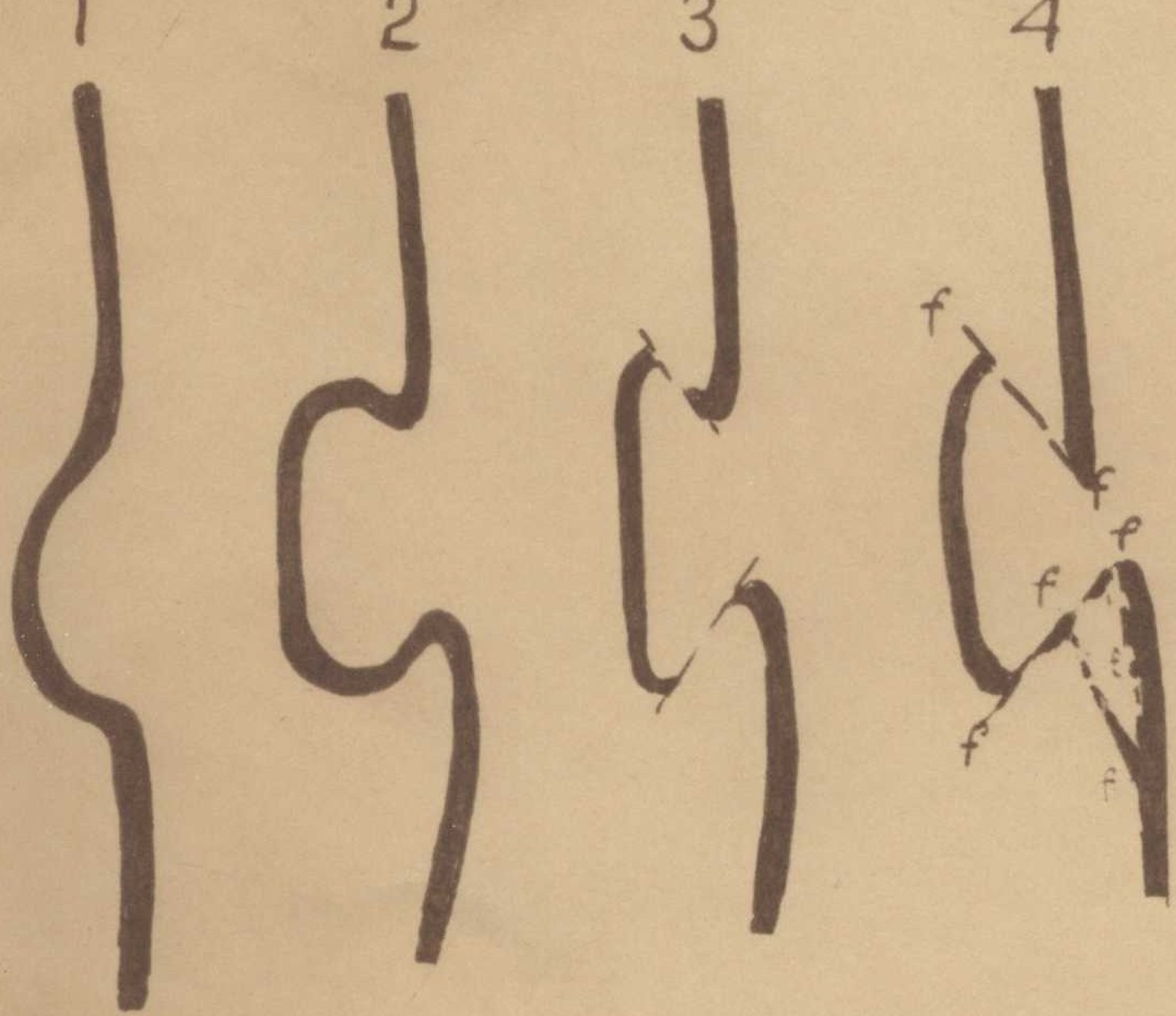
GEOLOGICAL STRUCTURES.

