GEOLOGICAL SURVEY OF VICTORIA

BULLETIN NO. 55

A. N. CARTER, M.Sc.

TERTIARY FORAMINIFERA

From the

AIRE DISTRICT, VICTORIA

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D. E. THOMAS, D.Sc.
Chief Government Geologist

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TERTIARY FORAMINIFERA FROM THE AIRE DISTRICT, VICTORIA

Issued by
J. B. Tilley, Secretary for Mines

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The Hon. W. J. Mibus, M.L.A., Minister of Mines
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1958

FOREWORD.

The study of foraminifera is of prime importance in the correlation of strata which are water-bearing and in petroliferous areas, strata which are oil-bearing.

Many species are short-lived and the presence of foraminifera can fix the age of beds whether exposed at the surface or penetrated during drilling operations, with a high degree of precision. Since oil and water-bearing formations are often confined to strata of a particular age, the fixing of the age of the rock likely to yield these essential mineral substances is of great importance. As many of these foraminifera are characteristic and are confined to beds of a certain age, they can be used for correlating with beds containing the same organisms not only in other parts of Victoria and Australia but also in other parts of the world.

The presence of certain species in samples from widely different localities can indicate the limits within which useful surface and drilling investigations should be confined. Studies of this kind are therefore of major economic importance and can lead to considerable saving of both time and money in the search for both oil and underground water.

During his study of these micro-organisms, Mr. Carter has identified new forms and these together with some other useful foraminifera are described and figured.

D. E. THOMAS,
Chief Government Geologist.

ABSTRACT

The Lower Tertiary marine sedimentary rocks of the Aire district, near Cape Otway, Victoria, are briefly described and their relationships discussed, with particular reference to their foraminiferal contents. Correlations are made with an hitherto unreported occurrence of Eocene clays at Apollo Bay, Victoria; with the Torquay and Port Phillip regions and with the Maslin Bay-Port Willunga sequence in South Australia. The place of the sequence in relation to standard Lower Tertiary chronology is also discussed.

Sixty-five species of foraminifera from these beds have been identified and their stratigraphical ranges determined. Thirty-eight species have been described in detail and figured. Of these, the following eleven are described as new species: *Vaginulinopsis acanthonucleus, Spirillina medioscabra, S. tuberosa, Heronallenia parri, Cibicides brevoralis, Anomalinoides procolligera, Planorbulinella johannae, Astrononion centroplax, Elphidium centrifugalis, Notorotalia crassimura, Lamarckina airensis.*

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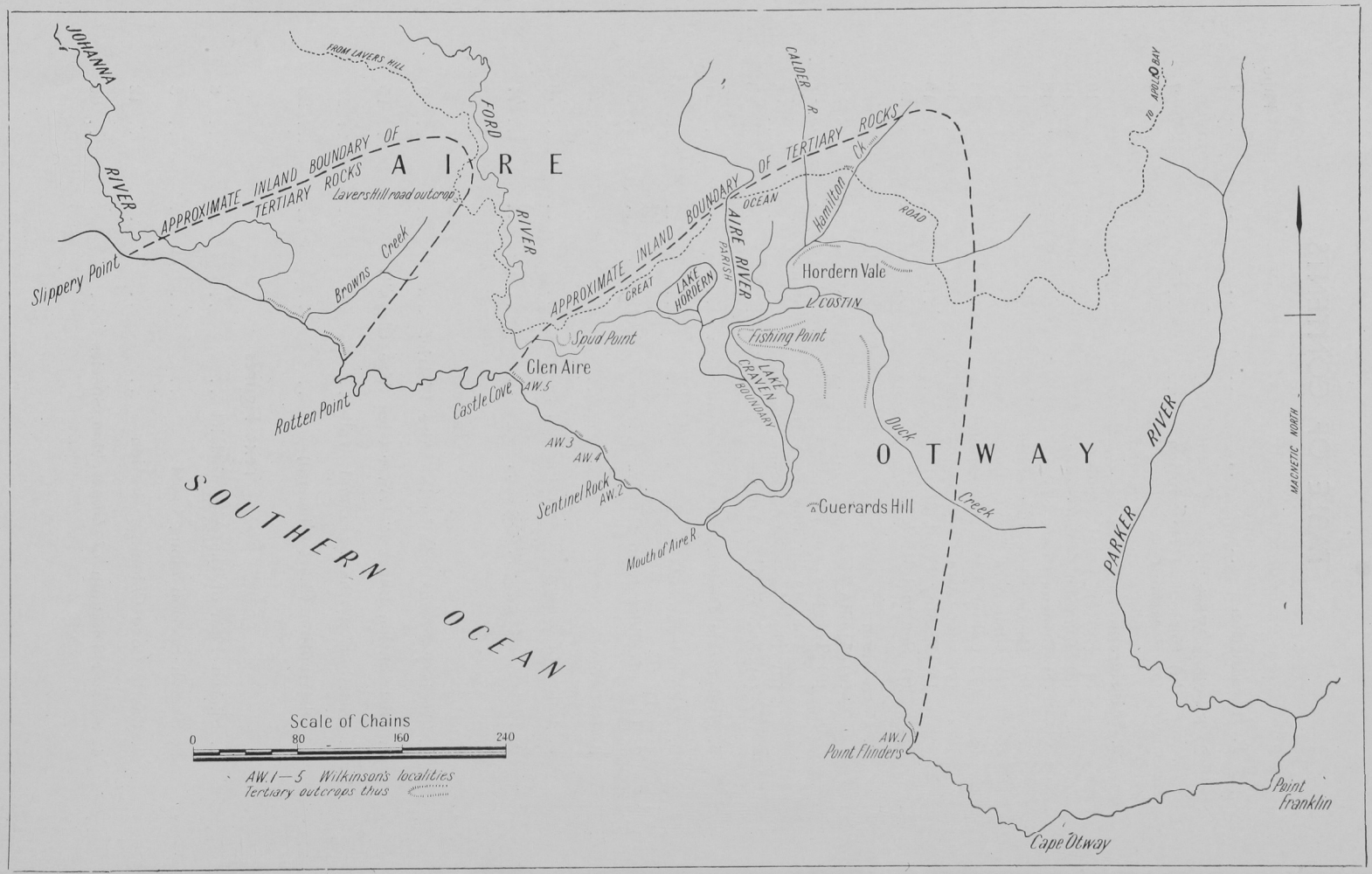


Text Fig. 1. SKETCH MAP OF THE AIRE DISTRICT. Parishes of Aire and Otway

1. INTRODUCTION.

The Tertiary rocks of the Aire district occur in two roughly triangular areas extending inland from the 8 miles of coastline between Cape Otway and the mouth of the Johanna River (Text Fig. 1). Elsewhere they are bounded by the Jurassic rocks of the Otway Ranges. The stratigraphic sequence for the area has been compiled from the correlation of scattered outcrops (Table 1), because outcrops are rarely continuous for more than a few hundred yards and at no locality is the complete sequence exposed. Certain localities are referred to by the field numbers AW. 1-AW. 5. (Wilkinson 1865).

Rock samples collected from all the localities shown in Table 1 have been examined and certain foraminifera, selected chiefly because they exhibit restricted stratigraphic ranges, have been carefully studied.

2. PREVIOUS WORK.

(*a*) *Geological Description.*

Of the work recorded in previous papers, three items may be mentioned as having a specific bearing on the present paper. Wilkinson (1865), published a sketch section along the coast between Castle Cove and the mouth of the Aire River. This has been amended and amplified. (Text Fig. 2). The sequence at AW. 4 was described and measured by Hall and Pritchard (1899), and that between Rotten Point and the mouth of the Johanna River was described and measured by Raggatt and Crespin (1952, 1955).

Field work in the district, begun about twelve years ago by the late Dr. F. A. Singleton, is being continued by his son, Dr. O. P. Singleton, and an account of the stratigraphy and structure is expected to appear in the near future.

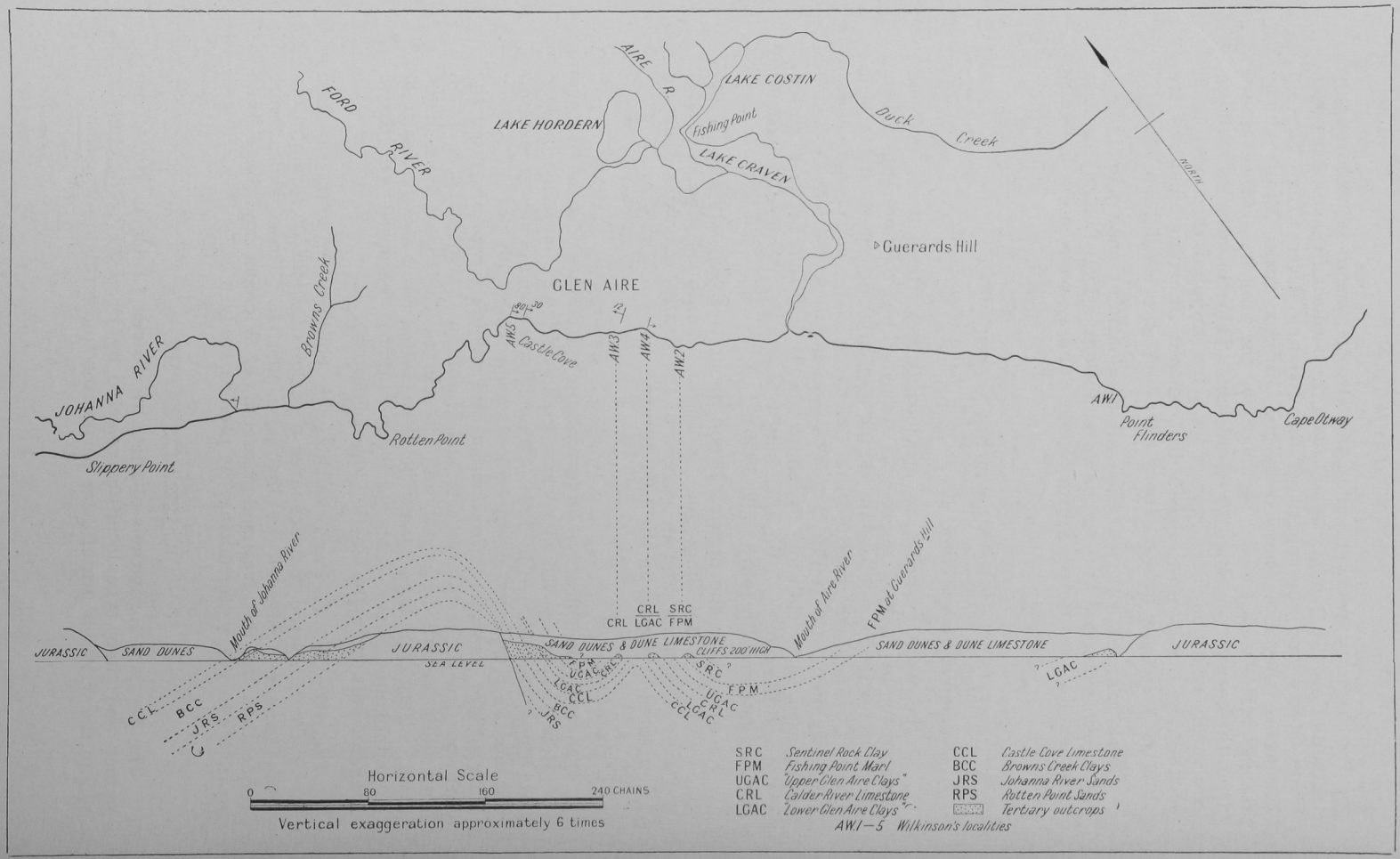
(*b*) *Foraminifera.*

The first identification of foraminifera from the district was by W. Howchin, whose list of species from AW.1 was published by Tate and Dennant (1895). In 1904, Chapman described some arenaceous foraminifera collected from near Browns Creek by A. E. Kitson. Parr (1947), described *Hantkenina alabamensis compressa* from the Browns Creek coastal sections and Hamilton Creek, and also listed associated genera. Raggatt and Crespin (1952, 1955), have listed foraminifera from the sequence between Rotten Point and the mouth of the Johanna River. Mary Wade (1955), recorded *Crespinina kingscotensis* from the Castle Cove Limestone.

The late W. J. Parr, working in conjunction with the late Dr. F. A. Singleton had prepared a series of slides of foraminifera from samples collected in the Aire district. These slides were bequeathed to the National Museum of Victoria and have been available to the writer during the present study.

3. STRATIGRAPHY.

The Tertiary formations of the Aire district (Table 1), have been named and their type localities selected by Dr. O. P. Singleton, to whom the writer is grateful for permission to use this information.



Text Fig. 2.—SKETCH SECTION ALONG COAST

In this paper, the emphasis has been placed on the distribution of selected foraminiferal species in the sequence, in view of Dr. Singleton's forthcoming paper on the stratigraphy and general geology, but some reference to the stratigraphy has been unavoidable.

Table 1.

TABLE OF TERTIARY FORMATIONS IN THE AIRE DISTRICT

Formational names after O. P. Singleton, unpublished.

Thickness. (feet)	Formation.		Localities at which Formations are Exposed.
?	Sentinel Rock Clay		Sentinel Rock (AW.2)
50 +	Fishing Point Marl		Fishing Point Guerards Hill Castle Cove Sentinel Rock (AW.2)
108	Glen Aire Clays of O.P.S. at Castle Cove	"Upper Glen Aire Clays"	Castle Cove Calder River Duck Creek
54 ±		Calder River Limestone ..	Calder River, Duck Creek, AW.3, AW.4, Spud Point Castle Cove
67		"Lower Glen Aire Clays"	Castle Cove (AW.4) Duck Creek (AW.1)
85	Castle Cove Limestone		Castle Cove Mouth of Johanna River
160	Browns Creek Clays		Browns Creek and nearby coastal sections Hamilton Creek Castle Cove Laver's Hill road
80	Johanna River Sands		Coastal section between Rotten Point and Browns Creek Castle Cove (base of sequence)
84	Rotten Point Sands		Rotten Point

The views expressed in this paper on the sequence of formations and the correlation of certain beds are those held by the writer after study of the foraminifera and are not necessarily those of Dr. Singleton.

Sample numbers bearing the prefix " CC " are shown on the Castle Cove columnar section and slide numbers bearing the prefix " NMV " are from the Parr Collection in the National Museum of Victoria.

(*a*) Rotten Point Sands

On the western side of Rotten Point, variegated sands of this formation, in which no fossils have been found, overlie the Jurassic sandstone. Raggatt and Crespin (1952, 1955) record a thickness of 84 feet for these beds.

(*b*) Johanna River Sands

Overlying the Rotten Point Sands between Rotten Point and the mouth of Browns Creek are fine-grained grey and pale purplish sands containing tests of *Cyclammina* spp. in at least one bed. This is apparently the formation from which Chapman (1904) described a fauna of arenaceous foraminifera. Raggatt and Crespin (1955) record these beds as being 80 feet in thickness.

Capping the Johanna River Sands at the mouth of Browns Creek, there is a layer of hard ferruginous sandstone, above which is a covered interval of about 30 feet.

At the base of the sequence at Castle Cove, a bed of black carbonaceous silt, standing almost vertically and containing decomposed tests of *Cyclammina* spp., abuts against the Jurassic. This bed is correlated with the Johanna River Sands and it is overlain by ferruginous sandstone, above which again, there is a covered interval.

(*c*) Browns Creek Clays

In the valley of Browns Creek and the coastal sections between the mouth of the creek and the base of the limestone which crops out at the mouth of the Johanna River, there is a sequence of approximately 160 feet of dark grey sandy clays, greensand, glauconitic clays and bryozoal marls, which has been described by Raggatt and Crespin (1955, p. 134).

Within the Browns Creek Clays, a twofold faunal division can be recognized, certain species being present in the lower division but not in the upper one and vice versa. The elaboration of this division must await a more detailed sampling of the section and further study of the foraminifera. The most characteristic species of the lower part of the sequence are *Hantkenina alabamensis compressa* Parr, *Asterigerina adelaidensis* (Howchin) and the continuously-ribbed form of *Vaginulinopsis acanthonucleus* n.sp. Other important species at higher levels in the formation are *V. acanthonucleus* (s.str.), *Lamarckina airensis* n.sp., and *Globigerina linaperta* Finlay. *Globigerinella micra* (Cole) occurs throughout the formation but is restricted to it. *Globigerinoides index* Finlay, *Cibicides pseudoconvexus* Parr, *Anomalina perthensis* Parr and *Gümbelina rugosa* Parr are common throughout the formation but range higher.

Portion of the sequence at Castle Cove is correlated with the Browns Creek Clays (Text Fig. 3). The lowest exposed bed of this unit is a dark grey glauconitic clay containing a fauna (slide N.M.V. 14975) which is similar in every respect to that of dark grey coarse sandy clays about 100 feet above the greensand in the Browns Creek coastal section.

At Castle Cove, above the dark clays are buff clays and thin intercalated limestone beds which are more continuously exposed and contain a foraminiferal fauna which is identical with that in light brownish-grey bryozoal marls recently found exposed beneath the limestone at the mouth of the Johanna River. *Crespinina kingscotensis* Wade occurs rarely near the top of this formation at Castle Cove. (Sample CC.9.)

Outcrops at Hamilton Creek and in a cutting beside the Great Ocean Road between Glen Aire and Lavers Hill are correlated with the Browns Creek Clays.

(*d*) Castle Cove Limestone

This formation is typically developed at Castle Cove as a sequence of hard limestone beds with intercalations of sands composed of quartz, limonitic and calcareous grains, with very little clay. Details are given in Text Fig. 3.

The overall assemblage of foraminifera in the soft beds is fairly uniform, though the relative abundance of the different species varies from bed to bed. The distinctive species are as follows: *Cibicides pseudoconvexus* Parr, *Anomalina perthensis* Parr, *Crespinina kingscotensis* Wade, *Planorbulinella johannae* n.sp., *Vaginulinopsis acanthonucleus* n.sp., *Cibicides temperata* Vella *Globigerinoides index* Finlay and *Globigerina linaperta* Finlay. The highest known occurrence of *G. index* is sample CC.19.

Pelagic foraminifera are rare and apparently were largely excluded from the environment of sedimentation of the Castle Cove Limestone. *Globigerinella micra* and *Gümbelina* have not been found in the formation.

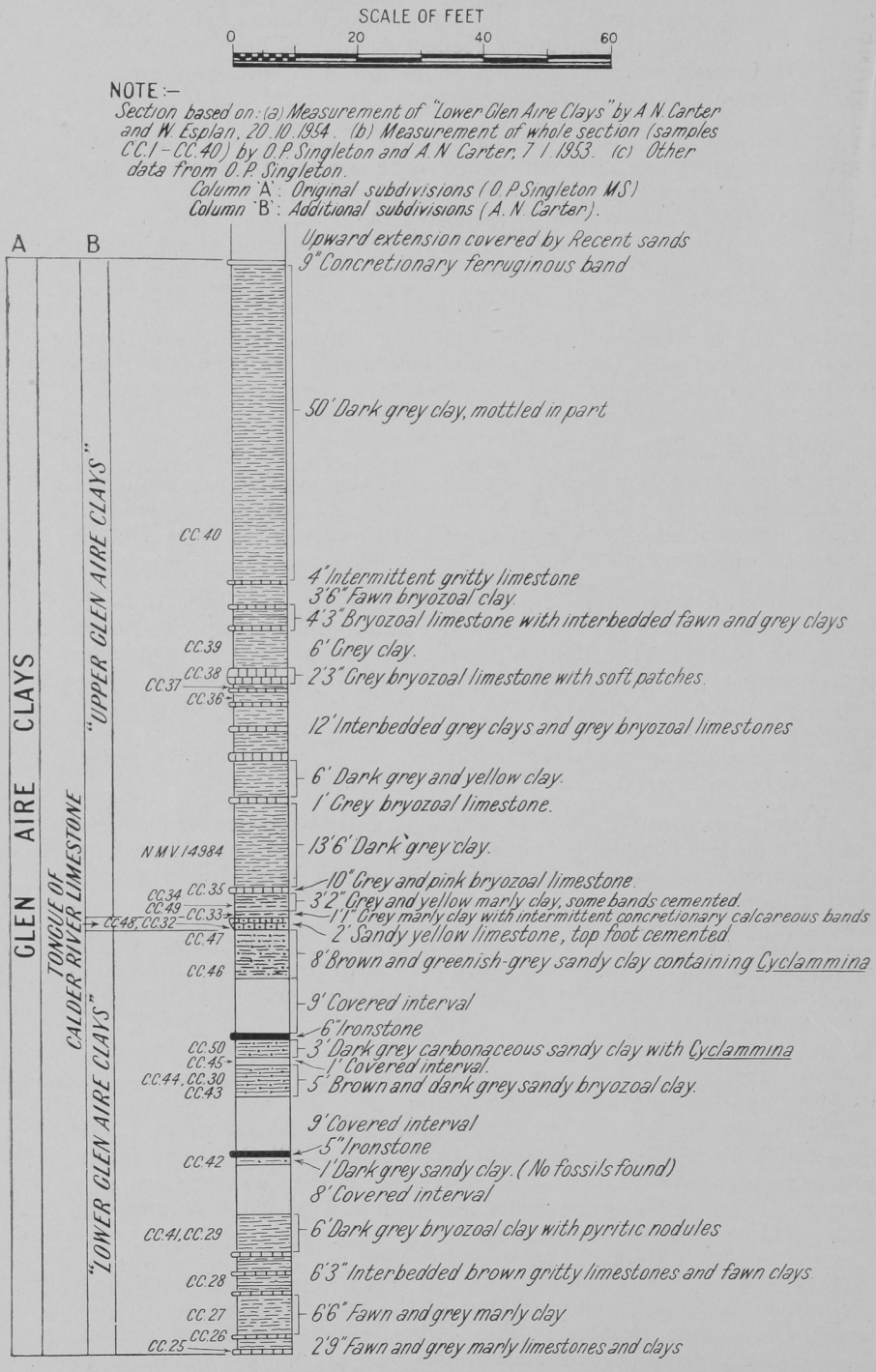
The limestone which overlies the Browns Creek Clays at the mouth of the Johanna River is correlated with the Castle Cove Limestone, because its foraminiferal fauna is identical with that described from Castle Cove.

(*e*) Glen Aire Clays (Lower Beds)

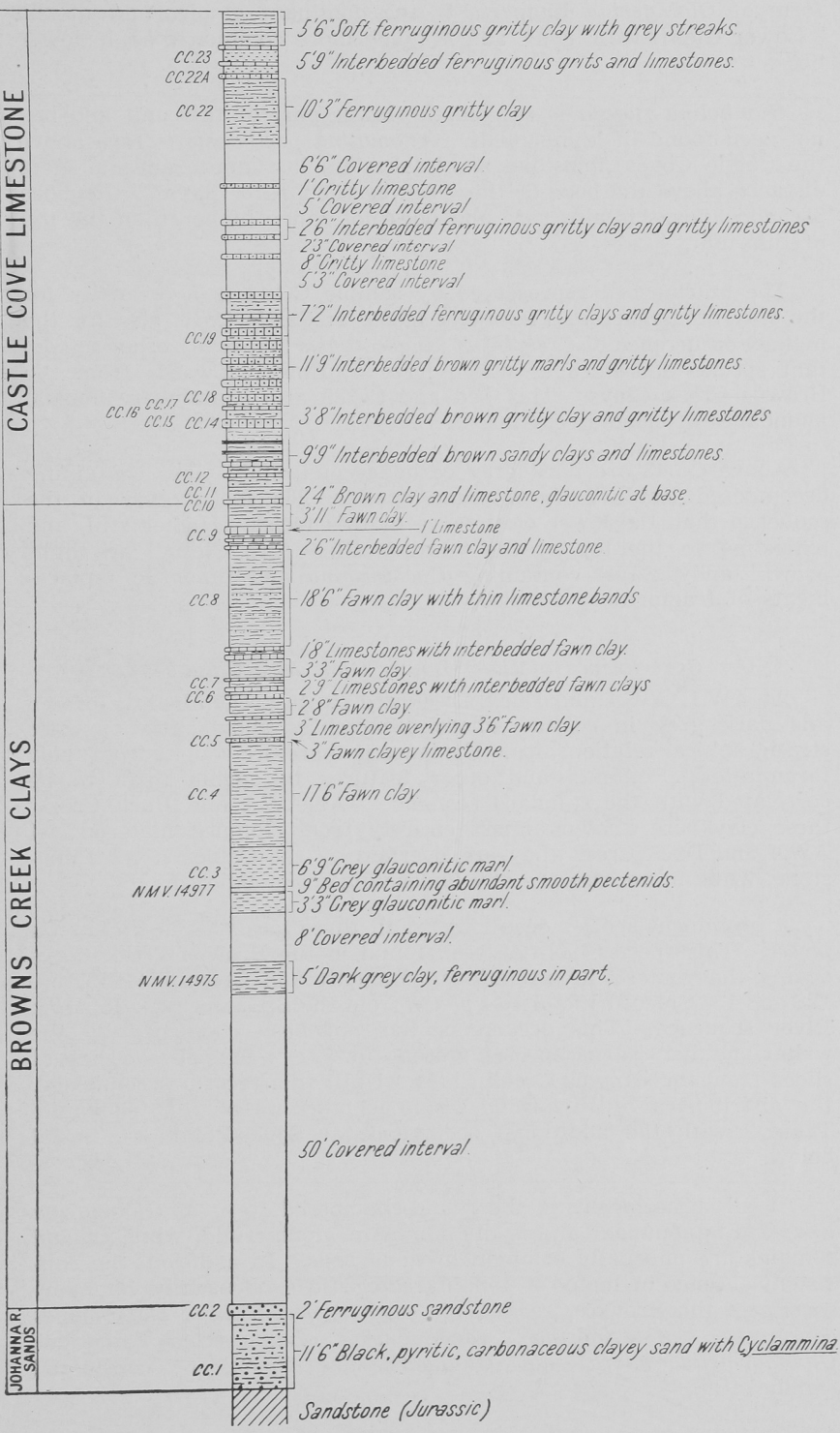
The lower 67 feet of Dr. Singleton's Glen Aire Clays at Castle Cove are here distinguished on the basis of both lithology and fauna. For convenience, these beds are referred to as the "Lower Glen Aire Clays." The lithological sequence is shown in Text Fig. 3 and certain of its features are discussed below.