The strata in the parish of Kullatine form part of the eastern limb of the Parrabel Anticline or Anticlinorium which pitches in a northerly direction. (Voisey 1934a). Within the area described, complicated faulting has taken place. The conditions arising from this have brought about some interesting topographical results. Gowing's Mountain, for instance, is an isolated hill which (obviously) has been more resistant to erosion than the surrounding rocks. Actually it is a hard mass of Carboniferous conglomerates and tuffs brought by folding and faulting into the midst of the younger rocks. To the south-west of the Mount, patches of limestone occur under rather puzzling circumstances. They are sometimes in contact with Carboniferous beds and at other times with fragments of rocks associated with them elsewhere, but differently disposed. By tracing these blobs and other anomalies, one was led to a point south of Dungay Creek where the Yessabah limestone turned to run east and west before being truncated by the Carboniferous conglomerates. It was then apparent that a fault (a) had moved the limestone about two miles to the north-east. The limestone masses which had been so puzzling had been dragged along the fault-plane into these positions.

Another large fault (b) resulting in an equivalent amount of movement explains the break in continuity of the Yessabah limestone to the north. The paucity of outcrops makes the accurate location of this fault an impossibility, but its position as shown on the map has been inferred from the outcrops available. The strata around Gowing's Mount have been extensively folded and faulted as shown by Map 2. The most conspicuous fault is that which runs near the north-western corner of portion 137 and the north-eastern corner of portion 200 (fault c). Movement along this has dragged the limestone westwards into a sharp fold which can be seen to advantage in portion 173.

Minor faults associated with the major ones have resulted in the twisting and movement of some beds into seemingly anomalous positions. The limestone of the Macleay Series is in contact with the Kullatine conglomerates in portions 163 and 176 and explanations are very difficult. Strike faults in portions 173 and 157 have further complicated the situation and further north, in line with these, the beds are overturned (portion 158). Instead of dipping easterly as they do in the northern creek, those in the southern creek are dipping west or are vertical. Small folds and faults are apparent in many places, but it was impracticable to show them even on the large scale map. The area is recommended to anyone interested in structural geology for there is still plenty of work to be done in it.

At Yessabah the limestone band dips easterly for the most part, but near the faulted area beside Dungay Creek it has been overturned and dips westerly. The dips range from 40° to 90° to the east or west along the extent of the outcrop. It seems that the Dondingalong beds on the south and the Willi Willi Road beds on the north were once continuous with the Yessabah beds, but when fracturing took place, they were separated from each. The collapse of the eastern limb of the huge Parrabel Anticline is the probable explanation and has been sufficient to cause the faulting and folding. A suggestion explaining the stages in the development of the structures is shown in the accompanying diagrams:-



SUGGESTED STAGES IN THE
DEVELOPMENT OF THE
YESSABAH FAULTS.

The effects of this disturbance have extended into the beds of the Kullatine Series. These in some areas are vertical or possess reversed dips although the strata generally dip east. Strike faulting is well developed.

The Boonanghi Series to the west has suffered little deformation. The beds have been folded on a north-south axis into gentle undulations which pitch north. Dips are generally from 5° to 10° rarely reaching 15° or 20°. It is rather interesting to observe the large areas of older rocks so little disturbed while the younger ones have been excessively faulted and folded only a mile or two away.

PHYSIOGRAPHY.

The physiography bears a most direct relationship to the nature of the rocks. It may be stated quite generally that the Kullatine rocks can be picked out immediately from the rocks of the Macleay Series because they occupy the points of greatest relief. The Caves Hill, composed of limestone, is the only prominent feature produced by other than Carboniferous rocks.

The main range of hills which can be seen by looking west from Kempsey to Sherwood consists of Kullatine rocks. The highest points are composed of the Lower tuffaceous beds, while the fluvio-glacial conglomerates form the foot-hills; Gowing's Mountain, which is quite conspicuous by reason of its grassy eastern slope, is mainly conglomerate. East of Gowing's Mount, there are two ridges, the first of the pecten sandstone (Macleay Series) and the second of silicified limestone and the overlying sandstone. These two ridges are separated by limestone, which, as usual, occupies the gullies. The pecten sandstone swings west while a flat between this and the Kullatine hills southward is carved out of limestone.

The Caves Hill owes its relief to the silicified limestone band which forms a hard protective capping. The eastern dip of 40° is low enough to make this capping effective. Where the beds are vertical or nearly so, the silicified limestone forms low ridges and the limestone hollows. Further to the north-west where the dip becomes more gentle, there happens to have been less silicification, so the limestone does not give rise to high hills until Sebastopol is reached. Here the dip is north at about 25°, and the upper beds are silicified. A limestone range results.

West of the range of Kullatine rocks which passes 1,300-ft. in Secomb's Mount, there is rugged country, some of it composed of Boonanghi Series. Eastwards we find only grassy or wooded undulating hills. The soft beds overlying the Macleay Series occupy this region. Some of the hills are gravel covered, but this is indicated usually only by the presence of rounded pebbles in the soil.

The physiographical history of a larger region including the parish of Kuttung has been described elsewhere. (Voisey, 1934b).

GEOLOGICAL HISTORY.

Probably simultaneously with the deposition of the Burindi beds elsewhere in New South Wales the mudstones and tuffs of the Boonanghi Series were laid down during Lower Carboniferous times. Marine conditions prevailed to the accompaniment of explosive volcanic eruptions. During periods of inactivity greyish-green mudstones were laid down while occasional floods washed in coarser material giving rise to conglomerates and sandstones. While the volcanoes were active the ash from them kept falling into the sea covering the crinoids and other marine organisms. That most of the ash suffered little transportation is demonstrated by the fact that the felspars in the tuff are sub-idiomorphic and undecomposed.

Uplift terminated the marine period, but volcanic activity continued throughout a time of fresh-water conditions. Plants growing round the lake were washed into it and became buried in the finer muds. There followed a glacial epoch. Ice-bergs floated on a sea fringed with active volcanoes.

After an uplift and probably a period of erosion, there was subsidence and a marine transgression during Permian times. Crinoids, bryozoa, corals and shell fish flourished under the closing stages of the glaciation. Though still active the volcanoes no longer provided the bulk of the sedimentary material.

It is likely that there was another change over to fresh-water conditions during the deposition of part at least of the Kempsey Series.

At the close of the Palaeozoic Era great folding movements took place resulting in the development of the Parrabel Anticline. During the period of stress the eastern limb of the Anticline fractured and adjustments by faulting gave rise to the complicated structures in the parish of Kullatine.

Then came a long period of erosion and reduction of the land nearly to a peneplain, but leaving a comparatively low divide remaining between the eastern and western rivers. The Kosciusko Uplift at the close of Tertiary times produced the highlands into which the Macleay cut its valley. Gravel deposits now found on the tops of low hills round Sherwood were laid down on an old valley floor which has since suffered dissection. The river and its tributaries are entrenched in this older valley.

CONCLUSION.

This paper is the first attempt to describe in detail the rocks outcropping in the Macleay District. It is far from complete, even for the small area discussed, because of the multitude of rock types and complex structures therein. Moreover, it has not been possible to have identified all the fossils collected.

The question of correlation has been dismissed with a few words here, but will be discussed more fully in a subsequent publication.

ACKNOWLEDGMENTS.

I desire to thank all the members of the geological staff of the University of Sydney, especially Mr. L.L. Waterhouse under whose direction the work was carried out.

Dr. Ida Brown, and Messrs. Fletcher and F. Booker have been of great assistance to me in the identification of fossils.

My thanks are also due to Messrs. Hodge-Smith and Chalmers who have been responsible for the storing and cataloguing of the specimens collected by me. These specimens are available for inspection at the Australian Museum, should anyone wish to examine them.

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Yessabah District.

Granite Erratic in Kullatine
(Glacial Stage.)

South Commong Creek - Yessabah.