At the base of this unit, the lithology and foraminiferal assemblage are both of a facies similar to that of the upper part of the Browns Creek Clays, but *Globigerinoides index, Globigerinella micra* and *Lamarckina airensis* are noticeably absent and *Vaginulinopsis acanthonucleus* is of occasional occurrence. The round-chambered

COLUMNAR SECTION AT CASTLE COVE



Text Fig. 3—Upper Part



Text Fig. 3—Lower Part

form of *Globigerina linaperta* is the dominant globigerinid of the "Lower Glen Aire Clays" and is much more common than in lower beds.

Gümbelina rugosa is rare in the lower part of this unit and has not been found in higher beds. *Anomalina perthensis* is rare above the Castle Cove Limestone and makes its last appearance a short distance above the base of the "Lower Glen Aire Clays." *Cibicides pseudoconvexus* is also rare and does not range higher than the top of this unit.

The marine bed represented by sample CC.43 is noteworthy for the only occurrence of *Victoriella plecte* at Castle Cove, also for the highest occurrence of *Crespinina kingscotensis* and many other important species and lineages which have continued upwards from the Browns Creek Clays. This bed and CC.29 also contain an unusual abundance of crinoid remains.

Above CC.43 are dark grey carbonaceous sandy clays containing decomposed tests of *Cyclammina* species, 265 feet higher in the sequence than the lower occurrence of this facies. Higher still, and extending to the top of the "Lower Glen Aire Clays" are light brown sandy clays, containing *Cyclammina* and limonitic replacements of fragmentary fossils.

Correlatives of the "Lower Glen Aire Clays".

At AW.1, AW.4 and Duck Creek are clays, predominantly brown and dark grey in colour, whose occurrences show little of their stratigraphical relationships. Evidence is therefore sought from their foraminiferal contents and other features to enable them to be correlated with the standard sequence. At AW.1 and Duck Creek, these clays are known almost entirely from slumped material; at AW.4 and Duck Creek they are overlain by the Calder River Limestone, while in no case are any underlying rocks exposed.

A prominent species occurring at all three localities is *Victoriella plecte*. This species has not been found in the Browns Creek Clays during the writer's investigations. Raggatt and Crespin (1955, pp. 128 and 134) record *Victoriella plecte* from the Browns Creek-Johanna River sequence. This occurrence has not been confirmed by the writer, neither is the species present in Parr's extensive series of slides from the Browns Creek Clays. Until this record is confirmed, the distribution of *Victoriella plecte* is taken to be that shown in Table 2 with the additional occurrence at Spud Point, mentioned below.

At all three localities, the round-chambered form of *Globigerina linaperta* is abundant and is the dominant globigerinid, while crinoid remains are unusually common in some beds. In addition, the consistent absence of many of the characteristic (and usually common) species of the Browns Creek Clays, such as *Hantkenina alabamensis compressa, Asterigerina adelaidensis, Lamarckina airensis, Globigerinella micra* and *Globigerinoides* index, is considered significant.

Table 2.

—	Browns Creek Clays.	Castle Cove Limestone.	"Lower Glen Aire Clays" CC.27 and CC.28.	"Lower Glen Aire Clays" CC.29 and NMV. 14980.	"Lower Glen Aire Clays" CC.30 and CC.43.	AW.4 "4 ft. Grey Clay rich in fossils."	Duck Creek Lower Beds.	AW.1.
Victoriella plecte	..	..	..	..	*r*	*c*	*c*	*r*
Globigerina linaperta (round-chambered form)	..	..	*c*	*a*	*a*	*a*	*a*	*a*
Vaginulinopsis acanthonucleus	*r*	*r*	*r*	*r*	..	*c*	*c*	*c*
Cibicides pseudoconvexus ..	*c*	*a*	*r*	*r*	..	*r*	*c*	*r*
Anomalina perthensis ..	*c*	*a*	*r*	..	..	..	..	*r*
Gümbelina rugosa ..	*c*	..	*r*	*r*	..	..	..	*r*
Crespinina kingscotensis ..	*r*	*c*	*r*	..	*r*	..	..	..
Planorbulinella johannae ..	..	*c*	..	..	..	..	..	..
Globigerina linaperta (s. str.)	*c*	*r*	..	..	..	..	..	..
Lamarckina airensis ..	*c*	..	..	..	..	..	..	..
Globigerinoides index ..	*c*	*r*	..	..	..	..	..	..
Globigerinella micra ..	*r*	..	..	..	..	..	..	..
Asterigerina adelaidensis ..	*r*	..	..	..	..	..	..	..
Hantkenina alabamensis compressa	*r*	..	..	..	..	..	..	..

Distribution chart of selected foraminiferal species on which is based the correlation of the lower beds at AW.4 and Duck Creek and the clays at AW.1 with the "Lower Glen Aire Clays".

a = abundant, *c* = common, *r* = rare.

The brown and dark grey clays at AW.1, AW.4 and Duck Creek are consequently correlated with the "Lower Glen Aire Clays" on the basis of the distribution of foraminifera shown in Table 2 and the following features which are common to all:

(i) The abundance of the round-chambered form of *Globigerina linaperta.*

(ii) The abundance of crinoid remains, including stem joints of striking appearance, not found elsewhere in the sequence.

(iii) The occurrence of *Victoriella plecte* which is apparently restricted.

(iv) The occurrence of a bed of tough grey clay containing long, unbranched bryozoan filaments, 21 feet below the top of the clays at AW.4 and an almost identical bed 40 feet below the top of the "Lower Glen Aire Clays" at Castle Cove.

(v) The rarity of *Anomalina perthensis* and *Cibicides pseudoconvexus.*

(vi) The absence of *Hantkenina alabamensis compressa, Asterigerina adelaidensis, Lamarckina airensis, Globigerinella micra* and *Globigerinoides index.*

(vii) The absence of any beds which are richly glauconitic.

(*f*) Calder River Limestone (= "The Calder Limestones" of Hall and Pritchard, 1899.)

Typically developed along the east bank of the Calder River, north-west of Hordern Vale, the Calder River Limestone contains a sparse and poorly-preserved fauna in which the following species have been identified: *Sherbornina atkinsoni* Chapman, *Astrononion centroplax* n.sp., *Notorotalia crassimura* n.sp., *Calcarina mackayi* (Karrer), *Gypsina globulus* (Reuss), *Amphistegina* sp., *Carpenteria* sp. At the type locality, the Calder River Limestone is overlain by clays which are correlated with the "Upper Glen Aire Clays" (see below).

The Calder River Limestone is principally composed of fairly coarse comminuted particles of organic calcium carbonate, predominantly bryozoal, but it also contains appreciable quantities of quartz sand, much of which is highly polished.

The underlying beds are not visible at the type locality, but nearby, on the west side of Duck Creek, the undoubted extension of the Calder River Limestone overlies dark grey and brown clays which are correlated with the "Lower Glen Aire Clays." Similarly, at AW.4, Calder River Limestone overlies clays which are correlated with the "Lower Glen Aire Clays." At Castle Cove, the "Lower Glen Aire Clays" are directly overlain by a bed of sandy bryozoal limestone, 2 feet in thickness, which is believed to be a tongue of Calder River Limestone both on account of its distinctive lithology and its foraminiferal fauna. The lithology is very similar to that of the Calder River Limestone elsewhere and it contains *S. atkinsoni, N. crassimura and A. centroplax. Globoquadrina dehiscens* has not been found although a considerable quantity of material (samples CC.32 and CC.48) has been examined and pelagic species are quite plentiful.

The limestone which forms Spud Point (see Hall and Pritchard, 1899) contains *Victoriella plecte* Chapman, *Sherbornina atkinsoni* Chapman, *Astrononion centroplax* n.sp., and *Amphistegina* sp. The latter species is the commonest foraminifer at Spud Point. Although the specimens of *Victoriella plecte* are always broken and abraded, there is no reason to doubt that they are indigenous to the limestone, which is correlated with the Calder River Limestone.

At AW.3, a clay intercalation near the top of the limestone has yielded a rich foraminiferal fauna including all the species elsewhere recorded from the Calder River Limestone with the exception of *Victoriella plecte. Sherbornina atkinsoni, Notorotalia crassimura* and *Astrononion centroplax* are common and, although a large quantity of material from this bed has been searched, no specimens of *Globoquadrina dehiscens* have been found.

Spiroloculina canaliculata d'Orbigny and *Lamarckina glencoensis* Chapman and Crespin have not been found in the Calder River Limestone.

Relationships of Calder River Limestone to Underlying Strata.

The Calder River Limestone is considered by the writer to be a lenticular formation overlying the "Lower Glen Aire Clays." It is at least 54 feet in thickness at AW.4 (Hall and Pritchard, 1899), but apparently thins towards the Jurassic and is only 2 feet in thickness at Castle Cove.

The characteristic foraminiferal species of the "Lower Glen Aire Clays," many of which have ranged upwards from the Browns Creek Clays, are almost completely absent from the overlying Calder River Limestone and "Upper Glen Aire Clays," in which a very different fauna is present. The lower and upper groups of strata may be designated the "Zone of *Globigerina linaperta*" and the "Zone of *Astrononion centroplax*" respectively. Although the ranges of *G. linaperta* and *A. centroplax* are mutually exclusive in the Aire district, until more is known about their ranges elsewhere, no conclusion can be drawn as to whether the sharp contact between the "Lower Glen Aire Clays" and the Calder River Limestone represents merely a lithological change in a continuous sequence or a diastem. The latter alternative seems more likely.

Relationships of Calder River Limestone to Overlying Strata.

The "Upper Glen Aire Clays" follow in the sequence above the Calder River Limestone without any visible stratigraphic break. *Globoquadrina dehiscens* is present in clays immediately overlying Calder River Limestone at all localities where the junction is exposed, namely Calder River, Duck Creek and Castle Cove but it has not been found in the Calder River Limestone.

Occurrences of *Sherbornina atkinsoni* and *Notorotalia crassimura* in association and in considerable numbers are restricted to the Calder River Limestone and to clays immediately overlying it, including Castle Cove (sample CC.33). The only known higher occurrence of *S. atkinsoni* is a solitary specimen in sample CC.40 and *N. crassimura* is not known higher than sample CC.36.

(*g*) Glen Aire Clays (Upper Beds)

This unit, comprising the upper 106 feet of Dr. Singleton's Glen Aire Clays, and referred to hereafter as the " Upper Glen Aire Clays," consists of the more or less continuously exposed sequence overlying the 2 feet bed of sandy limestone which in turn overlies brown sandy clays with *Cyclammina* (the top of the " Lower Glen Aire Clays ") at Castle Cove (Text Fig. 3).

The writer considers it important to view the " Upper Glen Aire Clays " and the Fishing Point Marl as non-overlapping parts of a continuous sequence of dominantly argillaceous sediments with thin limestone intercalations, whose lower portion is exposed at Castle Cove where the upward extension is almost completely covered by Recent sands. Its upper portion is exposed at Fishing Point, where the downward extension is covered by slumped material and alluvium. It is the writer's personal recommendation that the formational name —Glen Aire Clays—be restricted ultimately to the unit called " Lower Glen Aire Clays " in this paper and that the " Upper Glen Aire Clays " be included in the Fishing Point Marl. A borehole section at Fishing Point would be a desirable preliminary to such a change.

The " Upper Glen Aire Clays " at Castle Cove consist of light grey and buff bryozoal marls and clays with thin limestine intercalations. At the base, the beds contain *Sherbornina atkinsoni* Chapman, *Astrononion centroplax* n.sp., *Notorotalia howchini* (Chapman, Parr and Collins), *N. crassimura* n.sp., with the important addition of *Globoquadrina dehiscens* (C., P. & C.) to the fauna. In addition to the above association, the "Upper Glen Aire Clays " contain the following foraminifera: *Spiroloculina canaliculata* d'Orbigny, *Lamarckina glencoensis* Chapman and Crespin, *Anomalinoides procolligera* n.sp., *Discorbis haliotis* Heron-Allen and Earland, *Gypsina globulus* (Reuss), *Calcarina mackayi* (Karrer) and *Amphistegina* sp.

At the type locality of the Calder River Limestone and at Duck Creek, the limestone is overlain by clays which contain *Sherbornina atkinsoni, Notorotalia crassimura, Astrononion centroplax* and *Globoquadrina dehiscens.* These clays are correlated with the " Upper Glen Aire Clays " and the dip shown by the Calder River Limestone in the area to the north and west of Hordern Vale would carry these *Sherbornina*-bearing clays well below the level of the alluvial flats at Fishing Point.

The palaeontological characteristics of the "Upper Glen Aire Clays " which distinguish that formation from the underlying Calder River Limestone are:

(*a*) The presence of *Lamarckina glencoensis.*

(*b*) The presence of *Globoquadrina dehiscens.*

(*c*) The diminishing frequency of occurrence of *Sherbornina atkinsoni* at successively higher levels in the " Upper Glen Aire Clays " after both being common in the bryozoal marls near the base.

(*d*) The absence of *Victoriella plecte.*

(*h*) Fishing Point Marl

At Fishing Point, a sequence of about 50 feet of brown and grey marls is exposed, though its base is not visible. At the top of the sequence are coarse bryozoal marls and thin, hard limestomes.

On the south-east side of Fishing Point, *Planorbulinella plana* (Heron-Allen and Earland) is present near the base of the section. At this level, *Astrononion centroplax* and *Lamarckina glencoensis* are present and *Globoquadrina dehiscens* is common. This bed is younger than the top of the Castle Cove columnar section (Text Fig. 3). Higher in the Fishing Point sequence, *Globigerinoides bispherica* Todd makes its first appearance and continues to the top. It is associated with *Astrononion centroplax* for a short stratigraphic interval before the latter disappears. The highest beds exposed are coarse friable marls and thin, hard limestones. The marls contain *Lepidocyclina* sp., *Cycloclypeus* sp., *Amphistegina* sp., *Gypsina howchini* Chapman, *Hofkerina semiornata* (Howchin), *Calcarina verriculata* (Howchin and Parr), *Operculina victoriensis* Chapman and Parr and *Globigerinoides bispherica* Todd.

At AW.2, Wilkinson (1865), reported fossiliferous marine clay underlying the "leaf bed" (Sentinel Rock Clay). One slide in the Parr Collection (NMV.15045) contains a small collection from this bed, including *Cancris* sp., which suggests correlation with the Fishing Point Marl. *Astrononion centroplax* is not present in this slide.

With the exception of the coarse-grained marl at the top of the Fishing Point section, the various beds of the formation contain foraminiferal assemblages in which pelagic species predominate numerically over benthonic species. In the "Upper Glen Aire Clays," however, benthonic species predominate. On the eastern side of Castle Cove, the upward extension of the sequence shown in Text Fig. 3, is permanently covered by Recent sand and fallen blocks of Pleistocene dune limestone from the cliffs, but on July 26, 1956, the writer observed and sampled three small ephemeral exposures approximately (*a*) 80, (*b*) 120 and (*c*) 200 yards respectively east of the top of the measured sequence. These outcrops gave no indications of dip and the gradually decreasing dip (eastwards) of the Castle Cove sequence makes it impossible to place these outcrops on the stratigraphic columnar section (Text Fig. 3). The foraminiferal assemblages of all three samples can be matched with samples from the Fishing Point cliffs. Sample (*b*) contains rolled bryozoan fragments, numerous large *Amphistegina* sp., *Operculina victoriensis, Gypsina howchini, Planorbulinella inaequilateralis, Sherbornina cuneimarginata, Astrononion .centroplax, Globigerinoides triloba* (common) and *G. bispherica* (rare). Sample (*c*) consists almost entirely of pure clay and pelagic foraminifera, including *Globigerinoides bispherica* (common), *G. triloba* (rare) and *G. rubra.* It is identical with the bed which underlies the coarse marl containing *Lepidocyclina* at Fishing Point.

Small exposures of fossiliferous marl in road cuttings near Guerards Hill are also correlated with the Fishing Point Marl.

(*i*) Sentinel Rock Clay

This formation is known only from Sentinel Rock on the coast about one and a half miles west of the mouth of the Aire River. It consists of leaf-bearing dark grey clays (see Deane, 1904) from which no marine fossils have been recorded.

4. CORRELATION

(*a*) Apollo Bay

At Apollo Bay, about fifteen miles north-east of the Aire district, dark grey glauconitic clays have been encountered on the sea floor about 100 yards off-shore during the testing of breakwater foundations by drilling. A small sample of this material received from Mr. C. O'Malley of the Victorian Public Works Department was found to contain a sparse foraminiferal fauna including *Globigerinella micra.* The submarine outcrop of this formation can be seen in Plate 1.

The writer has subsequently collected pebbles of fossiliferous clay from the beach on the western side of the breakwater at Apollo Bay, clearly derived from the same deposit. One of these, a dark grey glauconitic clay has yielded many of the restricted species of the Browns Creek Clays, including *Hantkenina alabamensis compressa, Globigerinoides index, Lamarckina airensis, Vaginulinopsis acanthonucleus, Globigerinella micra* and *Anomalina perthensis.* The deposit is therefore of Upper Eocene age and is correlated with the lower part of the Browns Creek Clays.

(*b*) Torquay and Port Philip Region

For purposes of correlation between the Aire district and Torquay, two associations of foraminifera are considered to be of particular importance. Firstly, there is the association ("a") of *Hantkenina alabamensis compressa, Globigerinoides index* and *Globigerinella micra* which, in the Aire district, is restricted to the lower part of the Browns Creek Clays and, secondly, the association ("b") of *Sherbornina atkinsoni, Astrononion centroplax, Anomalinoides procolligera* and *Lamarckina glencoensis* which occurs in the "Upper Glen Aire Clays." In the Aire District, these associations are mutually exclusive and separated by a stratigraphic interval of about 300 feet.

Raggatt and Crespin (1955, Table VII.) have recorded from one bed about 30 feet above the base of the exposed sequence at Bird Rock Bluff (near Torquay) a foraminiferal assemblage which includes associations "a" and "b" mixed together. Association "a" and its accompanying species in the Browns Creek Clays have been vainly sought in this bed (BR.5) by the writer. The assemblage found by him here and also lower in the sequence has invariably been association "b" and other species which do not occur below the Calder River Limestone in the Aire district.

On the basis of the mutually exclusive ranges in the Aire district of the two important foraminiferal associations mentioned above, it is claimed that *Hantkenina alabamensis compressa* and *Globigerinoides index* are not indigenous to the fauna of the Jan Juc Formation. This also applies to the other species shown to be restricted to BR.5 on Table VII. of Raggatt and Crespin.

At Torquay, a distinctive association of *Victoriella plecte, Sherbornina atkinsoni* and *Astrononion centroplax* is present in beds D to F of Raggatt and Crespin (1955, p. 94) at Bird Rock Bluff. The same association occurs in the Calder River Limestone at Spud Point. Although *Globoquadrina dehiscens* has not been recorded from the Torquay Group by Raggatt and Crespin (1955), the writer has found this species in the Puebla Formation (*Ancilla* Clays of Pritchard, 1923), but not lower in the sequence at Bird Rock Bluff. The mutually exclusive ranges of *Victoriella plecte* and *Globoquadrina dehiscens* at Torquay supports the contention that the Calder River Limestone is older than the "Upper Glen Aire Clays."

When the ranges of certain foraminifera in the Tertiary rocks of the Aire district, Torquay and the Port Phillip Basin are compared eleven faunal units can be recognized. They are shown in Table 3.

Sufficient is known of the stratigraphic occurrence of these faunal units for them to be, in effect, tentative foraminiferal zones. The writer does not wish to apply formal names to them until the stratigraphic sequences they represent are more precisely defined. They come within the category of geochronological units as defined by Jeletzky (1956) and since they are diagnosed largely by appearances of pelagic foraminifera, their limits are synchronous events throughout the region. Preliminary definitions of these geochronological units are as follows:

Unit 1 is represented by the lower part of the Browns Creek Clays in the Aire district. It is distinguished by the association of *Hantkenina alabamensis compressa* and *Globigerinoides index.*

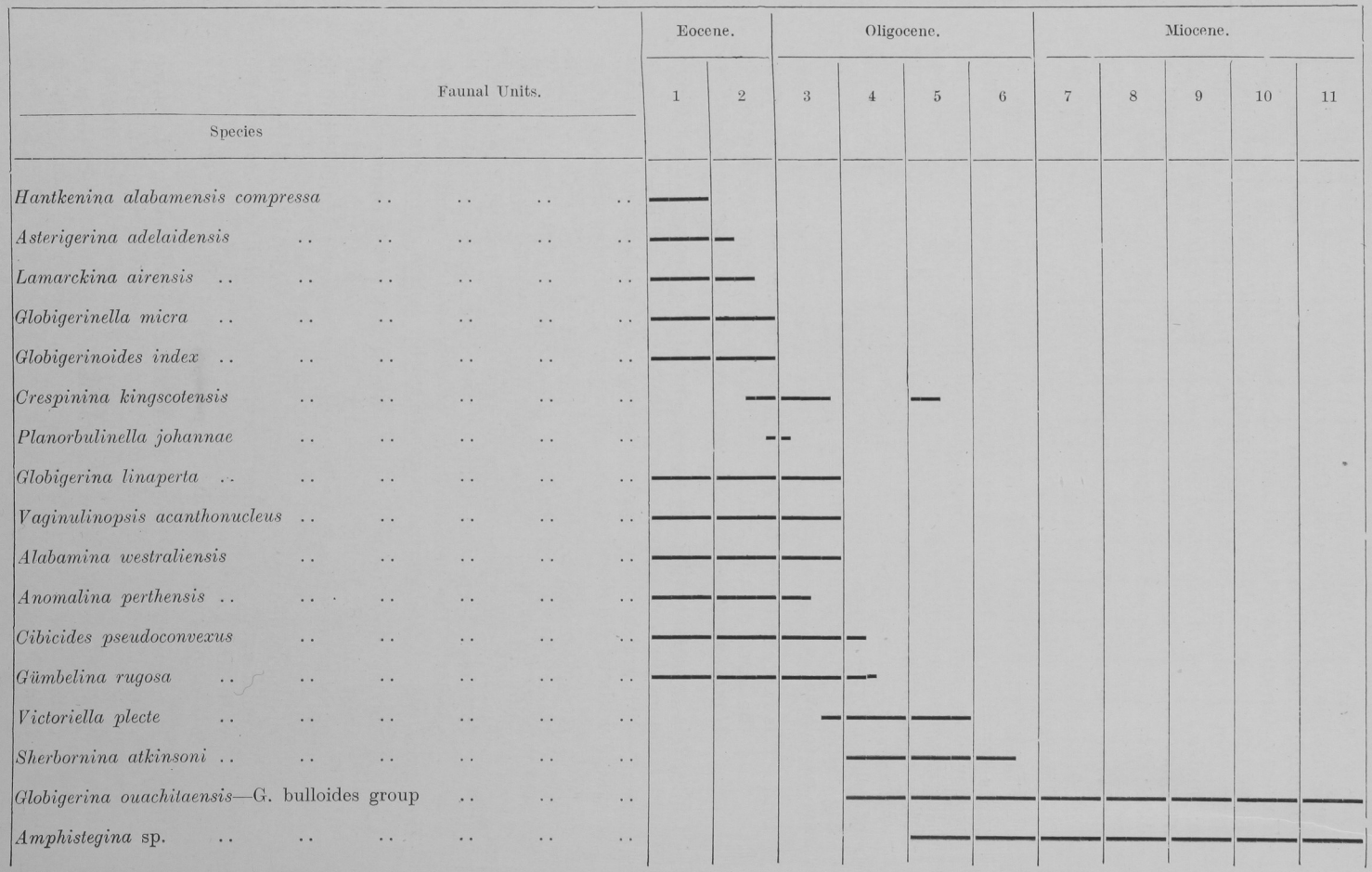
Unit 2 is represented by the upper part of the Browns Creek Clays and the lower part of the Castle Cove Limestone. It is distinguished by the occurrence of *Globigerinoides index* without *Hantkenina.*

Unit 3 is represented by the upper part of the Castle Cove Limestone and by the "Lower Glen Aire Clays." The overall fauna of Unit 3 is closely similar to that of Units 1 and 2 and is distinguished more by the absence of species restricted to these older units than by the appearance of "younger" species. The pelagic fauna of this unit is dominated by a form of *Globigerina linaperta* with swollen chambers.

Unit 4 Marine clays underlying the Point Addis Limestone on the west side of Bells Headland in the Torquay district apparently represent a zone intermediate between Units 3 and 5. Unit 4 has not been recognized in the Aire district. It is distinguished by the disappearance of *G. linaperta* and its replacement by another species of *Globigerina* comparable with *G. ouachitaensis* Howe and Wallace. *Sherbornina atkinsoni* makes its first appearance in this unit.

Unit 5 is represented by the Calder River Limestone in the Aire district and by the Jan Juc Formation at Torquay. This unit is distinguished by the appearance of *Astrononion centroplax.* The pelagic element of the fauna is unchanged from the preceding unit. *Victoriella plecte* has not been found higher than Unit 5.

Table 3.


Eocene.
Oligocene.
Miocene.
Faunal Units.
Species
1
2
3
4
5
6
7
8
9
10
11
Hantkenina alabamensis compressa
Asterigerina adelaidensis
Lamarckina airensis
Globigerinella micra
Globigerinoides index
Crespinina kingscotensis
Planorbulinella johannae
Globigerina linaperta
Vaginulinopsis acanthonucleus
Alabamina westraliensis
Anomalina perthensis
Cibicides pseudoconvexus
Gümbelina rugosa
Victoriella plecte
Sherbornina atkinsoni
Globigerina ouachitaensis—G. bulloides group
Amphistegina sp.


Calcarina mackayi
Lamarckina glencoensis
Astrononion centroplax
Globigerina ciperoensis
Globoquadrina dehiscens
Operculina victoriensis
Sherbornina cuneimarginata
Hofkerina semiornata
Planorbulinella plana
Planorbulinella inaequilateralis
Gypsina howchini
Globigerinoides triloba
Globigerinoides bispherica
Globigerinoides rubra
Globigerina apertura
Cyclolypeus victoriensis
Lepidocyclina (Trybliolepidina) sp.
Globigerinoides transitoria
Orbulina suturalis
Orbulina universa
Biorbulina bilobata
Cibicides victoriensis

Unit 6 is represented by the "Upper Glen Aire Clays" in the Aire district and by the "*Ancilla* Clays" (Pritchard, 1923) at Torquay. It is distinguished by the appearance of *Globoquadrina dehiscens* and *Globigerina ciperoensis* Bolli.

Unit 7 is represented by the lower part of the Fishing Point Marl in the Aire district and by part, if not all, of the "*Cellepora* Limestone" (Pritchard, 1923) at Torquay. It is distinguished by the appearance of *Globigerinoides triloba* which gives rise to *Globigerinoides bispherica* within this unit. *Globigerina apertura* Cushman also makes its first appearance here.

Unit 8 is represented in the Aire district by most of the upper part of the Fishing Point Marl, i.e. between the lowest occurrence of *Globigerinoides rubra* and the lowest occurrence of *Lepidocyclina*. At Torquay it is represented by the "*Scutellina* Limestone" (Pritchard, 1923) at Jan Juc Point and by clays and limestones at Point Danger and Yellow Bluff. The lower part of the Batesford Limestone is also assigned to this unit. This unit is distinguished by the appearance of *Globigerinoides rubra* and the highest occurrence of *Astrononion centroplax*.

Unit 9 is represented by the uppermost beds exposed at Fishing Point in the Aire district and in the Moorabool Valley by the *Lepidocyclina*-bearing upper part of the Batesford Limestone and the lower part (about 30 feet) of the Fyansford Clay. The only distinctive pelagic species is a form of *Globigerinoides triloba* with two large arched apertures at the base of the last chamber. The remainder of the pelagic fauna is indistinguishable from that of the preceding unit. *Lepidocyclina* sp. and *Cycloclypeus victoriensis* occur in this unit in suitable facies.

Unit 10 is represented by portion of the Fyansford Clay and has not been recognized in the Aire district. It is distinguished by the appearance of *Globigerinoides transitoria* Blow and *Orbulina suturalis* Bronnimann.

Unit 11 is represented by the upper part of the Fyansford Clay and by clays at Grice Creek and Dennant Creek on the eastern side of Port Phillip. It has not been recognized in the Aire district. It is distinguished by the appearance of *Orbulina universa* and *Biorbulina bilobata*.

(c) The Maslin Bay—Port Willunga sequence in South Australia

The Tertiary sequence between Maslin Bay and Port Willunga described by Reynolds (1953) and Glaessner (1953.a) and the sequence in the Aire district both exhibit features which suggest that similar successions of events occurred in the geological histories of the two areas. Direct correlation of the two rock sequences is not possible at present and is not implied in this paper.

Each sequence begins with sands in which no marine fossils have been found—the North Maslin Sands and the Rotten Point Sands respectively. Glaessner (1953.a, pp. 38, 40) has reported lateritization

at the top of the North Maslin Sands and the uppermost portion of the Rotten Point Sands is conspicuously ferruginous. (Raggatt and Crespin, 1955, p. 134).

Dominantly sandy beds of a restricted marine facies follow in each sequence—the South Maslin Sand and the Johanna River Sands. Glaessner (1953.a, pp. 39, 40) considers possible lateritization to have occurred at the top of the South Maslin Sand and the Johanna River Sands are capped by a bed of ferruginous sandstone at the mouth of Browns Creek and at Castle Cove.

In both areas, the sands are followed by marine sequences—Tortachilla Limestones and " Transitional Marls " in South Australia and the Browns Creek Clays in the Aire district—each of which contains *Hantkenina* and is richly glauconitic in some beds.

The next-highest unit in each sequence is prominently banded (" Banded Marls " and Castle Cove Limestone), suggesting alternation of environmental conditions at the time of deposition. *Globigerinoides index* occurs in the Castle Cove Limestone and it has been found by the writer in the " Banded Marl ", though the upper limit of the range of this important species in South Australia is not recorded.

The succeeding unit in each area consists predominantly of dark grey argillaceous rocks—the " Soft Marls " and the " Lower Glen Aire Clays " respectively. The " Soft Marls " are overlain by the Chinamans Gully Beds which are considered to be non-marine. Although marked changes in facies occur near the top of the " Lower Glen Aire Clays ", none of the beds so far sampled (some are covered by Recent sands) have any positively non-marine characteristics.

Overlying the Chinamans Gully Beds are the Port Willunga Beds which consist of richly bryozoal sandy limestones at their base, but pass up into argillaceous beds. The fauna of the Port Willunga Beds includes *Sherbornina atkinsoni, Astrononion centroplax* and *Notorotalia crassimura,* all of which are among the characteristic species of the " Upper Glen Aire Clays " at Castle Cove. In the Aire district, the Calder River Limestone intervenes between the " Lower " and " Upper Glen Aire Clays." The Port Willunga Beds, however, contain *Gümbelina,* 18 feet above their base (Reynolds, 1953, p. 129) which suggests that their lower portion is older than the " Upper Glen Aire Clays " which contain *Globoquadrina dehiscens* at their base.

Glaessner (1953.a, p. 38) has reported *Lepidocyclina* occurring at Myponga, S.A., near the top of a sequence whose lower portion is correlated with the Port Willunga Beds. In the Aire district, *Lepidocyclina* occurs at the top of a sequence whose lower portion is the " Upper Glen Aire Clays."

(*d*) The Eocene—Oligocene Boundary

Correlation of the lower part of the Aire district Tertiary sequence with areas beyond Australia can be made only on the basis of the occurrence of a relatively small number of pelagic foraminifera. Since information is not available to give the ranges of some of them in well-known Tertiary sequences overseas, particularly the type sections of the Tertiary Stages in Europe, the conclusions drawn must only be regarded as tentative.

The occurrence of *Hantkenina alabamensis compressa* in the lower part of the Browns Creek Clays is good evidence for these beds being of Upper Eocene age (Parr, 1947, et al.). *Globigerinoides index* occurs with *Hantkenina,* but ranges higher, through the Browns Creek Clays and through at least the lower third of the Castle Cove Limestone. In New Zealand the upper limit of the Runangan Stage (and hence the top of the Eocene) is marked by the end of the continuous occurrence of *Globigerinoides index* (Finlay and Marwick, 1947, p. 232). Other authors have considered *G. index* to be a restricted Eocene fossil in the U.S.A., the Caribbean Region and the Middle East. (Grimsdale, 1951; Beckmann, 1954.)

Globigerinella micra has not been found above the Browns Creek Clays, but pelagic foraminifera are rare in the Castle Cove Limestone and examination of larger quantities of material may yet reveal its presence in that formation. *Globigerinella micra* is considered by Grimsdale (1951) to be restricted to the Eocene.

Since the top of the range of *Globigerinoides index* is taken to mark the top of the Eocene in other parts of the world, the top of its range in the Aire district is suggested as the position of the Eocene-Oligocene boundary. *G. index* is not known at present above sample CC. 19 (Text Fig. 3) but further work may extend its range a little higher, though not above the top of the Castle Cove Limestone.

Another species worth future consideration is connexion with the Eocene-Oligocene boundary is *Globigerina linaperta.* This species was originally described from the Middle Eocene (Finlay, 1939) and has been recorded by Dorreen (1948) from a fauna considered by Hornibrook (1953, p. 438) to be of Runangan age. It is not known from beds younger than Eocene. (Finlay and Marwick, 1940, p. 111, confirmed by Hornibrook—personal communication 5th July, 1955.)

In the Aire district, typical specimens of *Globigerina linaperta* with slightly flattened chambers occur in the Browns Creek Clays. In the "Lower Glen Aire Clays" there is a common form which represents the continuation of the *Globigerina linaperta* lineage and whose chambers are more evenly rounded. Individuals with a compact arrangement of chambers are frequently seen near the top of the "Lower Glen Aire Clays." It is noted that Finlay (1939, p. 125) recorded a tendency for *G. linaperta* to develop swollen chambers in the upper part of its range in New Zealand.

More information from other parts of the world will be required before it can be decided whether the *G. linaperta* lineage is restricted to the Eocene and, therefore, the age of the "Lower Glen Aire Clays" is in doubt.

(e) Evidence for Oligocene and Miocene Age

Drooger (1956, p. 188) has presented foraminiferal data relative to the type areas of the Tertiary Stages of Europe and has offered a reliable basis for correlation. *Globoquadrina* is shown to make its first appearance in the Aquitanian, a little after *Globigerinoides triloba.* In the Aire district, *Globoquadrina dehiscens* makes its appearance earlier than *Globigerinoides triloba,* but the overall

evidence favours correlation of the " Upper Glen Aire Clays "—Fishing Point Marl sequence with the Aquitanian—Burdigalian of Europe. The position of the Oligocene—Miocene boundary in relation to these stages is at present an unresolved controversy and data from the Aire district has no bearing upon it.

It seems clear that the Calder River Limestone can be assigned to the Oligocene and possibly also some of the underlying beds (see above).

It seems that *Globigerinoides bispherica* makes an earlier appearance in the Aire district than in Europe, although the later appearance of *G. triloba* could account for this. On Drooger's evidence, the first appearance of *G. bispherica* is an indisputably Miocene event.

5. SYSTEMATIC DESCRIPTIONS OF FORAMINIFERA

Sixty-five species have been identified and are listed with their stratigraphical ranges in Table 4. Of these, thirty-eight are described in this paper, three are described elsewhere (Wade, 1955; Wade and Carter, 1957) and it is hoped to publish descriptions of the remainder in the near future.

Type and figured specimens other than from the Parr Collection are deposited in the Geological Survey Museum, Mines Department, Melbourne.

Table 4

Species. \ Formations.	Browns Creek Clays.	Castle Cove Limestone.	"Lower Glen Aire Clays."	Calder River Limestone.	"Upper Glen Aire Clays."	Fishing Point Marl.
Cyclammina sp.			—			
Spiroloculina canaliculata d'Orbigny ..					—	—
Vaginulinopsis acanthonucleus sp. nov. ..	—	—	—			
Bulimina spicata Cushman and Parker						—
Bolivinopsis crespinae Parr	—	—	—			
Trifarina bradyi Cushman	—	—	—	—	—	—
Pullenia quinqueloba Reuss				—	—	—
Spirillina decorata Brady	—					
Spirillina denticulata denticulata Brady					—	
Spirillina denticulata pulchra Parr ..					—	
Spirillina medioscabra sp. nov. ..	—					
Spirillina striatogranulosa Terquem ..	—				—	
Spirillina tuberosa sp. nov.					—	
Spirillina unilatera Chapman	—					
Spirillina vivipara Ehrenberg ..	—					
Stomatorbina concentrica (Parker and Jones)			—		—	—
Rosalina scopos (Finlay)				—	—	—
Heronallenia lingulata (Burrows and Holland)			—	—	—	—
Heronallenia parri sp. nov.				—	—	—
Eponides lornensis Finlay	—		—			
Eponides repandus (Fichtel and Moll) ..				—	—	—
Alabamina westraliensis Parr	—					
Cancris ovatus Cushman and Todd ..						—
Siphonina australis Cushman				—	—	—
Cibicides perforatus (Karrer)				—	—	—
Cibicides pseudoconvexus Parr ..	—	—	—			
Cibicides brevoralis sp. nov.				—	—	—
Anomalinoides procolligera sp. nov. ..				—	—	—
Anomalina perthensis Parr	—	—	—			
Globigerina bulloides d'Orbigny				—	—	—

Table 4—*continued.*

Species. \ Formations.	Browns Creek Clays.	Castle Cove Limestone.	"Lower Glen Aire Clays."	Calder River Limestone.	"Upper Glen Aire Clays."	Fishing Point Marl.
Globigerina ciperoensis Bolli					—	—
Globigerina linaperta Finlay	—	—	—			
Globigerinoides index Finlay	—	—				
Globigerinoides triloba (Reuss)						—
Globigerinoides bispherica Todd ..						—
Globigerinoides rubra (d'Orbigny) ..						—
Globoquadrina dehiscens (Chapman, Parr and Collins)					—	—
Globigerinella micra (Cole)	—					
Hantkenina alabamensis compressa Parr	—					
Gümbelina rugosa Parr	—		—			
Planorbulinella jchannae sp. nov. ..		—				
Planorbulinella plana (Heron-Allen and Earland)						—
Planorbulinella inaequilateralis (Heron-Allen and Earland)						—
Crespinina kingscotensis Wade ..	—	—	—			
Gypsina globulus (Reuss)				—	—	—
Gypsina howchini Chapman						—
Victoriella plecte (Chapman)			—	—		
Hofkerina semiornata (Howchin) ..						—
Astrononion australe Cushman and Edwar				—	—	—
Astrononion sp.	—					
Astrononion centroplax sp. nov. ..				—	—	—
Elphidium centrifugalis sp. nov. ..					—	
Notorotalia crassimura sp. nov. ..				—	—	
Notorotalia howchini (Chapman, Parr and Collins)				—	—	—
Sherbornina atkinsoni Chapman ..				—	—	
Sherbornina cuneimarginata Wade ..						—
Lamarckina airensis sp. nov.	—					
Lamarckina glencoensis Chapman and Crespin					—	—
Epistomina elegans (d'Orbigny) ..	—		—		—	—
Amphistegina sp. cf. *A. lessonii* d'Orbigny				—	—	—
Asterigerina adelaidensis (Howchin) ..	—					
Calcarina mackayi (Karrer)				—	—	—
Lepidocyclina sp.						—
Operculina victoriensis Chapman and Parr						—
Cycloclypeus victoriensis Crespin ..						—

Genus **SPIROLOCULINA** d'Orbigny 1826.

SPIROLOCULINA CANALICULATA d'Orbigny 1846.

PLATE 2, FIGS. 1, 2.

Spiroloculina canaliculata d'Orbigny, 1846. *Foram. Foss. Bass. Tert. Vienne.* p. 629, Pl. 16, figs. 10-12.

Spiroloculina canaliculata d'Orbigny. Chapman, 1907. *Journ. Linn. Soc. Lond.* (*Zool.*) Vol. 30, p. 16, Pl. 1, figs. 20-21.

Spiroloculina canaliculata d'Orbigny. Crespin, 1943. Dept. of Supply and Shipping (Australia). *Pal. Bull.* 4 (Mimeo) p. 83. (list).

Spiroloculina canaliculata d'Orbigny. Cushman and Todd, 1944. *Cush. Lab. Foram. Res., Spec. Publ.* No. 11, pp. 22, 23. Pl. 4, figs. 1-11.

Diagnosis.

Spiroloculina, margin concave to convex, rounded ridges at outer corners of all chambers on both sides, aperture elliptical, without a tooth.

Description.

A free test of moderate size, planispiral, biconcave. Peripheral outline is rhomboidal. Margin may be flat, slightly convex or slightly concave. Twelve to fifteen chambers are usually present, arranged in an evolute coil, two chambers always present in last whorl. Each chamber bears two thickened longitudinal ridges at the upper and lower angles of the margin. These ridges are usually paler in colour than the intervening troughs. Sutures are indistinct, flush with surface, always on the outer sides of the raised ridges. Shell wall is calcareous, opaque, smooth, imperforate. The distal end of the last chamber forms a projecting, contracted neck at the end of which is an elliptical aperture with its long axis parallel to the axis of coiling. The aperture is without a tooth.

Figured specimen.—G.S.M. No. 54664.

Dimensions.—Length: 0·74 mm. Width: 0·40 mm. Height: 0·14 mm.

Locality.—West bank of Barwon River, ½-mile south of Birregurra, Victoria.

Distribution.—" Upper Glen Aire Clays " and Fishing Point Marl.

Remarks.

The species is well-preserved and plentiful in the outcrop at Birregurra, whence the figured specimen was taken.

The present specimens have been compared with a topotype specimen from Baden in the Vienna Basin (Glaessner Collection) and they are considered identical.

Genus **VAGINULINOPSIS** Silvestri, 1904.

VAGINULINOPSIS ACANTHONUCLEUS sp. nov.

PLATE 2, FIGS. 3-7.

Diagnosis.

Vaginulopsis, long spines at initial end; short spines on lateral walls of early chambers, test ornamented with about six oblique, discontinuous serrate ridges on each side and serrate keels.

Description.

A large free test, elongate, slightly compressed laterally, elliptical in transverse section. In megalospheric generation, initial chamber is globular, followed by a widely-open spiral of two chambers; later chambers have the form of rhombohedra with curved faces and are arranged in a straight or slightly curved linear series. In microspheric generation, initial chamber is globular, followed by an open spiral of about five chambers. The succeeding chambers are as in megalospheric generation. Sutures of early part of test usually obscured by secondary shell material, those of later chambers oblique, slightly curved, unthickened, depressed. Wall of test thick, calcareous, opaque. Surface is ornamented with short thick spines on early part of test; a variable number of chambers immediately following the initial part bear about six serrate ridges on each side which are not continuous from chamber to chamber. The two or three last-formed chambers may bear very short serrate ridges or clusters of spines and the last chamber may be smooth. A serrate keel is present along the median line of the test, usually it is indented at the sutures. Aperture large, with a serrate margin, situated at the end of a short, straight neck.

Holotype (megalospheric).—G.S.M. No. 54665.

Dimensions.—Length: 3·58 mm. Width: 0·68 mm. Thickness: 0·55 mm.

Type Locality.—Aire Coast, Wilkinson's Locality, AW.1, 2 miles north-west of Cape Otway.

Paratype (topotype—microspheric).—G.S.M. No. 54666.

Dimensions.—Length: 2·55 mm. Width: 0·58 mm. Thickness: 0·47 mm.

Paratype (continuously—ribbed form).—N.M.V. No. P.16001. (W. J. Parr Collection).

Dimensions.—Length: 2·09 mm. Width: 0·67 mm. Thickness: 0·48 mm.

Locality.—Browns Creek, Parish of Aire. "Glauconite bed at base of hillside section, west side of creek, 20 chains from mouth." (Slide N.M.V. 14929).

Paratype (juvenile).—G.S.M. No. 54668.

Dimensions.—Length: 1·55 mm. Width: 0·58 mm. Thickness: 0·39 mm.

Locality.—Aire Coast, Wilkinson's Locality, AW.4 "4 feet grey sandy clay rich in fossils" (see Hall and Pritchard, 1899, p. 47).

Paratype.—G.S.M. No. 54667.

Dimensions.—Length: 3·48 mm. Width: 0·79 mm. Thickness: 0·67 mm.

Locality.—Aire Coast, Wilkinson's Locality, AW.4, "4 feet grey sandy clay rich in fossils" (see Hall and Pritchard, 1899, p. 47).

Distribution.—Browns Creek Clays, Castle Cove Limestone (very rare), and "Lower Glen Aire Clays".

Remarks.

The jagged, discontinuous ridges are the most characteristic feature of this species, which is also more inflated than *V. gippslandica* (Chapman and Crespin) 1930.

In the greensand bed and the dark clays beneath it in the lower part of the Borwns Creek Clays, there occurs a continuously-ribbed form of *V. acanthonucleus* which is not associated with *V. acanthonucleus* s. str. The continuously-ribbed form lacks the serrate, knife-like edges of the ridges possessed by *V. acanthonucleus* s. str., also the short spines on the lateral faces of the early chambers are much reduced and frequently absent altogether. Higher in the Browns Creek Clays, both forms are present with the continuously-ribbed form predominating. In the "Lower Glen Aire Clays" at Castle Cove, *V. acanthonucleus* is rare but in the lower beds at Duck Creek and AW.4 (which are correlated with the "Lower Glen Aire Clays") both forms are quite common, but *V. acanthonucleus* s. str. is predominant.

In all cases, the ridges on adult tests are more pronounced than those on juveniles, indicating that the ridges are added secondarily. Although the continuously-ribbed form is superficially more like *V. gippslandica* than *V. acanthonucleus* s. str., it is distinct from that species in being more inflated and in possessing ribs which are more prominent.

Gr. *akantha,* a spine; *nucleus* signifying the initial portion of the test.

Genus **PULLENIA** Parker and Jones 1862.

PULLENIA QUINQUELOBA (Reuss) 1851.

PLATE 2, FIGS. 8, 9.

Nonionina quinqueloba Reuss, 1851. *Zeitschr. deutsch. geol. Ges.* Vol. 3, p. 71, Pl. 5, fig. 31.

Pullenia quinqueloba (Reuss). Cushman and Todd, 1943. *Contr. Cush. Lab. Foram. Res.* Vol. 19, Pt. 1, pp. 10, 11, Pl. 2, fig. 5, Pl. 3, fig. 8.

Diagnosis.

Pullenia, chambers slightly inflated, compressed towards periphery, five or five and a half in last whorl.

Description.

A free, somewhat compressed test of moderate size. Peripheral outline is pyriform, slightly lobulated at the sutures. Margin is narrowly rounded. Chambers are arranged in an involute planispiral coil with five or five and a half comprising the last whorl. They are slightly inflated but constricted towards the periphery. Sutures are slightly recurved, unthickened, initially slightly depressed, flush with surface on earlier part of test. Wall of test is thin, translucent, smooth, very finely and evenly perforate, even on the apertural face. Aperture is a narrow slit of fairly constant width extending around the entire base of the apertural face. It is bordered on its outer side by a thickened rim.

Figured specimen.—G.S.M. No. 54669.

Dimensions:

Diameter of test: 0·54 mm. (*a*)
Height of test: 0·30 mm. (*b*)
Height of last chamber: 0·30 mm. (*c*)
Height of apertural face: 0·11 mm. (*d*)
Ratio A (b : a) 1 : 1·8.
Ratio B (d : c) 1 : 2·75.

(cf. Cushman and Todd, 1943, p. 1. See below.)