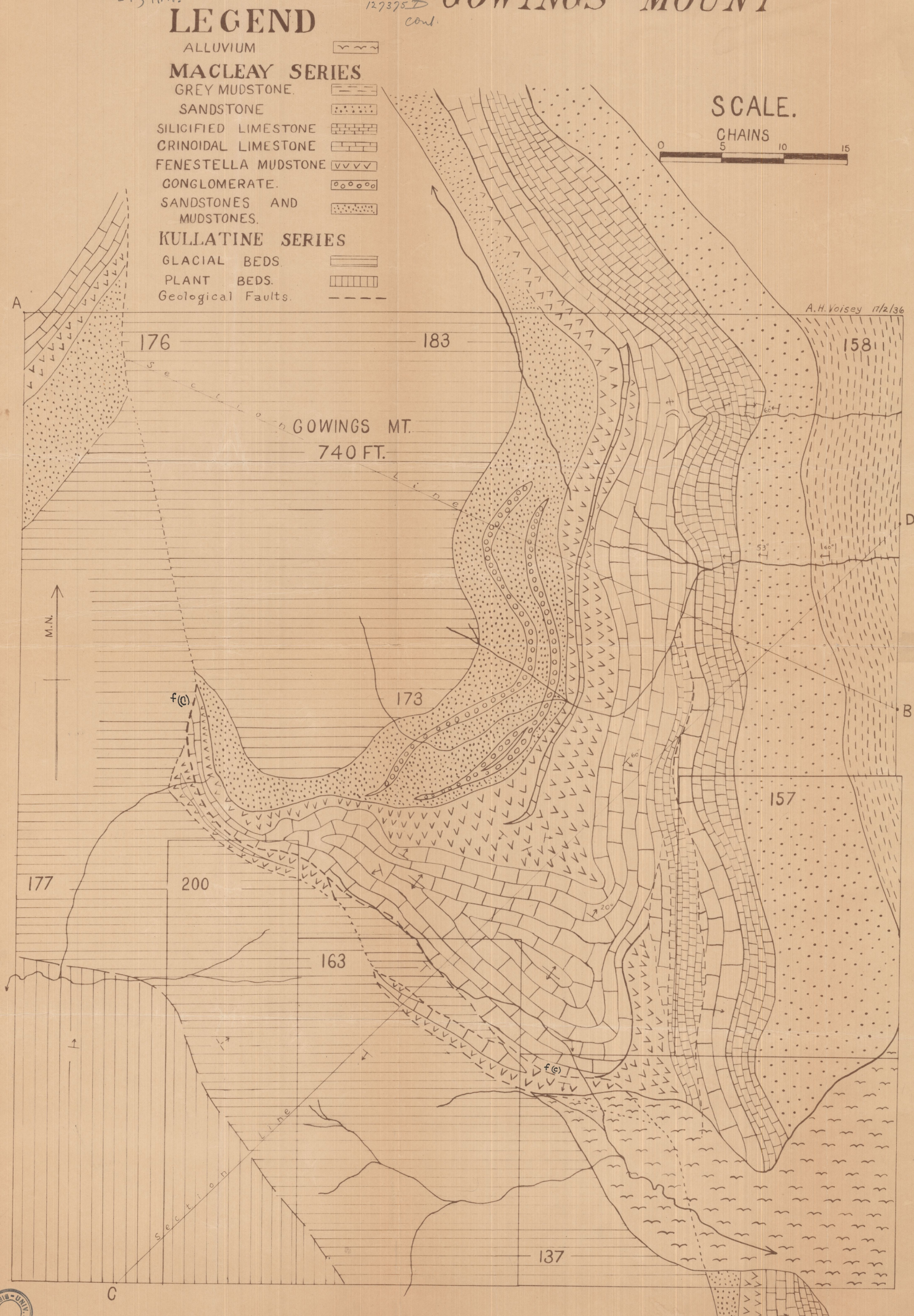
View looking East from Gowing's Mount
(Kullatine Series) -(Glacial Stage.)
First ridge - Pecten Sandstone.
White outcrops in next valley - Limestone.
Second ridge broken by creek - Silicified Limestone.
Poor outcrops in undulating country beyond.

Crescent Head.
Typical Section of the Kempsey Series
showing rhythms in sediments and small fault.

SECTION RUNNING EAST FROM BOOROOK.