Locality.—Gippsland Cement and Lime Co. Quarry on west side of Boggy Creek, allot. 15 of Section A, Parish of Coolungoolun, Gippsland, Victoria (near Longford).

Distribution.—Calder River Limestone, "Upper Glen Aire Clays" and Fishing Point Marl.

Remarks.

The specimens agree closely with those described and figured by Cushman and Todd (1943), for which the following ratios are given:

Ratio A-1 : 1·3 to 1 : 1·65
Ratio B-1 : 2

Genus **SPIRILLINA** Ehrenberg 1843.

SPIRILLINA DECORATA Brady 1884.

PLATE 3, FIGS. 22, 23.

Spirillina decorata Brady, 1884. *Rpt. Sci. Res. Voy. "Challenger" Zool.* Vol. IX., p. 633, Pl. 85, figs. 22-25.

Spirillina decorata Brady. Chapman, Parr and Collins, 1934. *J. Linn. Soc. Lond. Zool.* Vol. 38, pp. 558, 559, Pl. 8, fig. 1.

Spirillina decorata Brady. Parr, 1950. *B.A.N.Z.A.R.E. Repts. Ser. B.* Vol. 5 (6), p. 348.

Diagnosis.

Spirillina, symmetrical, biconcave, planispiral. Both sides of each whorl ornamented with small radial ridges on inner half and with anastomosing ridges on outer half. Whorls embracing, so that anastomosing ridges are visible only on last whorl. Wall thick, opaque.

Description.

A free test of moderate size, symmetrically planispiral, biconcave. Peripheral outline is sub-circular. Margin is keeled, with raised shoulders flanking the keel on either side. The tubular chamber is triangular in cross-section, with the dorsal and ventral faces of the last whorl slightly concave. Six to seven partly embracing whorls are present, each slightly higher than the previous one, causing the whorls to descend in steps from the periphery towards the proloculum. The spiral suture is depressed. Wall of test is thick, opaque, the only perforations which have been observed are occasional large pores along the spiral suture. The surface of each whorl is ornamented with close-set radial ridges and furrows extending outwards from the spiral suture for about half the distance to the keel, thereafter branching into anastomosing ridges surrounding shallow pits. On the whorls preceding the last, usually only the radial ornamentation can be seen, though the anastomosing ridges

are visible on the early whorls of some specimens. Aperture is a simple unconstricted opening with an overhanging lip, situated at the distal end of the spiral chamber.

Figured specimen.—N.M.V. No. P.16002.

Dimensions.—Diameter: 0·88 mm. Height: 0·15 mm.

Locality.—Cutting on Great Ocean Road on west side of Hamilton Creek, Parish of Otway. Ex slide N.M.V. No. P. 15002.

Distribution.—Browns Creek Clays, " Upper Glen Aire Clays " and Fishing Point Marl.

Remarks.

The Recent specimen described by Parr (1950, p. 348) and specimens from Balcombe Bay, similar to those described by Chapman, Parr and Collins (1934, p. 558), have been compared with examples from the Aire district, which are consistently larger and more strongly sculptured.

SPIRILLINA DENTICULATA DENTICULATA Brady 1884.

PLATE 3, FIGS. 13-15.

Spirillina limbata var. *denticulata* Brady, 1884. *Report Sci. Res. Voy. " Challenger ". Zool.* Vol. 9, p. 362, Pl. 85, fig. 17.

Spirillina denticulogranulata Chapman, 1907. *J. Queckett Micr. Club.* p. 133, Pl. 10, fig. 6.

Spirillina denticulogranulata Chapman. Parr, 1945. *Pro. Roy. Soc. Vic.* (*n.s.*) Vol. 56 (2), p. 200.

Spirillina denticulata Brady. Ovey, 1948. *Journ. Roy. Micr. Soc.* Vol. 67, pp. 17, 18.

Diagnosis.

Spirillina, asymmetrical, tuberculate ventrally, sutures limbate dorsally, radial denticulations cover dorsal surface between whorls of spiral suture. Wall thick, opaque.

Description.

A free test of moderate size, asymmetrically planispiral. Dorsal surface is flat, ventral surface is flat or concave. Peripheral outline is sub-circular, smooth. Margin is squarish, bluntly carinate at angles. Test consists of a proloculum followed by a coiled, undivided tube, with the proloculum at the highest point. Five to six whorls are present, embracing slightly ventrally but not dorsally. Dorsal spiral suture and periphery are raised, limbate, smooth. Raised, tooth-like processes (denticulations) extend inwards from the dorsal spiral suture along all of its length and may cross the intervening depressed area and join the preceding whorl of the suture. Ventral surface exclusive of last whorl is covered with tubercles of shell material. Ventral surface of last whorl is covered with fine growth-lines. In some instances, tubercles may cover part or even all of the ventral surface of the last whorl. Wall of test is thick, opaque. Occasional large pores may occur between the denticulations. Aperture is a simple opening with an overhanging lip, situated at the distal end of the spiral chamber and extending back along the ventral spiral suture for a short distance.

Figured specimen.—N.M.V. No. P.16003.

Dimensions.—Diameter: 0·44 mm. Height: 0·10 mm.

Locality.—" Browns Creek. South-east corner of hillside, west of and overlooking mouth of creek. Grey clay, exposure nearest beach ", Ex slide N.M.V. No. P.14894/94.

Distribution.—Browns Creek Clays, " Upper Glen Aire Clays ", and Fishing Point Marl.

Remarks.

The above description expands the rather brief diagnosis of the species given by Brady. The subspecies, *S. denticulata denticulata* is here restricted to forms which possess strongly-developed denticulations between the whorls of the spiral suture on the dorsal surface. Specimens from the Browns Creek Clays uniformly possess a shallow channel in the ventral surface of the last whorl, while in specimens from younger formations, the ventral surface of the last whorl is uniformly convex. The species was described from Recent material dredged in Bass Strait.

SPIRILLINA DENTICULATA PULCHRA Parr 1945.

PLATE 3, FIGS. 16-18.

Spirillina denticulogranulata var. *pulchra* Parr, 1945. *Proc. Roy. Soc. Vic.* (*n.s.*). Vol. 56 (2), p. 200, Pl. 8, fig. 9, Pl. 9, fig. 1.

Diagnosis.

Spirillina, asymmetrical, planispiral or trochospiral with very low spire, tuberculate ventrally, sutures limbate dorsally, denticulations reduced or absent. Wall thick, opaque.

Description.

A free test of moderate size, asymmetrically planispiral or trochospiral with very low spire, ventral surface flat or concave. Peripheral outline is sub-circular. Margin is squarish, carinate dorsally and rounded ventrally. Test consists of a proloculum followed by a coiled, undivided tube, with the proloculum at the highest point. Five or six whorls are usually present, embracing slightly ventrally but not dorsally. Dorsal spiral suture and periphery are raised, limbate, smooth. The depressed area between the whorls of the spiral suture is free of radial ridges and finely granulated. Ventral surface of last whorl is covered with fine growth lines. Within the last whorl, the ventral surface of the test is covered with coarse tubercles. Wall of test is thick, opaque. No pores have been observed. Aperture is a simple opening with an overhanging lip, situated at the distal end of the spiral chamber and extending back along the ventral spiral suture for a short distance.

Figured specimen.—N.M.V., P.16004.

Dimensions.—Diameter: 0·53 mm. Height: 0·12 mm.

Locality.—Castle Cove. " Thick bed of blue-grey clays immediately overlying lowest limestone band in top third of section." Sample 17 of W. J. Parr. 19.2.1945. Ex slide N.M.V. No. P.14984.

Distribution.—" Upper Glen Aire Clays."

Remarks.

When Parr (1945, p. 200) proposed *S. denticulo-granulata* var. *pulchra,* he mentioned "an undescribed species occurring at Muddy Creek, Victoria, in which the tooth-like processes are absent." Specimens agreeing with this description from Clifton Bank on Muddy Creek have been examined, and it is considered that Parr's variety and this non-denticulate form represent different degrees of one variation—namely, the reduction of the denticulations. It is therefore proposed to expand Parr's definition of *S. denticulata pulchra* to include all forms in which the dorsal denticulations are reduced or absent.

S. tuberculolimbata Chapman, 1900 and *S. limbata* var. *papillosa* Cushman, 1915 probably represent the same form lacking denticulations. Specimens of these species are not available, so a direct comparison cannot be made, but if they are ultimately proved to be identical with *S. denticulata pulchra, S. tuberculolimbata* has priority over Cushman's and Parr's names.

S. denticulata pulchra was described from Recent shore sands from Barwon Heads, Victoria.

SPIRILLINA MEDIOSCABRA sp. nov.

PLATE 3, FIGS. 24, 25.

Diagnosis.

Spirillina, bisymmetrical, thick walled. Ornamented with pits and ridges. On the penultimate whorls, pits are larger, more widely spaced and ridges more prominent than on last whorl. Four longitudinal ridges are present on margin.

Description.

A relatively large, free, planispiral, bisymmetrical test, biconvex, with a shallow depression in the centre of each face. Peripheral outline is sub-circular, smooth. Margin is broadly rounded, with four blunt, slightly wavy longitudinal ridges. Six whorls of the undivided tubular chamber are usually present. The last whorl embraces about half the width of the previous whorl. The suture between these whorls is marked by the junction between the rough central area and the less-rough annulus. Wall of test is thick, opaque. Upper and lower surfaces are uniform, ornamented by anastomosing ridges surrounding fairly large pores. On the last whorl, the pores are relatively small and closely spaced, the depressions into which they open are small and ridges between the depressions are small. The central portion of each face is rougher, the pores are fewer in number and larger, the depressions into which the pores open are also larger and the intervening ridges are higher, wider, more vitreous and have a tendency to become tuberculate. Aperture is a simple opening with an overhanging lip, at the distal end of the spiral chamber.

Holotype.—N.M.V. No. P. 16005.

Dimensions.—Diameter: 0·95 mm. Height: 0·21 mm.

Type locality.—Inland exposure on west bank of Browns Creek, about 20 chains from mouth.

Paratype (topotype).—N.M.V. No. P. 16006.

Dimensions.—Diameter: 1·15 mm. Height: 0·22 mm.

Distribution.—Browns Creek Clays.

Lat. *medianus,* in the middle; *scabra,* rough.

SPIRILLINA STRIATOGRANULOSA Terquem 1882.

PLATE 3, FIGS. 19-21.

Spirillina striatogranulosa Terquem, 1882. *Mem. Soc. Geol. de France* Ser. 3, tome 2, No. 3, p. 33

Spirillina striatogranulosa Terquem. Le Calvez. 1949. *Mem. serv. expl. Carte Geol. de France.* Mem. 1949. pp. 11, 12 Pl. 1. figs. 3, 4.

Diagnosis.

Spirillina, asymmetrical, biconcave. Dorsal spiral sature limbate, raised into sharp, narrow ridge. Denticulations extend inwards from this ridge. Whorls embracing, outer half of last whorl ornamented dorsally with fine growth lines. Ventral surface ornamented with a spiral row of elliptical tubercles. Wall thick, opaque.

Description.

A free test of moderate size, asymmetrically planispiral, biconcave. Peripheral outline is sub-circular. Margin is smooth, rounded. Test consists of a proloculum followed by a coiled, undivided, tubular chamber forming six or seven whorls, each whorl being slightly higher than the preceding one and slightly embracing it. Dorsal spiral sature is raised into a thin, knife-like ridge from which short, raised, radical walls (denticulations) extend into the depressed area between the whorls of the ridge. Sometimes thes radial walls cross to the preceding whorl of the ridge and fuse with it. Between the outermost whorl of the sutural ridge and the periphery, the dorsal surface of the test is ornamented with fine growth-lines. Ventral spiral suture is depressed. Ventral surface of last whorl is covered with elongate, smooth, radial granules, the height of each granule decreasing towards the periphery and disappearing completely before reaching it, so that the periphery itself is smooth and unfurrowed. On the ventral surfaces of the whorls preceding the last, only the highest inner portion of each granule is visible, due to the embracing nature of the whorls, so that the inner ventral surface of the test is ornamented with a spiral row of circular granules, decreasing in size towards the centre. Wall of test is thick, opaque. The oblique tubules mentioned by Le Calvez can be seen in eroded specimens. Aperture is a simple opening with an overhanging lip, situated at the distal end of the spiral chamber.

Figured specimen.—G.S.M. No. 54670.

Dimensions.—Diameter: 0·34 mm. Height: 0·10 mm.

Locality.—Browns Creek coastal section, second gully west of the mouth of Browns Creek, approximately 80 feet above greensand.

Distribution.—Browns Creek Clays and "Upper Glen Aire Clays."

Remarks.

The raised, knife-like form of the limbate dorsal suture is the only feature of the present specimens which does not agree closely with Le Calvez's description of the species.

SPIRILLINA TUBEROSA sp. nov.

PLATE 4, FIGS. 30, 31.

Spirillina tuberculata Brady. Howchin, 1889. *Trans. Roy Soc. S. Aust.* Vol. 12, p. 11. (non Brady).

Diagnosis.

Spirillina, large, thick walled test, outer wall embraces one side more than the other. Sutures obscured. Coarse tubercles cover the entire test.

Description.

A large, free, planispiral test. Peripheral outline is almost circular. Margin is broadly rounded. Both lateral surfaces vary from slightly convex to slightly concave, but are usually flat. Test is composed of a coiled, undivided tube. Wall of test is thick, opaque. Sutures are concealed by the secondary thickening of the lateral walls and the number of whorls is indeterminate without sectioning. Course tubercles cover the entire surface of the test, those on the margin are slightly smaller than elsewhere. A few course pores are present between the tubercles. Aperture is a simple opening at the distal end of the spiral chamber, slightly asymmetrical, due to the outer wall embracing one side slightly more than the other.

Holotype.—N.M.V. No. P. 16007.

Dimensions.—Diameter 0·89 mm. Height: 0·34 mm.

Type Locality.—Castle Cove, Sample 17 of W. J. Parr, 19.2.1945. Ex slide N.M.V. No. P. 14984. " Thick bed of blue-grey clay immediately overlying lowest limestone bed in top third of section " (i.e. near base of " Upper Glen Aire Clays ").

Paratype (topotype).—N.M.V. No. P. 16008.

Dimensions.—Diameter: 0·99 mm. Height: 0·30 mm.

Distribution.—" Upper Glen Aire Clays ".

Remarks.

S. tuberosa is readily separable from *S. tuberculata* Brady which has the following characteristics: Thin wall, distinct and depressed sutures, small tubercles. The writer has examined specimens of the latter species from the Southern Ocean, now in the B.A.N.Z.A.R.E. (1929-31) collections at the University of Adelaide.

Lat. *tuberosa,* with swellings or protuberances.

SPIRILLINA UNILATERA Chapman 1902.

PLATE 4, FIGS. 26-29.

Spirillina decorata Brady var. *unilatera* Chapman 1902. *J. Linn. Soc. Lond.* (*Zool.*) Vol. 28, p. 410.

Diagnosis.

Spirillina, asymmetrical, planoconcave. Dorsal surface smooth. Ventral surface ornamented by a spiral of denticulations. Wall thin, transparent. Margin squarish.

Description.

A small free test, asymmetrically planispiral. Dorsal surface is flat or slightly concave, ventral surface concave. Peripheral outline is sub-circular. Margin is squarish or gently rounded. Test consists of a proloculum followed by a coiled, undivided, tubular chamber which forms ten completely evolute whorls, each higher than the preceding one. Dorsal surface is smooth. Ventral surface of each whorl bears a row of raised, inwardly-directed denticulations. Spiral suture is depressed on both sides. Wall of test is calcareous, thin transparent. Aperture is a simple opening at the distal end of the spiral chamber.

Figured specimen.—N.M.V. No. P. 16009.

Dimensions.—Diameter: 0·31 mm. Height: 0·05 mm.

Figured specimen.—N.M.V. No. P. 16010.

Dimensions.—Diameter: 0·25 mm. Height: 0·04 mm.

Locality.—Both specimens: Cutting on Great Ocean Road west of Hamilton Creek, Parish of Otway. Ex slide N.M.V. No. P. 15002.

Distribution.—Browns Creek Clays.

Although the specimens agree closely with Chapman's description, they have so few characters in common with the thick-shelled, symmetrical, carinate *Spirillina decorata* that the name is given specific rank.

SPIRILLINA VIVIPARA Ehrenberg 1843.

PLATE 4, FIGS. 32, 33.

Spirillina vivipara Ehrenberg, 1843. *K. Akad. Wiss. Berlin. Physik. Abh.* Teil. 1. pp. 323, 422.

Spirillina vivipara Ehrenberg. Parr, 1950. *B.A.N.Z.A.R.E. Rpts. Ser. B.* Vol. 5. Pt. 6. pp. 347, 348.

Diagnosis.

Spirillina, symmetrical, flat or planoconcave. Both surface smooth. Wall thin, transparent. Margin rounded.

Description.

A small, free, planispiral test. Dorsal surface flat, ventral surface flat or concave. Peripheral outline is subcircular. Margin is rounded. Test consists of a proluculum followed by a coiled, undivided tubular chamber forming ten evolute whorls, the later whorls being slightly higher than the early ones. Wall of test is smooth, thin, transparent, with irregularly disposed perforations. Spiral suture is depressed on both sides of test. Aperture is a simple opening at the distal end of the spiral chamber.

Figured specimen.—N.M.V. No. P. 16011.

Dimensions.—Diameter: 0·30 mm. Height: 0·06 mm.

Locality.—Browns Creek, Parish of Aire. "Marl bed about 3 ft. above base of section exposed on hillside, west side of Browns Creek and about 20 chains from mouth of creek." Ex slide N.M.V. No. 14936.

Distribution.—Browns Creek Clays.

Remarks.

The specimens have been compared with those described by Parr (1950, pp. 347, 348) and are considered identical.

Genus **STOMATORBINA** Dorreen 1948.

STOMATORBINA CONCENTRICA (Parker & Jones) 1864.

PLATE 4, FIGS. 37-39. PLATE 7, FIG. 75.

Pulvinulina concentrica Parker and Jones in Brady, 1864. *Trans. Linn. Soc. (Lond.)* Vol. 24, pp. 463-475. Pl. 48.

Eponides concentricus (Parker & Jones). Chapman, Parr and Collins 1934. *J. Linn. Soc. (Lond.) Zool.* Vol. 38, p. 565,. Pl. 9 figs. 17 a-c.

Diagnosis.

Stomatorbina, biconvex. Chambers inflated. Total number of chambers about fifteen. Apertural flap large, arrowhead-shaped with a constricted base, extending far across the umbilicus. Deep grooves between apertural flaps. Sub-reniform vestiges of original chamber wall show through areas of secondary thickening on ventral side. No areal or exterio-marginal apertures are present.

Description.

A moderately large, free, trochospiral test. Peripheral outline is rounded, somewhat pyriform, lobulated at the sutures. Margin is narrowly rounded and thickened. Dorsal side is convex, completely evolute. Ventral side is less strongly convex than the dorsal side, involute, with a wide umbilicus largely filled with a series of overlapping apertural flaps. The total number of chambers is about fifteen, of which five or six form the last whorl. Dorsal sutures are strongly recurved, limbate, initially depressed. Later, they become raised, their height and width increase and they encroach considerably on the intervening areas of chamber wall which are usually of a darker colour than the sutural ridges. Ventral sutures are almost straight and radial, initially depressed and slightly thickened. Later, these sutures become raised but do not widen appreciably. The marginal thickening expands towards the centre ventrally and the apertural flaps are later heavily thickened by secondary shell material. The thickening of the apertural flaps also encroaches on the ventral chamber walls, the visible areas of which also decrease rapidly on progressively older chambers. Ventral chamber walls are usually darker in colour than the surrounding secondarily-thickened areas. Wall of test is initially fairly thick, finely perforated. No perforations have been observed in the secondarily-thickened parts of the test, namely the sutures and apertural flaps. Aperture extends for a little more than half-way along the ventral inner edge of the last chamber and can be divided into three regions. The outer region begins just below the margin and

extends to the edge of the umbilical depression. This region of the aperture is more arched than the remainder and it also has a thickened ventral rim. The median region of the aperture is overhung by a thin, roughly triangular apertural flap which extends from the ventral margin of the aperture across the umbilical depression. The third region of the aperture consists of a notch between the posterior edge of the apertural flap and the suture between the last and second-last chambers. The second-last chamber opens to the exterior beneath the posterior edge of its apertural flap.

Figured specimen (3 views): G.S.M. No. 54678.

Dimensions.—Length: 0·90 mm. Width: 0·78 mm. Height: 0·41 mm.

Figured specimen (ventral side only): G.S.M. No. 54679.

Dimensions.—Length: 1·39 mm. Width: 1·18 mm. Height: 0·58 mm.

Locality (both specimens): Fossil Beach, Balcombe Bay, Victoria.
Bed " i " of F. A. Singleton (1941. p. 27).

Distribution.—" Lower Glen Aire Clays ", " Upper Glen Aire Clays " and Fishing Point Marl.

Remarks.

This species has a wide distribution in the Tertiary rocks of Victoria, though frequently is poorly-preserved. A closely-related species occur rarely in the Browns Creek Clays. This species is less convex dorsally than *S. concentrica,* has seven chambers in the last whorl and more expansive thickening of the dorsal sutures. The visible area of the ventral chamber walls are narrow and narrowly reniform.

Genus **ROSALINA** d'Orbigny 1826.

ROSALINA SCOPOS (Finlay) 1940.

PLATE 4, FIGS. 34-36.

Discorbis bertheloti d'Orbigny. Chapman, Parr and Collins, 1934. *Journ. Linn. Soc. Lond. (Zool.)* Vol. 38, p. 561. Pl. 9, figs. 13 a-c. (non d'Orbigny).

Discorbis scopos Finlay 1940. *Tr. Proc. Roy. Soc. N.Z.* Vol. 69, Pt. 4, p. 466, Pl. 67, figs. 212, 213.

Diagnosis.

Planoconvex, compressed. Slightly evolute on both sides with a shallow umbilicus ventrally. Aperture extends along outer half of base of chamber on ventral side and is covered by a triangular apertural flap with straight edges. Apertural flaps of last five or six chambers remain distinct. No umbilical plug is present.

Description.

A free test of moderate size, trochospiral with a very low spire, planoconvex. Peripheral outline is sub-circular. Margin is carinate, slightly thickened. Dorsal side is convex, slightly evolute. Ventral side is usually flat, sometimes very slightly convex, slightly evolute with a small shallow umbilicus. Two to three whorls are present, with eight

or nine chambers in the last. Dorsal sutures are recurved, initially depressed, later thickened and slightly raised. Ventral sutures are recurved, slightly thickened, flush with surface. Wall of test is thin, translucent, finely and evenly perforated, though the density of pores is greater on the dorsal side. Chambers are inflated but compressed towards the periphery on the dorsal side. Size of chambers increases rapidly in the last whorl. Aperture is a narrow slit along the base of the chamber on the ventral side, extending from the periphery to the nearest part of the penultimate chamber. The aperture is covered by a ventral, triangular apertural flap with straight edges, which widens gradually towards the last suture and then narrows rapidly. Each apertural flap projects into the umbilical depression and overlaps the preceding flap. Apertural flaps are visible on about the last six chambers, those on earlier chambers have become enveloped by secondary shell material.

Figured specimen.—G.S.M. No. 54671.

Dimensions.—Greater diameter: 0·67 mm. Smaller diameter: 0·60 mm. Height: 0·23 mm.

Locality.—Aire Coast. Wilkinson's Locality AW.3. Clay bed 9"-15" below top of section.

Distribution.—Calder River Limestone, "Upper Glen Aire Clays", Fishing Point Marl.

Remarks.

In all members of the genus, the aperture consists of a distinct protoforamen and deuteroforamen (terminology of Hofker, 1951) with an intervening apertural flap. *R. scopos* has larger apertural flaps than typical members of the genus. The increased size of the flap is the only criterion by which the generic name *Discopulvinulina* Hofker 1951, could be applied to *R. scopos*. Hofker included the type type species of *Rosalina* (*R. globularis* d'Orb.) in *Discopulvinulina* at the time of its erection.

In the absence of authentic representatives of the latter genera for comparison, a conservative interpretation of the genus *Rosalina* is adopted. (See Brotzen 1948, p. 72; Bermudez 1952, p. 34).

Genus **HERONALLENIA** Chapman & Parr 1931.

HERONALLENIA LINGULATA (Burrows & Holland) 1895.

PLATE 5, FIGS. 40-42.

Discorbina lingulata Burrows & Holland, 1895, in Jones, *Palaeontogr. Soc. Lond.* 1895, Pl. 7, figs. 33 a-c.

Heronallenia lingulata (Burrows & Holland), Chapman, Parr & Collins, 1934. *Journ. Linn. Soc. Lond. (Zool.)*. Vol. 38, pp. 564, 565. Pl. 8, figs. 11 a-c.

Diagnosis.

Heronallenia, planoconcave, planispiral, reniform, margin rounded. Dome-shaped structures present on dorsal chamber walls.

Description.

A moderately large, free, test, planoconcave, planispiral. Peripheral outline is reniform, slightly lobulate at sutures. Margin is narrow, rounded, slightly thickened. Dorsal side is completely evolute. Ventral side is incompletely evolute, with a wide shallow umbilicus. Test is usually composed of one whorl, plus one or two chambers, the number of chambers in the last whorl being about eight. Dorsal sutures are distinct, recurved, limbate, slightly raised. Ventral sutures are indistinct, strongly sigmoidal, unthickened, depressed. Wall of test is thin, calcareous, translucent, finely perforate. Dorsal surface is smooth, almost flat. Small, low, dome-shaped structures are always present on the dorsal surface, adjacent to the last three or four sutures on their distal sides. Ventral surface is concave, with an umbilical depression and a deep indentation in the last chamber. Aperture is a short, narrow slit at the distal end of this indentation. A few low ridges on the ventral wall of the last chamber radiate out from the aperture.

Figured specimen.—G.S.M. No. 54672.

Dimensions.—Length: 0·74 mm. Width: 0·52 mm. Height: 0·15 mm.

Locality.—Aire Coast. Wilkinson's locality AW.3. Clay bed 9"—15" below top of section.

Distribution.

Calder River Limestone, "Upper Glen Aire Clays" and Fishing Point Marl.

Remarks.

All specimens from the Aire district have rounded margins—never the angular one originally figured by Jones (1895, Pl. 7, fig. 33c.). Specimens from younger formations elsewhere in Victoria agree more closely with the type figure in this respect.

HERONALLENIA PARRI sp. nov.

PLATE 5, FIGS. 43-45.

Discorbina wilsoni Heron-Allen & Earland, 1924 *Journ. Roy. Micr. Soc.* 1924, p. 172. (non Heron-Allen & Earland, 1922).

Heronallenia wilsoni (Heron-Allen & Earland), Chapman & Parr, 1931. *Proc. Roy. Soc. Vic. (n.s.).* Vol. 43, Pt. 2, Pl. 9, fig. 7. (non Heron-Allen and Earland, 1922).

Heronallenia wilsoni (Heron-Allen & Earland), Chapman, Parr & Collins, 1934. *Journ. Linn. Soc. Lond. (Zool.).* Vol. 38, p. 564, Pl. 8, figs. 11 a-c. (non Heron-Allen & Earland, 1922).

Heronallenia sp. Parr, 1950. *B.A.N.Z.A.R.E. Reports, Series B.* Vol. 5, Part 6, p. 357.

Diagnosis.

Heronallenia, concavoconvex, trochospiral, sub-elliptical, margin rounded. Dome-shaped structures never present on dorsal chamber walls.

Description.

A free test of moderate size, concavoconvex, trochospiral with a very low spire. Peripheral outline is sub-elliptical, lobulate. Margin is narrow, rounded. Dorsal side is completely evolute, ventral side is incompletely involute. A wide, shallow umbilicus is present. Test is composed of a little more than one whorl, about 6 chambers forming the last whorl. Dorsal sutures are distinct, recurved, limbate, slightly raised. Ventral sutures are indistinct, sigmoidal, unthickened, depressed. Wall of test is thin, calcareous, translucent, finely perforate. Dorsal surface is smooth, gently curved, convex. Ventral surface is smooth, concave, the greater part of the concavity being due to a deep, narrow indentation in the ventral suture of the last chamber. Low ridges radiating from this concavity ornament the ventral surfaces of the last two chambers. Aperture is a narrow slit at the inner end of the indentation of the ventral suture.

Holotype.—G.S.M. No. 54673.

Dimensions.—Length: 0·54 mm. Width: 0·45 mm. Height: 0·21 mm.

Type locality.—Aire Coast. Wilkinson's locality AW.3. Clay bed 9"—15" below top of section.

Paratype (topotype): G.S.M. No. 54674.

Dimensions.—Length: 0·53 mm. Width: 0·42 mm. Height: 0·19 mm.

Distribution.

Calder River Limestone, "Upper Glen Aire Clays" and Fishing Point Marl.

Remarks.

The separation of this species from *H. wilsoni* (Heron-Allen and Earland) 1922, has been fully discussed by Parr (1950, p. 357), in whose honour it is named. *H. vicksburgensis* Cushman, 1922, is similar to *H. parri* in general appearance, but has fewer chambers, differently-shaped ventral sutures and a wider and more centrally-placed depression leading to the aperture.

Genus **EPONIDES** Montfort 1808.

EPONIDES LORNENSIS Finlay 1939.

PLATE 4, FIGS. 48-50.

Eponides lornensis Finlay, 1939. *Trans. Proc. Roy. Soc. N.Z.* Vol. 68, Pt. 4, pp. 521, 522.

Eponides lornensis Finlay. Finlay, 1939. *Trans. Proc. Roy. Soc. N.Z.* Vol. 69, pt. 1, pp. 121, 122, pl. 13, figs. 52, 53.

Diagnosis.

Large, trochospiral, thick-walled test. Ventral side only slightly more convex than dorsal. Dorsal sutures slightly thickened. Dorsal surface sometimes pustulated. Six chambers in last whorl. No course pores in apertural face. Aperture expands ventrally.

Description.

A large, free test, trochospiral with a low spire, unequally biconvex. Peripheral outline is sub-circular to pyriform, smoothly curved, lobulated at the sutures. Margin is acute, limbate, narrowly rounded. Dorsal surface is evolute, convex, the degree of convexity decreasing with growth. Ventral surface is involute, more strongly and evenly convex than the dorsal side. Ventral side is about one and a quarter times as high as the dorsal side. Test is composed of about fourteen chambers arranged in three whorls, six chambers in the last. Dorsal sutures are recurved, initially slightly thickened and depressed, later more strongly thickened and raised. The thickened sutures and margin are usually lighter in colour than the intervening chamber walls. Ventral sutures are slightly recurved, unthickened, depressed. Wall of test is calcareous, thick, opaque. Knobs and ridges of secondary shell material are usually deposited in front of the aperture on the ventral surface of the preceding whorl. Small pustules are sometimes formed secondarily on the dorsal chamber walls. No pores have been observed. Aperture is a slit along almost the entire base of the last chamber, widening appreciably into a broad arch in its lower half. A very narrow, thin lip overhangs the upper part of the aperture.

Figured Specimen.—G.S.M. No. 54677.

Dimensions.—Length: 1·01 mm. Width: 0·85 mm. Height: 0·63 mm.

Locality.—Aire Coast. Wilkinson's locality A.W., 2 miles north-west of Cape Otway.

Distribution.—Browns Creek Clays and "Lower Glen Aire Clays".

Remarks.

This form is identified with *E. lornensis* Finlay because of its ventrally expanding aperture and the reduced convexity of the ventral side. The number of chambers in the last whorl is usually six, although specimens have been observed with five and a half. Finlay stated the number of chambers to be consistently five, but specimens in the National Museum of Victoria, sent by Hornibrook, have six chambers in the last whorl. The ventral expension of the aperture is never as great as in the specimen figured by Finlay (1939, Pl. 13, fig. 52).

EPONIDES REPANDUS (Fichtel and Moll) 1798.

PLATE 6, FIGS. 51-53.

Nautilus repandus Fichtel and Moll, 1798 *Testa microscopica etc.*, p. 35, Pl. 3, figs. a–d.

Eponides repandus (Fichtel and Moll) Cushman, 1946. *Cush. Lab. Foram. Res., Spec. Publ.* No. 17, p. 6, Pl. 1, figs. 5, a–c.

Eponides repandus (Fichtel and Moll) Chapman, Parr and Collins, 1934. *Journ. Linn. Soc. Lond.* (*Zool.*) Vol. 38, p. 565, Pl. 9, figs. 18, a–c.

Diagnosis.

Large, trochospiral, thick-walled test. Dorsal surface smooth, slightly curved, almost flat. Ventral surface strongly convex. Dorsal sutures thickened and raised. Six chambers in last whorl. Coarse pores sometimes present in apertural face. Aperture does not expand ventrally.

Description.

A large, free test, trochospiral with a very low spire. Peripheral outline is sub-circular to pyriform, smoothly curved, lobulated at the sutures. Margin is thickened, broadly rounded. Dorsal surface is evolute, smooth between sutures, slightly curved, almost flat. Ventral surface is involute, strongly convex. Test is composed of about twelve chambers arranged in about two and a half whorls, six chambers in the last. Dorsal sutures are recurved, limbate, slightly raised. The thickened sutures and margin are usually lighter in colour than the intervening chamber walls. Ventral sutures are curved, limbate, initially depressed, secondarily made flush with surface. Wall of test is calcareous, thick, opaque. The only pores that have been observed are coarse pores in the apertural face and these are not always present. Aperture is a slit of fairly constant width along the base of the apertural face. It is deeply depressed ventrally, narrowing slightly and becoming less depressed towards the margin.

Figured specimen.—G.S.M. No. 54675.

Dimensions.—Length: 0·78 mm. Width: 0·62 mm. Height: 0·41 mm.

Locality.—Fossil Beach, Balcombe Bay. Bed "i" of F. A. Singleton (1941, p. 27). (Preservation is superior to that of any specimen from the Aire district.)

Supplementary specimen (from same locality): G.S.M. No. 54676.

Dimensions.—Length: 0·78 mm. Width: 0·60 mm. Height: 0·38 mm.

Distribution.—Calder River Limestone (rare), "Upper Glen Aire Clays" and Fishing Point Marl.

Genus **CIBICIDES** Montfort 1808.

CIBICIDES PERFORATUS (Karrer) 1864.

PLATE 6, FIGS. 57-59.

Rotalia perforata Karrer, 1864. *Novara Expedit. Geol. Theil.* Vol. 1, p. 81, Pl. 16, fig. 13.

Truncatulina haidingeri (d'Orbigny). Chapman, 1926. *N.Z. Geol. Surv. Pal. Bull* No. 11, p. 77, pl. 1, fig. 13 (non d'Orbigny, 1846).

Diagnosis.

Cibicides, trochospiral, about equally biconvex. Dorsal side is almost involute with raised boss filling umbilicus and occupying about one-fifth of diameter of that side. Ventral side is slightly involute, with chamber walls curved between spiral suture and margin. The whole of the ventral surface is uniformly convex. Ventrally, chambers are wider than their length along the direction of coiling. Aperture extends along entire ventral edge of last chamber and at least two penultimate chambers have open umbilical foramina.

Description.

A free test of moderate size, trochospiral, almost equally biconvex. Peripheral outline is sub-circular, smoothly curved, slightly lobulate at the last four or five sutures. Margin is acute, bluntly keeled. Dorsal side is almost completely involute, the small umbilicus being filled with opaque shell material which often forms a raised boss. Ventral side is uniformly convex, slightly involute, early whorls covered by perforated, opaque shell material. Both dorsally and ventrally, sutures are radial, recurved, slightly thickened, depressed when first formed, secondarily made flush with surface. Three whorls are usually present, the number of chambers in the last whorl varying from ten to thirteen. Ventrally, width of each chamber is greater than its length in the direction of coiling. Wall of test is initially thin and translucent, secondarily thickened. Ventral wall of each chamber is curved across its width and is perforated by a relatively small number of large pores. Dorsal chamber walls are concave and imperforate on earlier half of last whorl, later inflated and perforated by fairly sparse, fine pores.

Aperture is a narrow slit which commences just above the periphery of the preceding whorl and extends ventrally around the entire base of the last chamber. It continues as a groove along the spiral suture, and at least one penultimate chamber opens into the groove. A raised lip is present on the outer margin of the aperture where it crosses the periphery of the preceding whorl.

Figured specimen.—G.S.M. No. 54682.

Dimensions.—Diameter: 0·69 mm. Height: 0·27 mm.

Locality.—Aire coast, Wilkinson's locality AW.3. Clay bed 9-in. to 15-in. below top of section.

Distribution.—Calder River Limestone, "Upper Glen Aire Clays" and Fishing Point Marl.

Remarks.

The writer has followed Brotzen (1948) in regarding the more-evolute side of *Cibicides* as the ventral side. Although there are objections to this (Hofker, 1951), it seems more consistent to regard the side with the greater apertural development and umbilical foramina as ventral and compare it with the less convex side of *Rosalina scopos.*

The uniformly convex ventral surface is an important feature of this species.

CIBICIDES BREVORALIS sp. nov.

PLATE 6, FIGS. 54-56.

Diagnosis.

Cibicides, trochospiral, usually unequally biconvex. Dorsal side completely involute, ventral side completely evolute and usually more strongly convex than dorsal side. Ventrally, chambers are longer in the direction of coiling than they are wide. Six to eight chambers form last whorl. Dorsally, chamber walls are convex and sutures are unthickened and depressed. Aperture extends from just above margin

to spiral suture and, as a narrow slit, along this for less than half the length of last chamber. There is no umbilical thickening on dorsal side and no umbilical foramina on penultimate chambers.

Description.

A free test of moderate size, trochospiral, usually unequally biconvex. Ventral (evolute) side is usually higher than dorsal (involute) side. Peripheral outline is sub-circular and lobulated at the sutures. Margin is acute, slightly thickened and carinate. Dorsal side is completely involute, chamber walls are slightly convex between centre and margin. Last chamber is often much more inflated dorsally than are the preceding ones. Dorsal chamber walls are all sparsely perforated with fine pores. Dorsal sutures are radial, gently recurved, unthickened, depressed; on early part of last whorl they may be secondarily made flush with surface. Ventral side is completely evolute, early whorls covered by perforated opaque shell material. Convexity of ventral side decreases towards margin, surface of last whorl may be almost flat. Three to four whorls are visible, total number of chambers is about thirty-five, with seven to nine in the last whorl. Ventrally, chambers are longer in the direction of coiling than they are wide. Pores in ventral walls are fine and fairly sparse, though denser than on dorsal side. Central sutures are curved, oblique, slightly thickened, flush with surface. Each suture is notched, adjacent to spiral suture, outlining a former aperture, now covered by shell wall. Wall of test is thin, translucent. Aperture is a narrow slit which extends along base of apertural face from just above margin of previous whorl, then turns along the spiral suture for about one-third of the length of the last chamber. A lip is present on the portion of the aperture above the periphery.

Holotype.—G.S.M. No. 54680.

Dimensions.—Diameter: 0·60 mm. Height: 0·25 mm.

Type Locality.—Birregurra, Victoria. Outcrop on west bank of Barwon River, ½ mile south of town.

Paratype (topotype).—G.S.M. No. 54681.

Dimensions.—Greater diameter: 0·67 mm. Lesser diameter: 0·56 mm. Height: 0·30 mm.

Distribution.—Calder River Limestone, "Upper Glen Aire Clays" and Fishing Point Marl.

Remarks.

This species is similar to the Recent New Zealand species *C. temperata* Vella, 1957, which is distinguished by its concave chamber walls and thickened sutures on the involute side and wider aperture on the evolute side. Another species possessing the characteristic notch in the sutures on the ventral side is *C. parki* Finlay, 1939. It is probable that many records of *C. victoriensis* Chapman, Parr and Collins, 1934 refer to *C. brevoralis.*

In the Aire district, *C. brevoralis* is of comparatively rare occurrence and is usually associated with abundant *C. perforatus* (Karrer) 1864. These two species can be readily separated by comparison of the following characteristics.

Cibicides brevoralis sp. nov.

(*a*) chambers longer than wide.

(*b*) aperture extends along spiral suture for less than half length of last chamber.

(*c*) completely involute dorsally, completely evolute ventrally.

(*d*) umbilical boss not present on dorsal side.

Cibicides perforatus (Karrer).

(*a*) chambers wider than long.

(*b*) aperture extends along spiral suture for full length of last chamber and continues as a groove, receiving foramina from several chambers.

(*c*) slightly evolute dorsally, slightly involute ventrally.

(*d*) umbilical boss present on dorsal side.

Lat., *brevis,* short; *oris,* mouth.

Genus **ANOMALINOIDES** Brotzen 1942.

ANOMALINOIDES PROCOLLIGERA sp. nov.

PLATE 6, FIGS. 60-63.

Anomalina rotula d'Orbigny. Chapman, Parr and Collins, 1934 *J. Linn Soc. Lond. (Zool.).* Vol. 38, p. 570, pl. 11. figs. 38 a–c. (non d'Orbigny, 1846)

Anomalina ammonoides (Reuss) Auct. (non *Rosalina ammonoides* Reuss, 1884.)

Diagnosis.

Anomalinoides, asymmetrical, slightly evolute with a shallow umbilicus on each side and a small boss in each umbilicus. Dorsal side imperforate, ventral side coarsely perforate. Sutures slightly depressed, later filled with secondary shell material until flush with surface. Last five chambers open along spiral suture on ventral side with small, triangular flaps shielding their umbilical foramina.

Description.

A free test of moderate size, trochospiral with a very low spire, biconvex, dorsal side more convex than ventral side (on which the chambers open along spiral suture). Peripheral outline is subcircular, smoothly curved, lobulated at the last three sutures. Margin is narrowly rounded. Test is slightly evolute with a shallow umbilicus on each side. In the centre of each umbilicus is a low boss of clear shell material, the ventral boss usually being perforated by large pores. Three whorls are present, the total number of chambers is about twenty-five, of which eleven to thirteen form the last whorl. Chambers are inflated, slightly compressed towards periphery. Sutures are radial, gently recurved, distinct, limbate and flush with surface on early part of test. Last three or four sutures are unthickened, slightly depressed. Wall of test is thin, remarkably transparent, coarsely perforate on ventral side, imperforate on dorsal side. Aperture is narrow, with a slightly raised lip on its outer margin, extending along basal suture of last chamber from just below

the periphery of the preceding whorl to the spiral suture and along this almost to the last radial suture. A groove extends back along the spiral suture for at least the width of the last five chambers, receiving umbilical foramina of these chambers. Each umbilical foramen and the ventral part of the aperture is concealed by a small triangular flap. These apertural flaps are clearly visible on only the last seven or eight chambers—those on earlier chambers become enveloped by the secondary shell material which forms the boss at the bottom of the umbilicus. On the last chamber, the apertural flap is continuous with the lip on the apertural face. The apertural flap of any one chamber overlaps that of the preceding chamber. Septal foramen is crescentic, situated at the base of the septum.

Holotype.—G.S.M. No. 54683.

Dimensions.—Diameter: 0·54 mm. Height: 0·19 mm.

Type locality.—Birregurra, Victoria. Outcrop on west bank of Barwon River, ½-mile south of town.

Paratype (topotype): G.S.M. No. 54684.

Dimensions.—Diameter: 0·59 mm. Height: 0·22 mm.

Tectoparatype (topotype): G.S.M. No. 54718.

Dimensions.—Length of Section: 0·47 mm. Width: 0·18 mm.

Distribution.—Calder River Limestone, "Upper Glen Aire Clays" and Fishing Point Marl.

Remarks.

This species is a close relative and probably the ancestor of the Australian Recent species *Anomalinoides colligera* (Chapman and Parr) 1937, which has a much higher test, a more inflated dorsal side and ventral sutures which are greatly thickened and raised. In both species the sutures are initially thickened and depressed. In *A. procolligera* the depressions are later filled until the secondary shell material is flush with the surface of the test. In *A. colligera* this secondary deposit forms high ridges above the ventral sutures and covers the intervening chamber walls. A New Zealand Tertiary species *A. fasciata* (*Rosalina fasciata* Stache, 1864) is similar but has less secondary thickening and is more inflated than *A. procolligera.*

Lat. *pro,* before and *colligera,* gathered together (after *Anomalina colligera* Chapman and Parr, 1937).

Genus **GLOBIGERINA** d'Orbigny 1826.

GLOBIGERINA LINAPERTA Finlay 1939.

PLATE 5, FIGS. 46, 47.

Globigerina linaperta Finlay, 1939. *Trans. Proc. Roy. Soc. N.Z.* Vol. 69, Pt. 1, p. 125, Pl. 13, figs. 54–57.

Diagnosis.

Globigerina, trochospiral with slightly flattened chambers. Aperture is a narrow slit at base of last chamber, displaced towards margin from umbilicus. Aperture is borded ventrally by a smooth-edged lip.

Description.

A moderately-sized, free test composed of a trochospiral coil of sub-globular chambers, of which three and a half form the last whorl. Two to three whorls are present and the total number of chambers is about eight. Chambers are typically somewhat compressed, and show a gradual increase in size. Wall of test is thin and translucent, pits are shallow, pores are small and the surface is closely covered with small spines. Sutures are depressed, unthickened. Aperture is a fairly narrow arched slit approximately in the umbilical position but slightly displaced towards the margin and usually not longer than the width of the third last chamber along the equatorial suture. The aperture is bordered ventrally by a thin, narrow, smooth-edged lip.

Figured specimen.—G.S.M. No. 54685.

Dimensions.—Length: 0·36 mm. Width: 0·29 mm. Height: 0·29 mm.

Locality.—Browns Creek coastal section. Second gully west of Browns Creek, approximately 80 feet above greensand.

Distribution.—Browns Creek Clays, Castle Cove Limestone and "Lower Glen Aire Clays."

Remarks.

Typical specimens of *G. linaperta* occur in the Browns Creek Clays and it is of rare occurrence in the Castle Cove Limestone. It is the dominant globigerinid in the "Lower Glen Aire Clays", where compact tests with swollen chambers are the usual form of the species. It is apparently the first record of the species outside New Zealand.

The record of *G. triloculinoides* Plummer from the Aire district (Raggatt and Crespin, 1955, p. 134) probably refers to this species. *G. triloculinoides* possesses a crenulated lip below the aperture, which distinguishes it from *G. linaperta.* Grimsdale (1951) restricts *G. triloculinoides* to beds which are older than the Browns Creek Clays.

Genus **GLOBIGERINOIDES** Cushman 1927.

GLOBIGERINOIDES INDEX, Finlay 1939.

PLATE 7, FIGS. 64-66.

Globigerinoides index Finlay, 1939. *Trans. Proc. Roy. Soc. N.Z.* Vol. 69. Pt. 1. pp. 124, 125, Pl. 14, figs. 85-88.

Diagnosis.

Compact trochospiral coil of sub-globular chambers, each slightly flattened on outer side. Sutures depressed, unthickened. Last chamber has three large arched apertures opposite sutures on earlier part of test.

Description.

A free, sub-globular test of moderate size. Individual chambers are also sub-globular, slightly flattened on the outer face, the degree of flattening tending to increase on older chambers. The size of chambers increases gradually. Last chamber is sometimes smaller than its predecessor. Total number of chambers is about nine, arranged in two

to three trochospiral whorls. Wall of test is thin and translucent. Pores are relatively small, set in pits with intervening raised spiny ridges. Sutures are depressed, unthickened. Three large arched apertures are present around the base of the last chamber, situated where the basal suture of this chamber intersects sutures on the earlier part of the test.

Figured specimen: G.S.M. No. 54687.

Dimensions: Length, 0·40 mm. Width: 0·33 mm. Height: 0·38 mm.

Locality: Browns Creek coastal section. First gully west of Browns Creek. Top of dark grey clay underlying greensand.

Distribution: Browns Creek Clays and Castle Cove Limestone.

Remarks.

In the Aire district, *G. index* is continuously common throughout approximately 200 feet of strata. Furthermore, in New Zealand, Finlay, and Marwick (1947) record continuous occurrence with an abrupt end as a feature of the lengthy stratigraphic range of *G. index*. It is claimed that the specimens of *G. index* recorded from bed BR. 5 at Bird Rock Bluff by Raggatt and Crespin (1955, p. 128; Table 7) are not indigenous to this bed, five feet in thickness, since the species has not been recorded from either higher or lower in the sequence and this single record of it has never been confirmed. (Vide section "Correlation—Torquay and the Port Phillip region" supra.)

GLOBIGERINOIDES TRILOBA (Reuss) 1850.

PLATE 7, FIGS. 67-69.

Globigerina triloba Reuss, 1850. *K. Akad. Wiss. Wien., Math.—Nat. Denkschr.* Vol. 1, p. 374 Pl. 47, fig. 11.

Globigerinoides triloba Reuss. Blow, 1956. *Micropaleontology* Vol. 2, No. 1, p. 62, figs. 1 (1-3), 3.

Globigerinoides triloba Reuss. Drooger, 1956. *Micropaleontology,* Vol. 2, No. 2, Pl. 1, figs. 36 a–c.

Diagnosis.

Globigerinoides, size of last chamber is not greater than that of earlier part of test. Two apertures open along equatorial suture.

Description.