Map 5

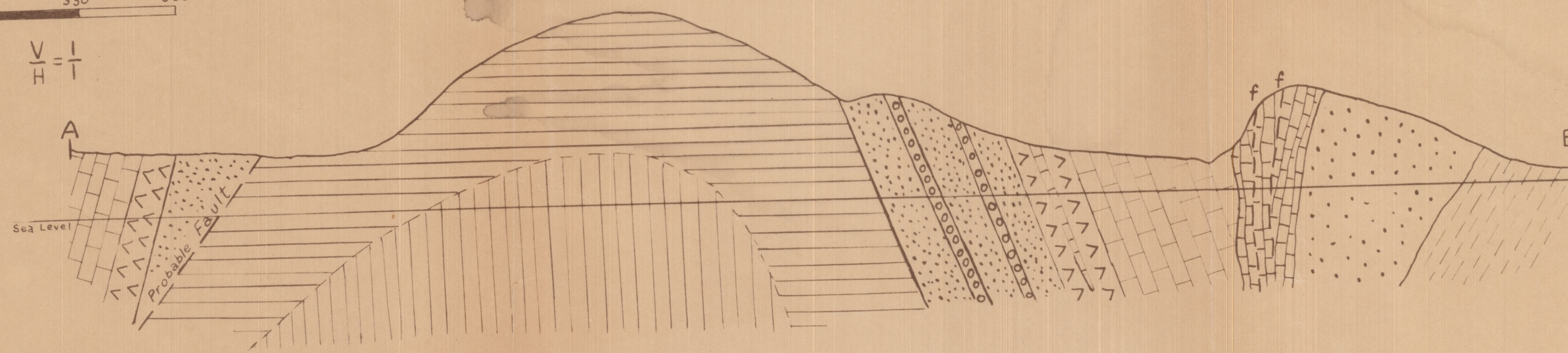
GOWING'S MOUNT

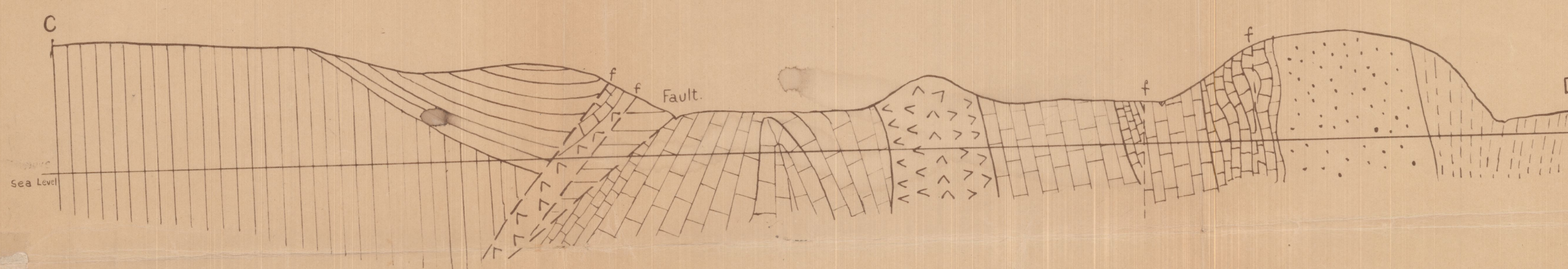


Scale
Feet.
0 330 660

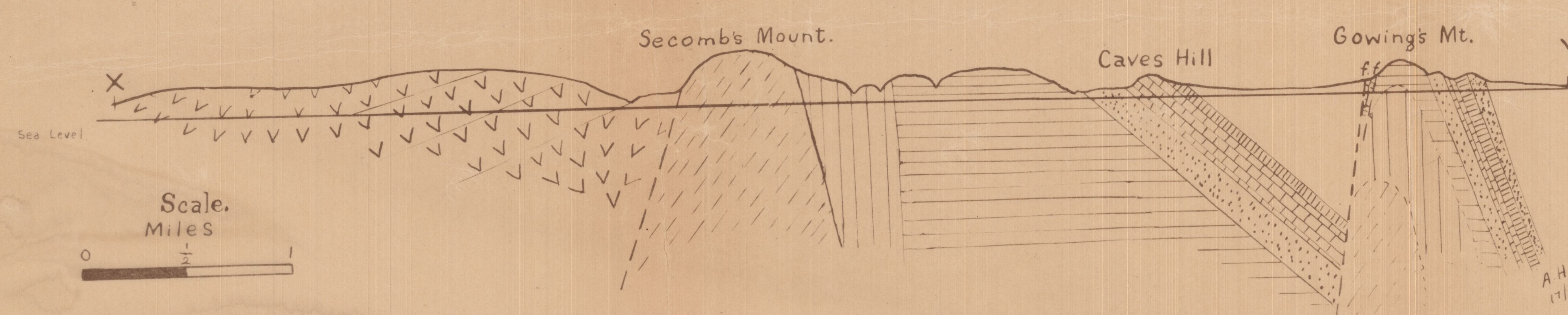
$\frac{V}{H} = \frac{1}{1}$

GOWING'S MOUNT





SECTIONS ACROSS GOWING'S MOUNT AREA



Scale.
Miles
0 ½ 1

SECTION ACROSS YESSABAH DISTRICT.

MAP 4
378.9450
M.Sc., 1936;
VOISEY, A. H.
Sketch Geological Map of the
BOOROOK - DRAKE
DISTRICT
CLARENCE SERIES
DRAKE SERIES
UPPER DIVISION
LOWER DIVISION
PLUMBAGO CK. SERIES
EMU CREEK SERIES
GRANITE
SCALE.
MILES
0 1 2 3
Fossil Localities.
Roads or Tracks.
Parish Boundaries.
M.N.
PARISH OF JENNY LIND
JUMP UP HILL
EMU CREEK
Road to Pretty Gully
PARISH OF ANTIMONY
KANGAROO CK.
LUNATIC GOLD FIELD
Old Mine Dumps
Lunatic Gully
RIVER
PARISH OF CALLANYN
PARISH OF BOOROOK
GILGURRY CK.
OLD BOOROOK TOWN
PARISH OF GILGURRY
BOOROOK STATION
SAWPIT GULLY
CATARACT
RED ROCK
CROOKED CREEK
Treatment Plant
BOOROOK CREEK
Cemetery
PARISH OF COLONGON
Track
Stock Route
KETTLE'S LIFT
TO TABULAM
PARISH OF FAIRFIELD
GIRARD CREEK
CHEVIOT HILLS STN
PLUMBAGO CREEK
PARISH OF GIRARD
ROAD
MAIN ROAD
Sawpit Gully
MT. CARRINGTON
PARISH OF WEST FAIRFIELD
TEA TREE CREEK
TIMBARRA RIVER
GIRARDS DOWNFALL
SANDY HILLS
DRAKE
A. H. Voisey
17/2/36