A free test of moderate size, composed of inflated, sub-globular chambers, trochospirally arranged in about two whorls. The total number of chambers is about eight. Wall of test is thin, translucent, with relatively large pores set in pits. Chambers increase in size quite rapidly, and the volume of the last chamber may equal that of the earlier part of the test, but is usually smaller. Early sutures are slightly thickened, but fairly distinct. Two apertures of unequal size are present on the equatorial suture as slightly depressed, bow-shaped slits. The larger of these apertures is in the umbilical position, displaced slightly towards the earlier whorls. The other is situated in the angle between the last chamber, the second-last chamber and the first whorl. Some earlier apertures may remain open.

Figured specimen: G.S.M. No. 54688.

Dimensions.—Length: 0·45 mm. Width: 0·36 mm. Height: 0·31 mm.

Locality: Castle Cove, sample CC.52 of A. N. Carter, 26.7.1956.

Distribution: Fishing Point Marl.

Remarks.

Typical specimens of *G. triloba* are fairly common in the lower part of the Fishing Point Marl at its type locality and also in sample CC.52 at Castle Cove. In this latter sample it is associated with less-frequent specimens of *G. bispherica.* At the top of the section at Fishing Point and in sample CC.53 at Castle Cove, *G. bispherica* is the dominant pelagic species and *G. triloba* is rare. The first appearance of *G. triloba* is at least 120 feet above the lowest occurrence of *Globoquadrina dehiscens* at Castle Cove.

GLOBIGERINOIDES BISPHERICA Todd, 1954.

PLATE 7, FIGS. 70-74.

Globigerinoides bispherica Todd, 1954. *Amer. J. Sci.* Vol. 252. No. 11, pp. 681, 682. Pl. 1, figs. 1, 4.

Globigerinoides bispherica Todd. Blow, 1956. *Micropaleontology,* Vol. 2. No. 1, pp. 62-64, figs. 1, 3.

Globigerinoides bisphericus Todd. Drooger, 1956. *Micropaleontology,* Vol. 2. No. 2. Pl. 1, figs. 20-22.

Diagnosis.

Globigerinoides, size of last chamber exceeds that of the earlier part of the test. Two to four narrow apertures open along equatorial suture. Earlier apertures may remain open to the exterior.

Description.

A free test of moderate size, composed of inflated, sub-globular chambers, trochospirally arranged in two whorls. The total number of chambers is about eight. Wall of test is thin, translucent with relatively large pores set in pits. Chambers increase in size rapidly, the last chamber is greater in volume than the earlier part of the test. Early sutures are secondarily thickened and obscure. A thick knobby ridge is added to the early chambers at the edge of the deeply incised equatorial suture. Two to four apertures are present as narrow slits around the base of the last chamber, opening along the equatorial suture. The number of apertures bears a direct relation to the proportional size of the last chamber. Two apertures are always present, one in the umbilical position, and, in a dextrally coiled test, the second aperture is almost diametrically opposite at the right-hand sutural junction on the spiral side. If a third aperture is present in a dextrally coiled test, it is at the left hand sutural junction, and if a fourth aperture is present, it is situated between the second and third apertures. Earlier supplementary apertures sometimes remain open.

Figured specimen: G.S.M. No. 54689.

Dimensions: Length, 0·38 mm. Diameter of last chamber, 0·33 mm.

Figured specimen (Showing enlargement of supplementary apertures): G.S.M. No. 54690.

Dimensions: Length, 0·42 mm. Diameter of last chamber, 0·37 mm.

Locality (of both specimens): Castle Cove, Sample CC·53 of A. N. Carter, 26.7.1956. (Stratigraphically highest sample from Castle Cove).

Distribution: Fishing Point Marl.

Remarks.

A series of specimens of *G. bispherica* will be seen to inter-grade with *G. triloba* on one hand, and with a number of different forms on the other. Some features of this intergradation have already been discussed by Blow (1956), whose hypothesis of the evolution of *G. bispherica* from *G. triloba* has been supported by the present extent of the writer's investigations. Unfortunately, the part of the sequence which is likely to yield stratigraphic confirmation of the hypothesis is very poorly exposed both at Fishing Point and at Castle Cove. However, a sample (CC. 52) containing frequent *G. triloba,* and "transitional" *G. bispherica,* with rarer specimens of more typical *G. bispherica* has been taken from Castle Cove. Higher in sequence, sample CC. 53 contains occasional *G. triloba,* common *G. bispherica,* including "advanced" forms (e.g. specimen 54690), and other species such as *G. rubra,* which are thought to have developed from *G. bispherica.* The writer has not encountered in the Aire district the forms such as *G. glomerosa* and *G. transitoria,* which Blow (1956) has included in lineages respectively leading to *Orbulina* and *Biorbulina.* Blow has envisaged the gradual envelopment of early chambers by later ones as the principal mechanism in the evolution of *Orbulina* from *Globigerinoides triloba.* To the writer, it would appear that the primary trend in the evolution of *G. bispherica* from *G. triloba* is an increase in the rate at which the size of the chambers increases during ontogeny, and the increasing envelopment of earlier chambers by later ones, is consequent upon it. If two lineages can be legitimately derived from *G. bispherica,* no reason can be seen at present why a third leading to *G. rubra* is not possible, produced by a tendency to increase the size of the supplementary apertures. (See specimen, G.S.M. No. 54690). More will be said of this lineage in connection with *G. rubra.*

The name *Globigerinoides bispherica* can be applied conveniently to specimens which come within the following arbitrary limits of variation:

(*a*) Early part of test is only slightly smaller than the last chamber. Two fairly large apertures are present. This end of the range grades into *G. triloba.*

(*b*) Early part of test is about one third the size of the last chamber and four small apertures are present.

Within these limits are seen tendencies to:—

(1) Increase the rate of chamber enlargement during ontogeny.

(2) Increase the amount of envelopment of early chambers by later ones.

(3) Increase the number of apertures but reduce their size.

GLOBIGERINOIDES RUBRA (d'Orbigny) 1839.

PLATE 8, FIGS. 81-84.

Globigerina rubra d'Orbigny, 1839 in Ramon de la Sagra, *Hist. Phys. Nat. Ile Cuba* p. 82.

Diagnosis.

Globigerinoides, size of last chamber never exceeds that of earlier part of test. Chambers evenly inflated, sutures depressed. Three apertures of different sizes open around base of last chamber opposite sutures of earlier part of test. Supplementary apertures remain open on two penultimate chambers.

Description.

A free test of moderate size, composed of about eight inflated, sub-globular chambers, trochospirally arranged in two whorls. Chambers increase in size fairly rapidly, but the volume of the last-formed chamber is always less than that of the earlier part of the test. Sutures are initially unthickened and depressed, later made flush with the surface. Wall of test is thin, translucent, relatively smooth for a globigerinid, closely, evenly and coarsely perforate. Three apertures are present at the base of the last chamber. They are usually of different sizes but all are slightly depressed, arched, with a thickened rim and situated at the intersections of the equatorial suture and the sutures of the earlier part of the test. Two apertures of the second-last chamber and one aperture of the third-last chamber usually remain open.

Figured specimen.—G.S.M. No. 54691.

Dimensions.—Length: 0·59 mm. Width: 0·51 mm. Height: 0·44 mm.

Locality.—Castle Cove, most easterly disconnected outcrop. Sample CC. 53.

Distribution.—Fishing Point Marl.

Remarks.

In *G. rubra,* the largest of the three apertures of the apertures of the last chamber is always in the umbilical position. When the spiral side of a dextrally coiled specimen is viewed, the next largest aperture is on the right hand side and the left hand aperture is the smallest of the three. This is the same order of size relationships found in dextrally coiled specimens of *G. bispherica* with three apertures. (See figure of specimen G.S.M. No. 54690.) Although a complete connecting series cannot yet be demonstrated, it seems probable that *G. rubra* was derived from a three-apertured form of *G. bispherica* by enlargement of the apertures.

At Castle Cove, a stratigraphic thickness of the order of 350 feet intervenes between the occurrence of *G. rubra* and the highest occurrence of the earlier *Globigerinoides* with three large apertures at the base of the last chamber, namely *G. index.* The two species can be readily distinguished: *G. rubra* is usually larger and its chambers are never flattened. The writer has never observed supplementary apertures on the penultimate chambers of *G. index.*

The separate origins at different times of these two similar species suggests that the genus *Globigerinoides* is polyphyletic.

Genus **GLOBOQUADRINA** Finlay 1947.

GLOBOQUADRINA DEHISCENS (Chapman, Parr and Collins) 1934.

PLATE 8, FIGS. 85-87.

Globorotalia dehiscens Chapman, Parr and Collins, 1934. *Journ. Linn. Soc. (Lond.) Zool.* Vol. 38, p. 569, Pl. 11, figs. 36 a–c.

Globoquadrina dehiscens (Chapman, Parr and Collins) Finlay, 1947. *N.Z. Journ. Sci. Tech.* Series B. Vol. 28, No. 5, pp. 290, 291.

Globoquadrina dehiscens (Chapman, Parr and Collins) Grimsdale, 1951 *Proc. Third World Petroleum Congr.* Sect. 1, pp. 471, 472.

Globoquadrina dehiscens (Chapman, Parr and Collins) Drooger, 1956. *Micropaleontology* Vol. 2, No. 2, pp. 185–188, Pl. 1, fig. 16.

Diagnosis.

Globoquadrina, quadrate in outline, somewhat rounded. Four chambers visible on ventral side. Aperture irregular in shape. Apertural flaps relatively large, projecting into umbilicus.

Description.

A free test of moderate size composed of inflated, wedge-shaped chambers, trochospirally arranged in two to three whorls. Peripheral outline is quadrate, somewhat rounded. The total number of chambers is usually about twelve, and the number in the last whorl is always four. The dorsal surface is flat or slightly convex, evolute, with all chambers visible. Ventral surface is involute with a deep quadrate umbilicus. Sutures are unthickened, depressed. Wall of test is thin, translucent, relatively smooth, perforated by evenly spaced fine pores set in small pits. Aperture is a slit, wider at one end than the other, opening into the umbilicus. A triangular flap, long but not wide, composed of imperforate shell material shields the aperture on the ventral side and projects slightly into the umbilicus. Apertures of at least the last three chambers remain open.

Figured specimen.—G.S.M. No. 54692.

Dimensions.—Greater diameter: 0·52 mm. Lesser diameter: 0·45 mm. Height: 0·38 mm.

Locality.—Castle Cove. Most easterly disconnected outcrop. Sample CC. 53.

Distribution.—" Upper Glen Aire Clays " and Fishing Point Marl.

Genus **PLANORBULINELLA** Cushman 1927.

PLANORBULINELLA JOHANNAE sp. nov.

PLATE 8, FIGS. 76-78.

Diagnosis.

Test is free, discoidal, planoconcave. Diameter is about three and a half times the thickness. Embryo is bilocular, followed by a pair of auxiliary chambers which are elongate-reniform in cross section. Twelve arcuate adult chambers comprise the first cycle.

Description.

External Features:

A fairly large, relatively thick, free test, discoidal, planoconcave. Peripheral outline is sub-circular. Margin is rounded, bluntly wedge-shaped. Wall of test is thick, layered, perforated by a relatively small number of coarse pores.

Internal Features:

A single layer of chambers is present; they increase in height gradually from the centre towards the periphery. A protoconch and deuteroconch are present, both sub-spherical, separated by a flat dividing wall. The deuteroconch is slightly larger than the protoconch, but does not embrace it. A pair of foramina perforate the deuteroconchal wall adjacent to the ends of the dividing wall. The embryonic chambers are followed by a pair of auxiliary chambers, whose length is slightly less than that of the embryonic chambers. The auxiliary chambers have a foramen at each end at the junction of the wall with the embryonic chambers. Four additional foramina are present in the wall of each auxiliary chamber, more or less evenly spaced along its length. A normal adult chamber develops from each of these foramina. Thereafter, growth is cyclic, the chambers of one cycle alternating with those of the next. Upwards of twelve cycles of adult chambers are usually present. Adult chambers are elongate-reniform, arcuate in cross-section, with a pair of foramina, one at each outer edge. (Neither distinct apertures nor canals have been observed.)

Holotype.—G.S.M. No. 54694.

Dimensions.—Diameter: 0·81 mm. Thickness: 0·22 mm.

Type Locality.—Limestone outcrop at the mouth of the Johanna River, Parish of Aire.

Paratype (topotype).—G.S.M. No. 54693.

Dimensions.—Diameter: 0·93 mm. Thickness: 0·29 mm.

Tectotype (topotype-figured): G.S.M. No. 54696.

Dimensions.—Diameter of test: 0·93 mm.

The following are measured from inner edges:

Longitudinal diameter of embryonic chambers: 0·16 mm.

Longitudinal diameter of protoconch: 0·074 mm.

Longitudinal diameter of deuteroconch: 0·078 mm.

Lateral diameter of protoconch: 0·086 mm.

Lateral diameter of deuteroconch: 0·11 mm.

Length of auxiliary chamber: 0·15 mm.

Width of embryonic and auxiliary chambers: 0·18 mm.

Distribution.—Castle Cove Limestone.

The trivial name of the species is derived from the Johanna River, on which the type locality is situated.

PLANORBULINELLA PLANA (Heron-Allen and Earland) 1924.

PLATE 8, FIGS. 79, 80.

Planorbulina plana Heron-Allen and Earland, 1924. *Journ. Roy. Micr. Soc.* pp. 174, 175, Pl. 12, figs. 92–95.

Diagnosis.

Test is free, discoidal, compressed. Diameter is about six times the thickness. Embryo is bilocular, followed by a pair of small rounded auxiliary chambers. Four arcuate adult chambers comprise the first cycle.

Description.

A relatively large, compressed, discoidal, free test. Peripheral outline is circular, regularly scallopped. Margin is rounded. Wall of test is thin, sometimes transparent with the chamber arrangement visible from the exterior. Dorsal and ventral walls of test are flat, with a finely granular surface; the outer faces of each chamber are perforated with closely-set fine pores. No distinct aperture is present.

Test originates from a protoconch and deuteroconch, the latter being slightly larger than the former. The embryonic chambers give rise to a rounded auxiliary chamber, with about the same diameter as the protoconch, on each side. The auxiliary chambers give rise to the first cycle of four arcuate adult chambers. Upwards of twelve cycles of adult chambers are usually present.

Figured specimen.—G.S.M. No. 54695.

Dimensions.—Diameter of test: 0·44 mm. Thickness of test: 0·07 mm.

The following are measured from inner edges:

Longitudinal diameter of embryonic chambers: 0·075 mm.
Lateral diameter of protoconch: 0·034 mm.
Lateral diameter of deuteroconch: 0·055 mm.
Diameter ("length") of auxiliary chambers: 0·027 mm.
Width of embryonic and auxiliary chambers: 0·11 mm.

Locality.—Robinson's Quarry, Parish of Glencoe, Gippsland, Victoria. (Chosen because of the transparency of the specimen.)

Distribution.—Fishing Point Marl.

Remarks.

Planorbulinella inaequilateralis (H–A and E.) 1924, a frequent associate of *P. plana* elsewhere in Victoria, is represented by a solitary specimen in sample CC. 52 at Castle Cove, where the two species occur together. *P. plana* also occurs occasionally in the Fishing Point section.

Genus **HOFKERINA** Chapman and Parr 1931.

HOFKERINA SEMIORNATA (Howchin) 1889.

PLATE 9, FIGS. 88-90.

Pulvinulina semiornata Howchin, 1889. *Trans. Roy. Soc. S. Aust.* Vol. 12, p. 14, Pl. 1, figs. 12 a–c.

Hofkerina semiornata (Howchin) Chapman and Parr, 1931. *Proc. Roy. Soc. Vic. (n.s.)* Vol. 43, Pt. 2, pp. 237, 238 Pl. 9, figs. 1–5.

Hofkerina semiornata (Howchin) Crespin, 1936. Dept. of Interior (Australia). *Pal. Bull.* 2. pp. 6, 7. Pl. 1, figs 3, 4.

Diagnosis.

Large, free-living, thick walled, finely perforate test, dorsally evolute, ventrally involute. Last chamber occupies about one third of total volume of test. Dorsal sutures almost straight. Early half of dorsal surface covered by large, secondarily-formed tubercles. Coarse pores in ventral surface of last chamber. Aperture formed by pores along basal suture of last chamber.

Description.

A large, free, trochospiral, ellipsoidal test. Peripheral outline is oval, lobulated at the sutures. Margin is broadly rounded. Test is composed of about ten chambers of which four to five form the last whorl. Chambers are inflated and increase in size quite rapidly, each one being equal to about half the total volume of all its predecessors. Dorsal side is evolute. Ventral side is involute, non-umbilicate. Dorsal sutures are almost straight, the last being at right angles to the long axis of the test. Ventral sutures are slightly curved, approximately radial. Wall of test is thick, opaque, finely and evenly perforated. Dorsal surfaces of the third-last and preceding chambers are ornamented with large tubercles. Rudimentary tubercles are usually present on the second-last chamber, but they never occur on the last. Ventral wall of the last chamber is perforated with a number of coarse pores. Aperture consists of a number of relatively large pores along the basal suture of the last chamber. Some apertural pores along earlier sutures remain open.

Figured specimen.—G.S.M. No. 54697.

Dimensions.—Length: 1·09 mm. Width: 0·97 mm. Height: 0·76 mm.

Locality.—Basal beds of cliff section at Limestone Creek Cliff, Glenelg River, Parish of Werrikoo.

Distribution.—Fishing Point Marl. (Restricted to coarse-grained friable rock at top of exposed section at Fishing Point.)

Remarks.

All the specimens from Fishing Point are broken and worn, so the figured specimen was chosen from well-preserved material from Limestone Creek Cliff.

Previous descriptions of the species, based largely on broken specimens, have over-emphasized the area occupied by large pores on the ventral surface. For instance, Howchin's type series, preserved in the Adelaide University Geology School museum, consists entirely of broken specimens. The large pores in the ventral walls are enlarged when they assume the role of septal foramina.

Genus **ASTRONONION** Cushman and Edwards, 1937.

ASTRONONION AUSTRALE Cushman and Edwards, 1937.

PLATE 9, FIGS. 91, 92.

Astrononion australe Cushman and Edwards, 1937. *Contr. Cush. Lab. Foram. Res.* Vol. 13, Pt. 1, pp. 33, 34. Pl. 3, figs. 13, 14.

Astrononion australe Cushman and Edwards. Cushman, 1939 *U.S. Geol. Surv., Prof. Paper.* No. 191, pp. 37, 38. Pl. 10, figs. 7, 8.

Diagnosis.

Astrononion, moderately inflated, about nine chambers in last whorl. Apertural flaps of moderate width, posterior edge bridges sutural depression widely at a very oblique angle. A deep narrow umbilicus is frequently present. Chambers are not compressed towards periphery.

Description

A free test of small to moderate size, symmetrically planispiral, involute on both sides. Peripheral outline is sub-circular, lobulated at the sutures. Margin is broadly rounded. The only whorl visible is the last, in which the numbers of chambers is usually about nine. Chambers are slightly inflated and increase gradually in size. They are tear-drop shaped in cross section. Sutures are gently recurved, unthickened, depressed, except at margin where they are flush with the surface. Inner portions of the sutures are concealed by the outwardly-directed points of the apertural flaps. Wall of test is thin, translucent, finely and evenly perforated, except on the apertural face and apertural flaps, which are imperforate. Apertural foramen is a narrow slit with an unthickened rim extending round the entire base of the last chamber; almost all of it remains open as the septal foramen. Each chamber is flanked by a pair of triangular apertural flaps which extend outwards and backwards from the umbilical ends of the aperture and fuse the anterior margins of the flaps on the preceding chamber. Each flap bears an peripherally directed, gradually tapering lobe which is fused along its anterior edge with the proximal part of the wall of its own chamber. The other edge of the lobe bridges the sutural depression very obliquely and fuses with the flap of the previous chamber. The posterior end of the aperture opens to the exterior along the sutural depression beneath the apertural flap. These supplementary apertures remain open on all chambers of the last whorl.

The overlapping, fused apertural flaps form a stellate plate with a slightly depressed centre on each face of the test. Frequently a narrow but fairly deep umbilicus opens into the centre of the depression

Figured specimen.—G.S.M. No. 54698.

Dimensions.—Greater diameter: 0·53 mm. Lesser diameter: 0·47 mm. Height: 0·22 mm.

Locality.—Robinson's Quarry, Parish of Glencoe, Gippsland, Victoria.

Supplementary Specimens.

G.S.M. No. 54701. Aire Coast. Wilkinsons Locality AW. 3. Clay bed 9″–15″ below top of section. (20 specimens).

G.S.M. No. 54700. Clifton Bank, Muddy Creek, Hamilton district, Victoria. (3 topotypes).

G.S.M. No. 54699. Robinson's Quarry, Parish of Glencoe. (4 specimens).

ASTRONONION sp.

PLATE 9, FIGS. 93, 94.

Diagnosis.

Generally similar to *A. australe* but with the following differences:

(*a*) Chambers are compressed towards the periphery.
(*b*) Margin is narrowly rounded.
(*c*) Sutures are more strongly recurved.
(*d*) Pores in shell wall are less closely spaced.
(*e*) Aperture has a slightly thickened outer rim.

Figured specimen: N.M.V. No. P. 16012.

Dimensions.—Diameter: 0·41 mm. Height, 0·21 mm.

Locality.—Marl bed about three feet above base of section exposed on hillside, west side of Browns Creek and about 20 chains from mouth. (ex slide in Parr Collection, N.M.V. No. P. 14936/56).

Distribution.—Browns Creek Clays.

Remarks.

This species is at present represented by one intact and one fragmentary specimen. Although these are readily separable from *A. australe,* a formal name will not be given to the species until more specimens are available.

The range of *Astrononion* has been given as " ? Oligocene, Miocene to Recent " (Glaessner 1945, Cushman 1950). This species definitely extends the known range of *Astrononion* into the Upper Eocene, because it occurs in association with *Globigerinoides index* in a bed which is only a few feet above beds containing *Hantkenina alabamensis compressa.*

ASTRONONION CENTROPLAX sp. nov.

PLATE 9, FIGS. 95-97.

Diagnosis.

Astrononion, symmetrical, planispiral. Last four or five chambers open by accessory apertures along spiral sutures on both sides. Each aperture shielded by an inwardly-directed triangular plate which overlaps the one behind it, but is not fused to it. Test slightly and equally evolute on both sides.

Description.

A free test of moderate size, symmerically planispiral, slightly evolute with a shallow umbilicus on each side. Margin is rounded. Peripheral outline is smoothly curved. The only whorl visible is

the last, in which the number of chambers varies from eight to eleven. Chambers are slightly inflated and increase gradually in size. Sutures are gently recurved, unthickened, depressed, except at margin where they are flush with surface. The last five or six sutures are clearly visible, but those on the early part of the last whorl are partly obscured by secondary shell-material. Wall of test is calcareous, structure of wall is "granular" (Wood, 1949) and is perforated by pores of moderate size except for the apertural face which is imperforate. Aperture of last chamber is a narrow slit extending around the entire base of that chamber. A narrow lip overhangs the aperature on the terminal face, but widens into a triangular plate overhanging the aperture on the dorsal and ventral sides of the last chamber. At the outer margins of the sutures between successive chambers, triangular pillars of shell material connect the wall of the last whorl to the preceding whorl. Between each pair of pillars is a crescentic septal foramen. Between successive pairs of pillars, each chamber opens to the exterior by sub-elliptical apertures on both the dorsal and ventral sides along the spiral sutures. These apertures along the spiral sutures remain open on only the last four or five chambers; those of earlier chambers are closed by secondary shell material. The triangular plates (apertural flaps) are present on the last six to eight chambers and the plate of any chamber overlaps that of the preceding chamber by approximately half its area. On the chambers, where the apertures along the spiral suture remain open, the triangular plates extend across the umbilical depression externally to the apertures. These apertures and the spaces beneath the triangular plates are filled with shell material as growth progresses. The triangular plates of the earliest chambers of the last whorl have lost their identity and merge with the mass of opaque shell material filling the umbilicus. A distinct round boss is sometimes present in the umbilical depression.

Holotype.—G.S.M. No. 54702.

Dimensions.—Diameter: 0·67 mm. Height: 0·26 mm.

Type locality.—Aire Coast, Wilkinson's locality AW. 3. Clay bed 9 in.–15 in. below top of section.

Paratype (topotype): G.S.M. No. 54703.

Dimensions.—Diameter: 0·69 mm. Height: 0·26 mm.

Paratype (topotype, figured, oblique view): G.S.M. No. 54704.

Dimensions.—Diameter: 0·67 mm. Height: 0·26 mm.

Distribution.—Calder River Limestone, "Upper Glen Aire Clays" and Fishing Marl.

Remarks.

The distinctive features of this stratigraphically important species are its bisymmetrical test and overlapping triangular plates in the umbilical region, each of which covers, at least initially, a supplementary aperture. It apparently has relationships with two New Zealand species: *Astrononion maoricum* (*Rosalina moarica* Stache, 1864) which has many more chambers and thicker, rod-like apertural flaps and *Astrononion novozelandicum* (Cushman) 1936 which has a

deep umbilicus and limbate sutures. A single specimen referable to this latter species has been found near the base of the "Upper Glen Aire Clays" (N.M.V. slide 14984/77.)

Gr. kentron, the centre; *plax,* plates, alluding to the overlapping apertural flaps.

Genus **ELPHIDIUM** Montfort 1808.

ELPHIDIUM (PARRELLINA) CENTRIFUGALIS sp. nov.

PLATE 9, FIGS. 98-100.

Diagnosis.

Elphidium, prominently unbonate on both sides, bluntly keeled, last whorl composed of about 19 chambers. Inter-sutural ridges number about 12 on each lateral face of adult chambers and are directed towards the periphery. Apertural face is chevron-shaped, narrow and buttressed.

Description.

A relatively large, free, lenticular test, planispiral, completely involute and prominently umbonate on both sides. Peripheral outline is smooth, almost circular. Margin is acute, slightly thickened, bluntly keeled. Last whorl is composed of about 19 chambers, which are narrow, compressed and increase in size very slowly. Sutures are sinuous, strongly recurved, limbate, raised and their inner ends fuse with the umbo. Wall of test is initially thin, translucent, but is secondarily thickened. Canal system opens into a row of deep, conical pits on the distal side of each suture. Between the pits, the lateral chamber walls are raised and each bears a sharp thickened ridge which is directed forwards from the suture and fuses with the sutural ridge at its proximal end. These ridges initially extend only about half way across the lateral face of the last chamber, the outer half of which face is usually smooth. With the addition of another chamber the ridges are continued across the lateral face of the chamber and fuse with the later sutural ridge, to form inter-sutural ridges (retral processes *auct.*). Inter-sutural ridges are directed slightly towards the periphery and adult chambers bear about twelve of them on each side. Apertural face is chevron shaped, smooth with occasional buttresses on to the previous whorl, narrow in the marginal line. No apertural pores have been observed.

Holotype.—G.S.M. No. 54705.

Dimensions.—Diameter: 1·00 mm. Height: 0·49 mm.

Type locality.—Castle Cove, Sample CC. 33.

Paratype (topotype-juvenile): G.S.M. No. 54706, (figured).

Dimensions.—Diameter: 0·74 mm. Height: 0·23 mm.

Paratype (topotype): G.S.M. No. 54707.

Dimensions.—Diameter: 1·08 mm. Height: 0·52 mm.

Distribution.—"Upper Glen Aire Clays"

Remarks.

This species somewhat resembles *E. crespinae* Cushman and *E. crassatum* Cushman (both described from the lower beds, Muddy

Creek) but is readily distinguished by being strongly umbonate and much less compressed. It is more prominently unbonate and has a narrower apertural face than *E. crispum* (Linne).

Lat. *centrum,* the centre; *fugere,* to flee, indicating the rapidly widening spiral described by successive interseptal ridges.

Genus **NOTOROTALIA** Finlay 1939.

NOTOROTALIA CRASSIMURA sp. nov.

PLATE 10, FIGS. 101-103.

Diagnosis.

Notorotalia, strongly biconvex network, of coarse ridges on dorsal side, large central boss on ventral side. Total number of chambers is about forty-five, of which about eighteen form the last whorl. Completely evolute dorsally. Slightly evolute ventrally with large central boss.

Description.

A large, free test, trochospiral, strongly biconvex. Peripheral outline is almost circular. Margin is bluntly keeled. Dorsal side is completely evolute, ventral side slightly involute. Umbilicus is filled with translucent shell material forming a large raised boss. Four whorls are present. Total number of chambers is about forty-five, of which seventeen to twenty form the last whorl. Dorsal sutures are strongly recurved, unthickened, depressed, marked by lines of coarse pores, early sutures may be obscured by secondary shell material. Ventral sutures are limbate, raised, radial, their inner ends merging with the central boss. Wall of test thick, calcareous, translucent. No pores visible except the coarse openings of the canal system, as a row of pores along sutures on dorsal side and as a row of coarse pores adjacent to the distal sides of the ventral sutures. Both dorsal and ventral surfaces ornamented by irregular anastomosing ridges of secondary shell material. Aperture consists of a row of about 6 pores in a narrow trough at the base of the aperatural face. Septal foramina are short rows of pores along the bases of the septa.

Holotype.—G.S.M. No. 54708.

Dimensions.—Diameter: 1·06 mm. Height: 0·67 mm.

Type locality.—Castle Cove, " Upper Glen Aire Clays ", Sample CC. 36.

Paratype (topotype): G.S.M. No. 54709.

Dimensions.—Diameter: 0·90 mm. Height: 0·48 mm.

Distribution.—Calder River Limestone and " Upper Glen Aire Clays ".

Remarks.

This species has a much higher and more thickly-walled test than any previously-described species of *Notorotalia.*

Lat. *crassus,* thick; *murus,* wall.

NOTOROTALIA HOWCHINI (Chapman, Parr & Collins) 1934.

PLATE 10, FIGS. 104-106.

Rotalia howchini Chapman, Parr, and Collins, 1934. *Journ. Linn. Soc., Lond. (Zool)*. Vol. 38, p. 566. Pl. 9, figs. 20 a-c.

Diagnosis.

Notorotalia, network of fine ridges on dorsal side. Last whorl composed of about ten chambers. Completely evolute dorsally, completely involute ventrally.

Description.

A free test of moderate size, trochospiral, biconvex, dorsal side usually more strongly convex than ventral. Peripheral outline is sub-circular. Margin is bluntly carinate. Dorsal surface is completely evolute, ventral surface is almost completely involute. Umbilicus is very narrow, filled with opaque shell material, flush with ventral surface. Two to three whorls are present, the last whorl consisting of from eight to eleven chambers. Dorsal sutures are strongly recurved, unthickened, flush with surface, the last three or four are distinct, earlier ones are obscured by secondary shell material. Ventral sutures are radial, straight, unthickened, slightly depressed. Shell wall is thin except for dorsal surface, which is secondarily thickened, calcareous, opaque, finely perforate. Canal system opens by coarse pores forming a row immediately in front of each of the dorsal sutures. Both dorsal and ventral surfaces are ornamented by narrow raised ridges forming an anastomosing pattern. No distinct aperture is present, two or three large pores may be present in the apertural face.

Figured specimen.—G.S.M No. 54710.

Dimensions.—Diameter, 0·74 mm. Height, 0·52 mm.

Locality.—Aire Coast. Wilkinson's locality AW.3. Clay bed, 9″–15″ below top of section.

Distribution.—Calder River Limestone, "Upper Glen Aire Clays" and Fishing Point Marl.

Genus **LAMARCKINA** Berthelin, 1881.

LAMARCKINA AIRENSIS, sp. nov.

PLATE 10, FIGS. 107-109.

Diagnosis.

Lamarckina, peripheral outline sub-circular. Dorsal pustules somewhat spiny. Blunt keel intervenes between pustulose dorsal surface and smooth ventral surface. Early dorsal sutures have the form of sharp, serrate ridges. Ventral sutures are visible.

Description.

A large, free, biconvex test, trochospiral with a low spire. Peripheral outline is sub-circular, somewhat reniform, lobulated at the last three or four sutures. Margin is slightly thickened, carinate. Ventral side of keel merges into the smooth ventral surface, dorsal side of keel is sharply distinguished from the pustulate area. Dorsal side is completely evolute, flat in early part of test, later curved. Ventral side is inflated, involute with an open, crescentic umbilicus. The test

is composed of about two whorls, the last usually containing seven chambers. Dorsal sutures are recurved, limbate, usually raised into sharp, crenulated ridges. Ventral sutures are indistinct, unthickened, sigmoidal, approximately radial, slightly depressed. Dorsal surface between sutures is pustulate or bears short spiny processes. Ventral surface is smooth, polished, secondarily thickened. Wall of test is calcareous, thick, opaque. Perforations have not been observed. Aperture is covered by a large ventral lip and opens into the umbilicus. Chambers preceding the last contain partial partitions attached to the inner walls of the chambers. Septal foramina are situated at the bases of the partitions and on the outer sides of them.

Holotype.—G.S.M. No. 54711.

Dimensions.—Length, 0·62 mm. Width, 0·52 mm. Height, 0·36 mm.

Type, locality.—Second gully on coast west of Browns Creek; shelly, gritty, grey clay, approximately 80 ft. above greensand.

Paratype (topotype).—G.S.M. No. 54712.

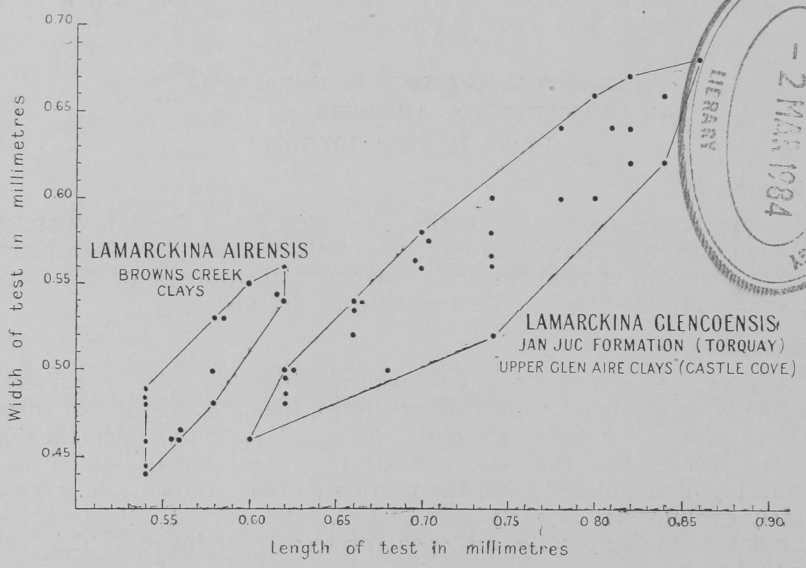
Dimensions.—Length, 0·63 mm. Width, 0·55 mm. Height, 0·38 mm.

Distribution.—Browns Creek Clays.

Remarks.

This species is readily distinguished from *L. glencoensis* Chapman and Crespin by its more circular outline, the shape and appearance of the sutures and the generally more spiny nature of the dorsal pustules.

Raggatt and Crespin (1955, footnote p. 128) state that the *Lamarckina,* which occurs at "Johanna River" is *L. novozelandica* Dorreen. Although this species bears some resemblance to *L. airensis,* the writer has been convinced that they are different, after examining



Text Fig. 4.—Scatter diagram of *Lamarckina* species

specimens of *L. novozelandica* kindly sent by Mr. Norcott Hornibrook, of the N.Z. Geological Survey. A statistical separation of *L. airensis* from *L. glencoensis* (Text fig. 4), illustrates the difference between these species and also that all specimens from the Jan Juc Formation at Torquay beyong to *L. glencoensis.*

The trivial name is derived from the Parish of Aire, in which the type locality is situated.

LAMARCKINA GLENCOENSIS Chapman & Crespin, 1930.

PLATE 10, FIGS. 110-112.

Lamarckina glencoensis Chapman and Crespin, 1930. *Proc. Roy. Soc. Vic.* (*n.s.*) Vol. 43, Pt. 1, pp. 99, 100. Pl. 5. Figs. 11, 12.

Lamarckina glencoensis Chapman and Crespin. Crespin, 1950. *Contr. Cush. Foram. Res.* Vol. 1. Pts. 3 and 4, p. 74. Pl. 10, Figs. 13 a, b.

Lamarckina glencoensis Chapman and Crespin. Raggatt and Crespin, 1955. *Proc. Roy. Soc. Vic.* (*n.s.*) Vol. 67. Pt. 1. Pl. 7, figs. 13 a, b.

Diagnosis.

Lamarckina, peripheral outline sub-elliptical. Dorsal pustules not spiny. Pustulated dorsal surface abuts against smooth ventral surface without a keel. Sutures thickened, but smooth on early part of test. Ventral sutures are not visible.

Description.

A large, free, biconvex test, trochospiral, with a very low spire. The last two or three chambers of the last whorl are not coiled in the same plane as the earlier part of the test. Peripheral outline is sub-elliptical, somewhat reniform, lobulated at the last two or three sutures. Margin is rounded. In marginal view, the pustulated dorsal surface abuts against the smooth ventral surface with a step separating them, the dorsal surface being on the low side of the step. Dorsal side is completely evolute, flat in the early part of the test, later curved. Dorsal surface between sutures is finely pustulate. Ventral side is inflated, involute with an open, crescentic umbilicus. The test is composed of about one and a half whorls, the number of chambers in the last being about nine. Dorsal sutures are slightly recurved, secondarily thickened, smooth, polished, forming low ridges. Ventral sutures are obscured by a polished, opaque deposit of secondary shell material. Wall of test is calcareous, thick, opaque. Perforations have not been observed. Aperture is covered by a large ventral lip and opens into the umbilicus. Wall of the umbilicus is pustulated on the side away from the aperture. Chambers preceding the last contain partial partitions attached to the inner walls of the chambers. Septal formina are situated at the bases of the partitions and on the outer sides of them.

Figured specimen.—N.M.V. No. P. 16013.

Dimensions.—Length, 0·74 mm. Width, 0·56 mm. Height, 0·41 mm.

Locality.—Castle Cove, Sample 17 of W. J. Parr (ex. slide N.M.V. No. P. 14984), "Thick bed of blue-grey clays overlying lowest limestone bed in top third of section."

Distribution.—"Upper Glen Aire Clays" and the Fishing Point Marl.

Genus **CALCARINA** d'Orbigny, 1826.

CALCARINA MACKAYI (Karrer), 1864.

PLATE 2, FIGS. 10-12.

Rosalina mackayi Karrer, 1864. *Novara Expedit. Geol. Theil.* Vol 1, p. 82, Pl. 16, fig. 14.

Diagnosis.

Calcarina, peripheral spines usually absent. Ventral side two to three times as high as dorsal side. Dorsal surface ornamented with a few large tubercles. Ventral surface of each chamber bears a keel and beads of shell material along the sutural troughs.

Description.

A large, free, trochospiral test. Peripheral outline is somewhat pyriform, irregular, lobulated at the sutures. Blunt spines are occasionally present on the last two or three chambers. Margin is acute, narrowly rounded. Dorsal surface is convex, completely evolute. Ventral surface is strongly convex, incompletely involute. Umbilicus is filled with a large, protruding plug which is sub-divided irregularly, by deep fissures. Wall of test is thick, opaque. Two to three whorls are present, the last being composed of about twelve chambers. Dorsal sutures are initially unthickened, depressed, later obscured. Dorsal surface is ornamented by large, low, smooth, round, or elongated tubercles, distributed irregularly and somewhat sparsely. Ventral sutures are initially unthickened, deeply depressed, slightly recurved, later obscured. Ornamentation of ventral surface of each chamber consists basically of a more or less straight radial keel and a row of small beads along each side, adjacent to the sutural depression. The central ridge may be broken into a row of about 3 tubercles, and the lateral tubercles are sometimes elongated at right angles to the central ridge. (Aperture has not been observed, the last chamber is absent from every specimen available.) Septal foramina consist of (*a*) a narrow slit with depressed margins at the base of the suture, (*b*) a slightly larger slit situated on the outer side of the former one, generally parallel to it, with raised margins and (*c*) a narrow slit at the base of the septum at its umbilical end.

Figured specimen.—G.S.M. No. 54713.

Dimensions.—Length, 1·24 mm. Width, 1·18 mm. Height, 1·09 mm.

Locality.—Castle Cove. Sample CC.33 of O. P. Singleton and A. N. Carter. Jan., 1953.

Distribution.—Calder River Limestone, "Upper Glen Aire Clays," Fishing Point Marl.

Remarks.

The most important features of this species are the sparse, low tubercles on the dorsal side, and the single keel on the ventral surface of each chamber. *C. verriculata* (Howchin and Parr), which occurs rarely at the top of the Fishing Point Marl and probably evolved from *C. mackayi,* possesses much more numerous, prominent, and closely-set dorsal tubercles and a pinnate system of ridges on the ventral surface of each chamber.

6. ACKNOWLEDGMENTS

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7. LIST OF SLIDES FROM THE W. J. PARR COLLECTION

The following slides mounted by the late W. J. Parr are now in the National Museum of Victoria, whose register numbers are given. They have been studied during this investigation and have contributed greatly to the determination of the stratigraphical ranges of the various species.

PARR'S SAMPLED SECTION AT CASTLE COVE, 19/2/1945.

Slide Number (N.M.V., P.)		
14973, 14974	1	Fawn-coloured clays with harder bands, about 6 feet above basal hard band of limestone.
14980	14	Thick bed of blue clay overlying sample 13 and about 3 feet higher. Sample from base of blue clays which are capped by a thin hard band.
14981, 14982	15	Dark bryozoan clays with much iron-stained quartz sand. From thick bed overlying hard (ferruginous) band overlying sample 14 and underlying a similar ferruginous band. Clays from below upper quartz of Tertiary Section.
14983, 14984	17	Thick bed of blue-grey clays (largely bryozoan) with *Spondylus gaederopoides, Cardium* and common *Limopsis,* immediately overlying lowest hard limestone band in top third of the section and underlying second hard limestone bed.
14958, 14959	18	Bryozoan marls with thin hard bands, above sample 17 and below bed with cowries, a little below top of section.
14985, 14986	19	Clay bed with *Cypraea* underlying harder brownish bed. Near top of section.
14957, 14987	22	Greyish to blackish clays overlying sample 21. These are exposed between boulders on beach and are apparently the highest Tertiary beds exposed at Castle Cove.

Castle Cove—Additional Slides.

Slide Number (N.M.V., P.)		
14962	to	Miocene, Castle Cove, Victoria, 12/29, Coll. Rev. E. Chapple.
14966		(5 slides).
14918		Castle Cove. 50 feet up.
14917		Castle Cove. 50 feet up cliff.
14919		Castle Cove—from bed exposed in washaway on side of pathway down cliffs. (N.W. side of Tertiary) and about 50 feet above beach. Coll. W. J. Parr 1/1947.
14960		Upper Part of Janjukian—Castle Cove. Coll. 1/35.
14961		Probably from near base of section. Coll. 1/35.
14962		Near base of section. Coll. 1/35.
14963		Base of Janjukian. Coll. 25/1/35.
14964		Just above base of Janjukian. Coll. 25/1/35.
14965		Upper part of Janjukian. Coll. 25/1/35.
14966		Highest bed—bryozoal marl. Coll. 23/12/39.
14967		Lowest bed of limestone series. Coll. 23/12/39.
14968		Dark shelly marl (Ostracoda). Coll. N. Osborne.
14969		Dark shelly marl. Coll. N. Osborne.
14970		Bryozoal Marl. 13 ft. 6 in. below top of section.
14971 14972		Bryozoan marl. 5 feet below uppermost bed.
14975		Dark sticky clay near base of section. Coll. W. J. Parr 3/2/40.
14976		Sample 3 of W. J. Parr. 3/2/40.
14977		Sample 4 of W. J. Parr. 3/2/40. "Bed full of Pectens".
14978		Fawn coloured marl from near base of section—below hard limestone beds. Sample 6 of W. J. Parr. 3/3/40.
14979		6-ft. bed, marl with creamy-grey concretions, echinoids and *Flabellum*. Top of this bed is about 1 foot below base of limestone series. Sample 7 of W. J. Parr. 3/2/40.
14988		Bed with Brachiopods in limestone, near base of limestone.

"Fisher's Point" (i.e. Fishing Point.)

14880	Probably Fisher's Point. (From matrix of a *Cypraea* presented to O. P. Singleton).
15038	Fisher's Point. 11/29.
15039	Fisher's Point.
15052	Clayey bed with Bryozoa, intercalated between harded bryozoan limestones. (Bed about 50 feet above river level) Fisher's Point.
15053	Fisher's Point. South side of Point and east end of exposure on south side—lowest bed exposed—grey marl about 1 foot showing. Coll. 21/2/1945.

Miscellaneous Localities.

14881	Guerard's Hill. (F. A. Cudmore).
14882	Spud Point. Glen Aire. Coll. W. J. Parr. 2/45.
14883	Duck Creek. 23/2/45. "Sticky clay bed a little higher up creek than (6) or (7)."
14992	Soft decomposed limestone. Road cutting on east side of road to Hordern Vale, and 300 yards from junction with Great Ocean Road. Coll. W. J. Parr. 6/1/47.
15022	Marly bed in limestone about 12 feet below top of section, and immediately above limestone shelf. Wilkinson's No. 3 locality. Coll. W. J. Parr. 2/40.
15045	Clay between tide levels below leaf bed.
15046	Sentinel Rock (AW. 2) Aire Coast. Coll. F. A. Cudmore. September, 1946.

Lavers Hill Road.

Slide Number (N.M.V., P.)

14993–14994 Ford River. Road cut on west side of road from Castle Cove to Lavers Hill. Coll. W. J. Parr. 1/35.

14995–14999 Lowest marine bed in road cut on Great Ocean Road, 4½ miles from Glen Aire 450 feet above sea level. Coll. W. J. Parr. 1/47.

Coastal Section from Browns Creek to Johanna River.

14910 Browns Creek. 8

14911 Browns Creek. 9

14912–14913 Browns Creek. 12

14914 Browns Creek. 8

14928 *Cyclammina coniplanata* Chapman 1904. Browns Creek, west of Cape Otway. Coll. A. E. Kitson.

14940 Browns Creek, above *Notostrea* bed.

14950 Soft sands in polyzoal limestone, between mouths of Johanna River and Browns Creek. W. J. Parr. 1/2/1940.

14884–14888 Shelly marls from Johanna River (? new locality). 100 feet east of mouth in washaway. Material not in situ. Coll. O. P. Singleton. 1/2/1944.

14893 *Gryphaea* bed, Browns Creek—outside. Gully nearest mouth of Creek in coastal section. Coll. F. A. Singleton. 2/44.

14894–14937 Browns Creek. Grey clay—exposure nearest beach. South-east corner of hillside, west of and overlooking mouth of creek. Coll. O. P. Singleton. 5/2/1944.

14920 Gully nearest mouth of Browns Creek—coastal section. Sample 5, bed underlying *Notostrea* bed. Coll. W. J. Parr.

14921 Browns Creek coastal section—gully nearest mouth of creek. Coll. W. J. Parr. (7) Glauconitic clay overlying *Notostrea* bed.

14922 Browns Creek, gully in coastal section nearest creek mouth. 4 ft. 6 in. glauconitic bed overlying dark (basal) bed. Coll. W. J. Parr.

14923–14945 Browns Creek—outside. Basal bed in gully nearest mouth of creek in coastal section. *Turritella* bed.

14941–14943 4 ft. 6 in. glauconitic bed overlying dark bed. Gully in coastal section nearest mouth of Browns Creek. Coll. W. J. Parr.

Wilkinson's No. 4 Locality (AW. 4).

15012 A.W. 4, Sample 5 of W. J. Parr, 3/2/40. (6 inches of grey clay underlying yellowish limestone).

15013 Sample 5 of W. J. Parr, 3/2/40. 6 inches grey clay underlying yellowish limestone. (See Hall and Pritchard 1899).

15014 Lower part of (9)—W. J. Parr, 2/40. 4 ft. 6 in. grey clay rich in fossils. (See Hall and Pritchard, 1899).

15015 Sample 9 of W. J. Parr, 3/2/40. 4 feet grey sandy clay rich in fossils. (See Hall and Pritchard, 1899).

15016 Sample 9 of W. J. Parr, 3/2/40. 4 feet grey sandy clay rich in fossils. (See Hall and Pritchard, 1899).

15017 Sample 7 of W. J. Parr, 3/2/40. 3 ft. 6 in. grey clay with *Turritella*. (See Hall and Pritchard, 1899).

15018 Sample 10 of W. J. Parr, 3/2/40. 1 foot of grey clay with abundant polyzoa. (See Hall and Pritchard, 1899).

Slide Number (N.M.V., P.)	
15019 15020	Fawn coloured clay with Bryozoa (lowest bed exposed underlying 15 feet bed of dark-grey clay.) Collection W. J. Parr, 20/2/45.
15021	Black sticky clay with Bryozoa at base of section (above fawn clay). Sample 12. 3/2/40. Coll. W. J. Parr.
15031	Sample 3 of W. J. Parr. 3/2/40. 6 in. clay underlying 1 ft. yellow limestone with Polyzoa. (See Hall and Pritchard, 1899.)
15032 15033	Sample 1 of W. J. Parr 2/40. 3-ft. bed of grey clay underlying 6-in. gritty limestone. (See Hall and Pritchard, 1899.)
15034	From limestone overlying clays.
15035	Soft bed in polyzoal limestone overlying highest marl bed and about 20 feet above the base of this limestone.