Map 4

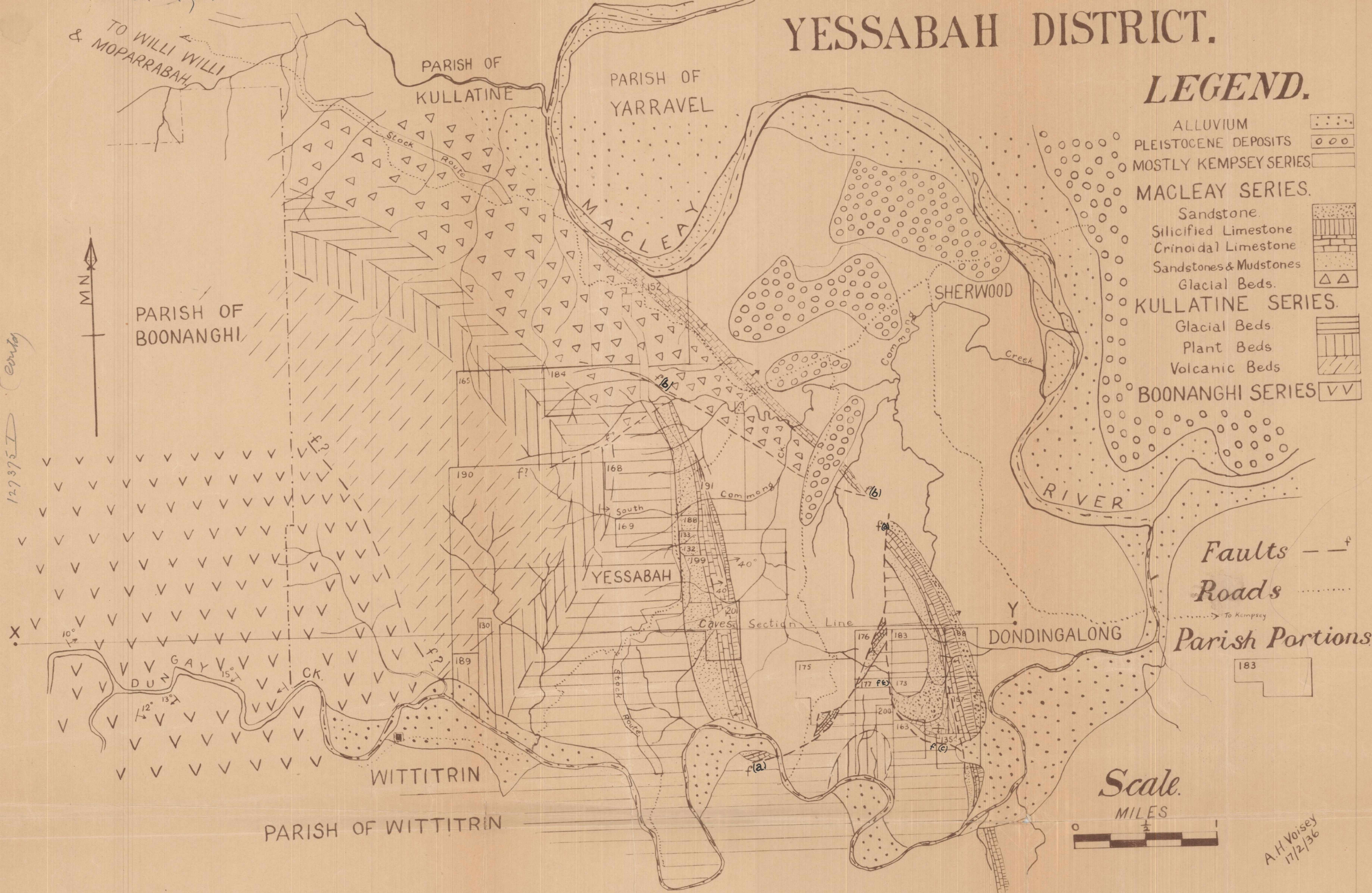
5 maps

to accompany

M. Sc. 1936 :

VOISEY, A. H

YESSABAH DISTRICT.



CORRELATIONS.

Owing to the lack of an established palaeontological standard with which collections of fossils might be compared it is unsafe for anyone to attempt detailed correlations of the Upper Palaeozoic beds in Eastern Australia. This standard can be built up after a great deal of field-work has been carried out. During the last seven years, the writer has made every effort to obtain material which could be used in such a compilation.

The greatest obstacle has been the difficulty of correlation between areas on other than palaeontological grounds. Two main connecting links have been used. The Macleay and Hunter Districts have been correlated because of basal glacial beds, (Woolnough 1911, Voisey 1934), and the fact that each overlies a fresh-water Series composed of comparable stages (i.e., glacial beds, Rhacopteris - Aniemites beds, and volcanic beds). Drake, Silverwood and the Lower Bowen Series of Queensland have been correlated by means of a volcanic stage which exhibits unusual and distinctive characteristics in each case. Support for this correlation is to be found in the statements of Richards and Bryan (1923, 1924) and Reid (1930). The interbedded marine sediments and the occasional plant beds, to say nothing of the petrological features of the volcanic suite, lend weight to this argument.

To connect the Macleay and Drake Districts on lithological grounds is possible only in a very general way as the sediments are similar only because they belong to what is regarded as the "Permian" type as opposed to the "Carboniferous" type. The change in the nature of the Lower Marine sediments from those in the Carboniferous has been noted elsewhere - Reid (1930b, p.50) states that, "Geological Survey work in Queensland seems to indicate a marked, wide-spread, and apparently almost constant difference in the marine sediments of the Carboniferous transition, ('Carboniferous type') as opposed to those of the 'Bowen Series' ('Permian type'). The former are prevailingly fine-grained, usually dark to black densely consolidated muds; the latter normally are light-coloured, coarser grained sandstones, etc., and weathering with exceeding rapidity.

"These types are constant for both the Lower and Middle Bowen Marine Sediments in the Great Syncline over a distance of about 400 miles from Collinsville to Springsure."

These generalisations, with regard to the Queensland Permian beds, hold good for New South Wales. This is strikingly shown in a comparison between the Drake Series and the Emu Creek Series.

Resort to palaeontology indicates that the Macleay Series and the Drake Series may be correlated in a general way and for the present this is all that is desired. With regard to more specific correlations on faunal evidence, it is of interest to note the correlation made by J.H. Reid between the Dilly Stage and the New South Wales Lower Marine (Reid, 1932, p.62). He states also:

> "Considering the association of *Linoproductus springsurensis*, *Productus* (?) *subquadratus*, *Aviculopecten mitchelli* and *Eurydesma* as strongly indicative of Dilly age, with the reservation that the evidence cannot yet be considered conclusive that they.