WILKINSON'S NO. 1 LOCALITY (AW. 1).

14899 14900 14901	"The Aire Coast" west of Cape Otway 11/29.
15026	Fawn Marl. AW. 1. Coll. W. J. Parr 26/2/45.
15027	Fawn marl. AW. 1. Coll. W. J. Parr 26/2/45.
15028 15029	Sticky marl, apparently in situ, about 70 feet above high tide level. Coll. W. J. Parr 1/40.
15030	AW. 1 near top of exposure. Coll. W. J. Parr, 26/2/45.
15047	Clays in situ in small watercourse, east side of fence about 300 yards inland from AW. 1.
14946	*Turritella* bed. Browns Creek—outside. Basal bed in gully nearest mouth of creek. Coll. F. A. Singleton.
14890 14891	Browns Creek. Coastal section. Gully nearest mouth of Johanna River. Basal calcareous marl. Coll. O. P. Singleton. 2/44.
14892	Browns Creek. Coastal section. Gully nearest mouth of Johanna River. Shell bed near top, about 32 feet above base
14951	Fawn marl—bottom 10 feet Tertiary exposure.
14952	Gully nearest mouth of Johanna River. Sample 9. 2/45.
14953	Gully nearest mouth of Johanna River. 10 feet to 16 feet above lowest beds exposed. Coll. W. J. Parr. 2/45.
14954 14955	Gully nearest mouth of Johanna River. Right fork of gully, top of gully, about top of marine beds. Sample 20. 2/45.
14926	Gully nearest mouth of Johanna River. Left fork of gully. Bed of bryozoan marl overlying black bed. Sample 23. 2/45.
14956	Gully, Johanna River end of section—left fork of gully, 2 feet black bed.

BROWNS CREEK.

14938 14939 14925 14927	Browns Creek—Tertiary exposure on lower part of hillside, west side of Browns Creek and about 200 yards further upstream than large hillside exposure. W. J. Parr. 2/45.
14924 14932	Browns Creek—from marl exposed on hillside, west side of creek and about 20 chains from mouth. Coll. W. J. Parr, 1/2/1940.
14936	Marl bed about 3 feet above base of section exposed on hillside, west side of Browns Creek and about 20 chains from mouth of creek. Coll. W. J. Parr. 1/2/1940.
14929	Grey marl (glauconitic) near base of cliff (180 feet (?) above sea level). Inland exposure on right bank of Browns Creek (F.A.S.)
14933 14934 14935	Browns Creek. Grey and fawn-coloured marl about 20 feet from base of section exposed on hillside on west side of creek and about 20 chains from mouth. Coll. W. J. Parr. 1/2/1940.

Slide Number (N.M.V., P.)	
14947 14948 14949	Browns Creek. Glauconitic bed at base of hillside section, west side of creek and 20 chains from mouth. Coll. W. J. Parr. 1/2/1940.

HAMILTON CREEK.

14867 14868 14869	Glauconitic clay underlying *Notostrea* bed, exposure of Tertiary nearest Princes Highway on west bank of Hamilton Creek.
14870 14871 14872	*Notostrea* bed. Most southerly exposure of Tertiary on creek, west bank of Hamilton Creek.
14873	Hamilton Creek. Most southerly exposure on creek—lowest bed exposed. (About 6 feet below *Notostrea* bed.)
14874	Glauconitic clay underlying *Notostrea* bed. Exposure of Tertiary nearest Great Ocean Road. West bank of Hamilton Creek.
14875	Hamilton Creek. From bed of creek just above (and north-east of) most southerly exposure of Tertiary on creek, Sample 3. W. J. Parr.
14876	Glauconitic bed, east side of Hamilton Creek, upstream from old hut. W. J. Parr.
14877 14878	Fawn marl with some glauconite. East side of Hamilton creek, upstream from old hut and 5 feet above glauconite bed.
14879	Hamilton Creek. Exposure on west side of creek almost at head of creek. Coll. W. J. Parr.
14903 14904 14905 14906 14907 14908	Hamilton Creek (3).
14909	Hamilton Creek. Glauconitic clay under *Notostrea* bed, most southerly exposure.
15000 15001 15002 15003 15004 15005	Road cutting on Great Ocean Road, near Hamilton Creek.

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9. INDEX OF DESCRIBED AND FIGURED SPECIES.

10. PLATES.

Plates 2-10 are camera lucida drawings by Miss Elizabeth Rowdon, to whom the writer is deeply indebted for the care and patience which their preparation has entailed.

PLATE 1.

Aerial photograph of Apollo Bay, showing the submarine outcrop of Eocene clays. The photograph was taken on the 10th of May, 1946, before the breakwaters were constructed.

Plate I

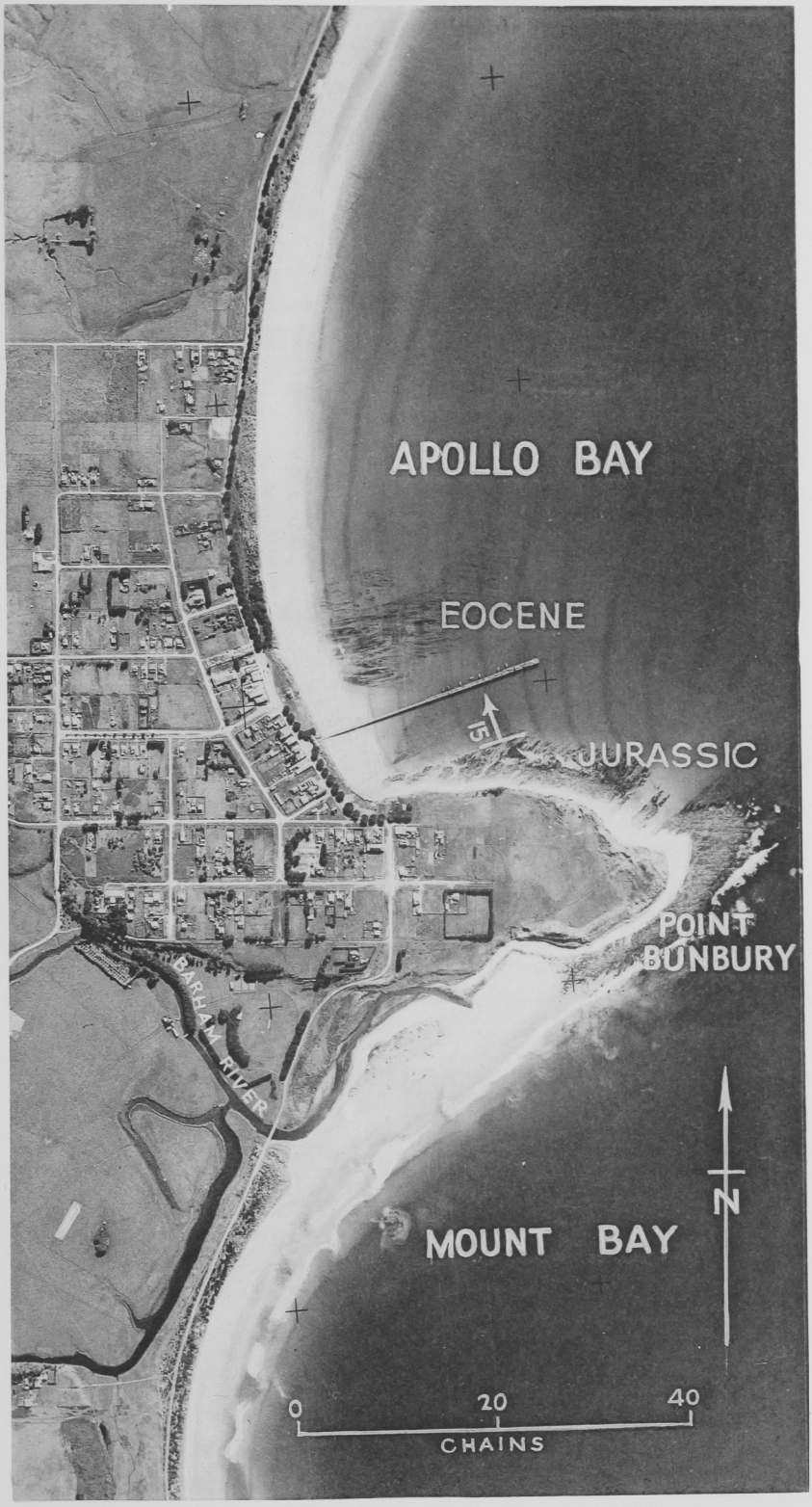
APOLLO BAY
EOCENE
JURASSIC
POINT BUNBURY
BARHAM RIVER
MOUNT BAY
N
0
20
40
CHAINS

PLATE 2.

Spiroloculina canaliculata d'Orbigny 1846

Fig. 1. G.S.M. No. 54664. x 65

Fig. 2. G.S.M. No. 54664. Apertural view. x 65

Vaginulinopsis acanthonucleus sp. nov.

Fig. 3. Paratype G.S.M. No. 54667. x 12

Fig. 4. Paratype (Juvenile) G.S.M. No. 54668. x 25

Fig. 5. Paratype (Microspheric) G.S.M. No. 54666. x 25

Fig. 6. Holotype (Megalospheric) G.S.M. No. 54665. x 21

Fig. 7. Paratype (Continuously-ribbed form) N.M.V. No. P.16001 x 26

Pullenia quinqueloba (Reuss) 1851

Fig. 8. G.S.M. No. 54669. x 65

Fig. 9. G.S.M. No. 54669. Peripheral view. x 65

Calcarina mackayi (Karrer) 1864

Fig. 10. G.S.M. No. 54713. Dorsal view. x 25

Fig. 11. G.S.M. No. 54713. Peripheral view. x 25

Fig. 12. G.S.M. No. 54713. Ventral view. x 25

Plate 2

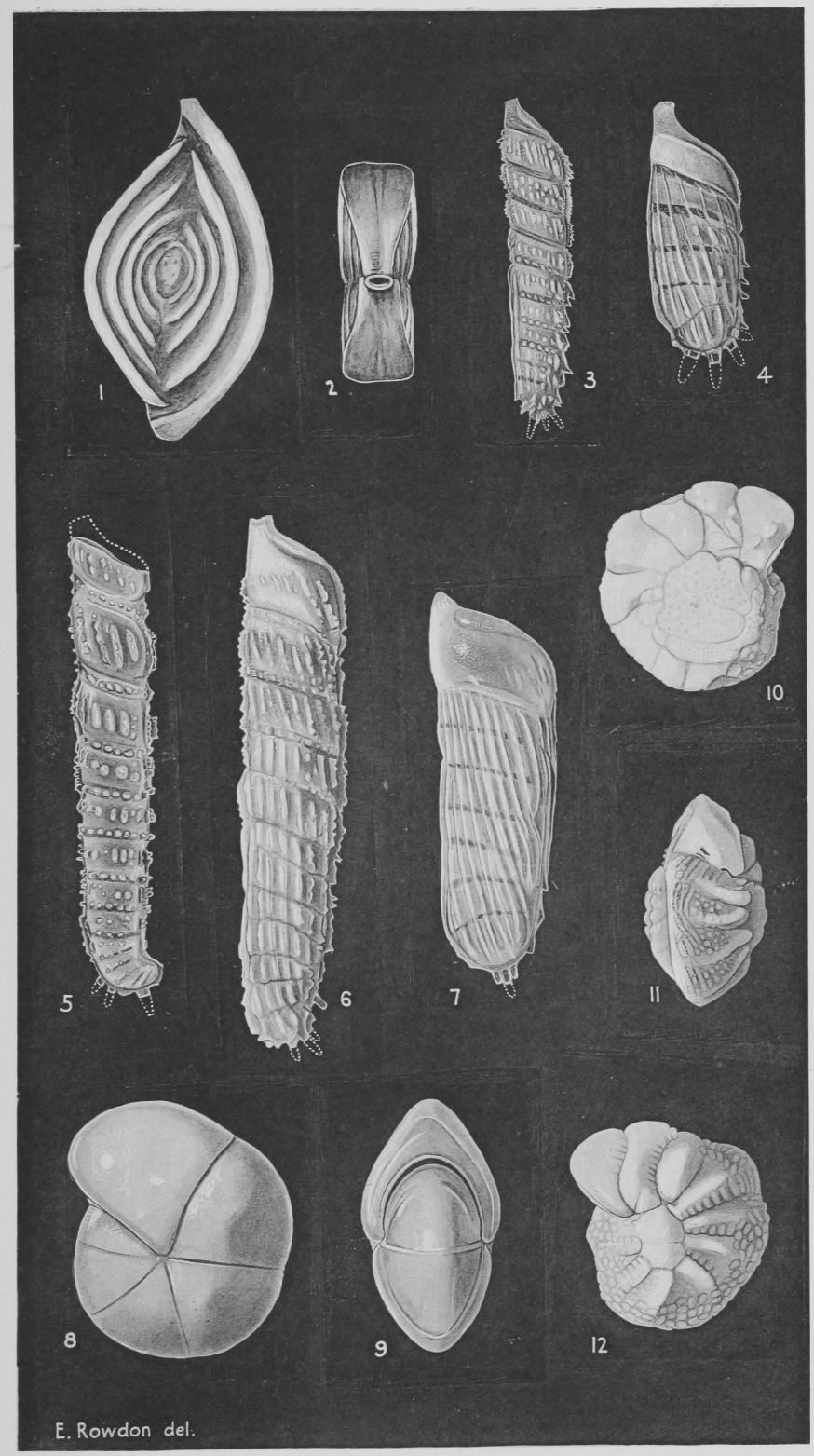

PLATE 3.

Spirillina denticulata denticulata Brady 1884

Fig. 13. N.M.V. No. P.16003. Ventral view. x 65

Fig. 14. N.M.V. No. 16003. Peripheral view. x 65

Fig. 15. N.M.V. No. P.16003. Dorsal view. x 65

Spirillina denticulate pulchra Parr 1945

Fig. 16. N.M.V. No. P.16004. Ventral view. x 80

Fig. 17. N.M.V. No. P.16004. Peripheral view. x 80

Fig. 18. N.M.V. No. P.16004. Dorsal view. x 80

Spirillina striatogranulosa Terquem 1882

Fig. 19. G.S.M. No. 54670. Ventral view. x 120

Fig. 20 G.S.M. No. 54670. Peripheral view. x 120

Fig. 21. G.S.M. No. 54670. Dorsal view. x 120

Spirillina decorata Brady 1884

Fig. 22. N.M.V. No. P.16002. x 45

Fig. 23 N.M.V. No. P.16002. Peripheral view. x 45

Spirillina medioscabra sp. nov.

Fig. 24. Holotype. N.M.V. No. P.16005. Peripheral view. x 35

Fig. 25. Holotype. N.M.V. No. P.16005. x 35

Plate 3

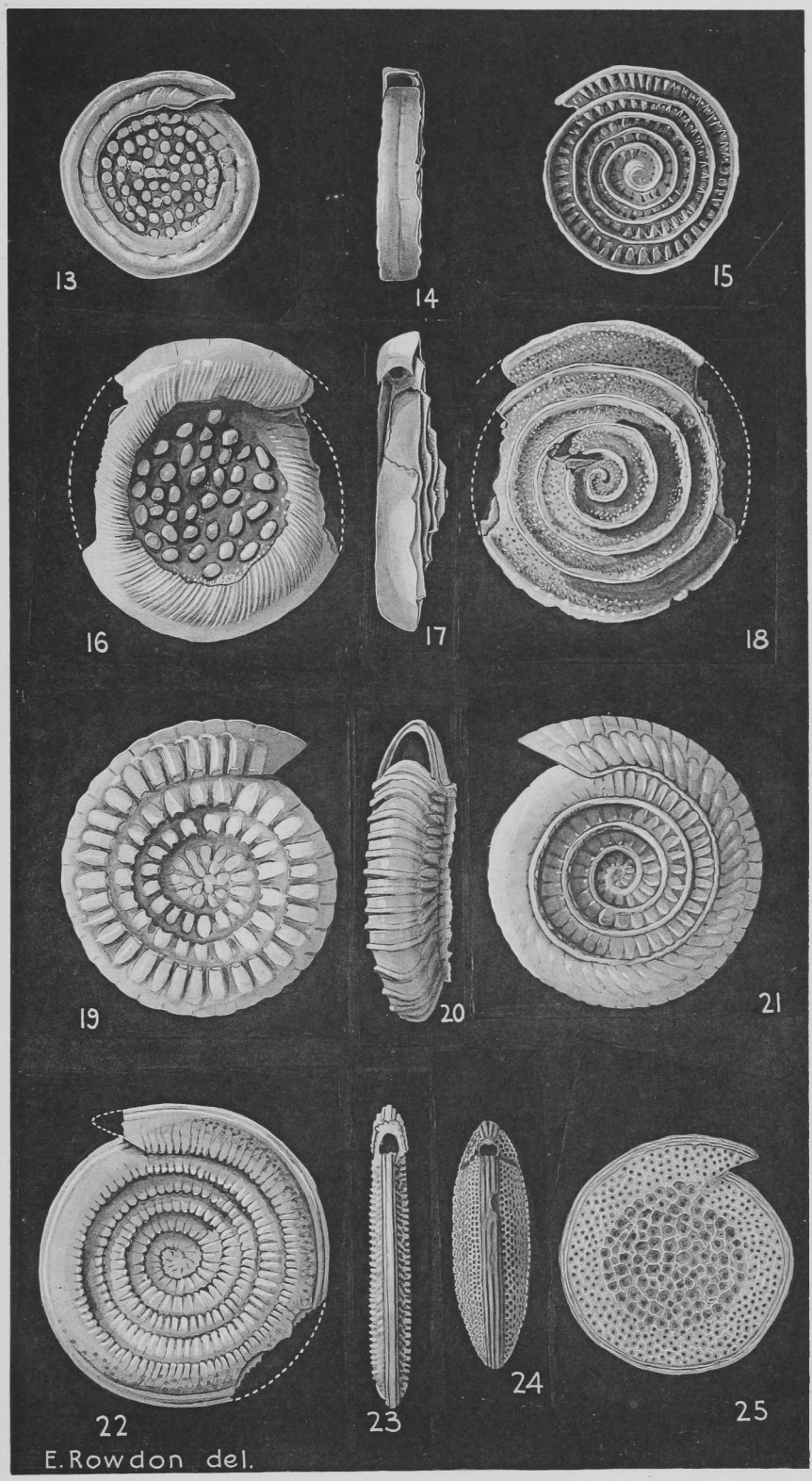

PLATE 4.

Spirillina unilatera Chapman 1902

Fig. 26. N.M.V. No. P.16009. Dorsal view. x 116

Fig. 27. N.M.V. No. P.16009. Peripheral view. x 116

Fig. 28. N.M.V. No. P.16010. Peripheral view. x 145

Fig. 29. N.M.V. No. P.16010. Ventral view. x 145

Spirillina tuberosa sp. nov.

Fig. 30 Holotype. N.M.V. No. P.16007. x 47

Fig. 31. Holotype. N.M.V. No. P.16007. Peripheral view. x 47

Spirillina vivipara Ehrenberg 1843

Fig. 32. N.M.V. No. P.16011. x 107

Fig. 33. N.M.V. No. P.16011. Peripheral view. x 107

Rosalina scopos (Finlay) 1940

Fig. 34. G.S.M. No. 54671. Dorsal view. x 50

Fig. 35. G.S.M. No. 54671. Peripheral view. x 50

Fig. 36. G.S.M. No. 54671. Ventral view. x 50

Stomatorbina concentrica (Parker and Jones) 1864

Fig. 37. G.S.M. No. 54678. Ventral view. x 45

Fig. 38. G.S.M. No. 54678. Peripheral view. x 45

Fig. 39. G.S.M. No. 54678. Dorsal view. x 45

Plate 4

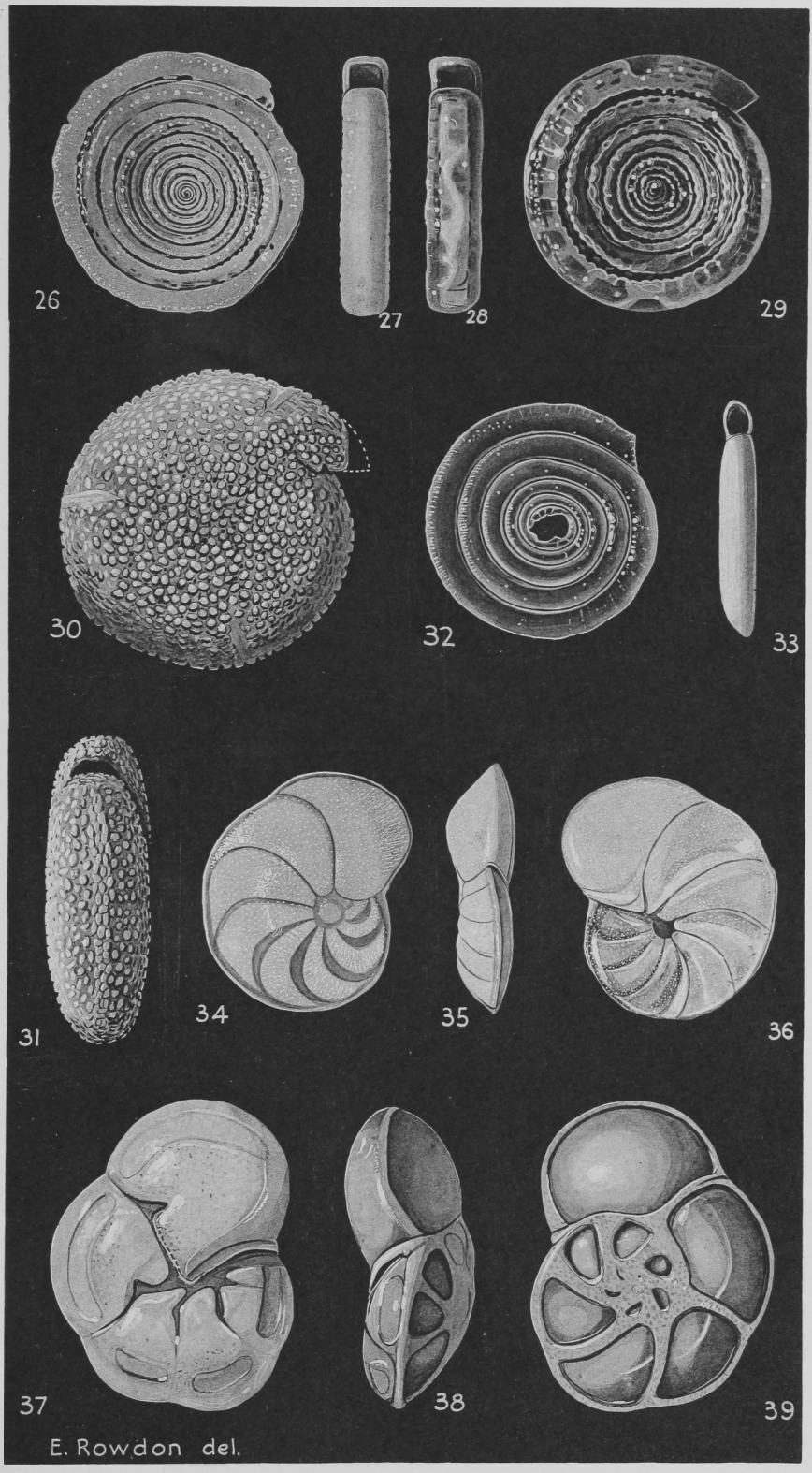

PLATE 5.

Heronallenia lingulata (Burrows & Holland) 1895

Fig. 40. G.S.M. No. 54672. Dorsal view. x 67

Fig. 41. G.S.M. No. 54672. Peripheral view. x 67

Fig. 42. G.S.M. No. 54672. Ventral view. x 67

Heronallenia parri sp. nov.

Fig. 43. Holotype. G.S.M. No. 54673. Dorsal view x 70

Fig. 44. Holotype. G.S.M. No. 54673. Peripheral view. x 70

Fig. 45. Holotype. G.S.M. No. 54673. Ventral View. x 70

Globigerina linaperta Finlay 1939

Fig. 46. G.S.M. No. 54685. Dorsal view. x 114

Fig. 47. G.S.M. No. 54685. Ventral view. x 114

Eponides lornensis Finlay 1939

Fig. 48. G.S.M. No. 54677. Ventral view. x 48

Fig. 49. G.S.M. No. 54677. Peripheral view. x 48

Fig. 50. G.S.M. No. 54677. Dorsal view. x 48

Plate 5

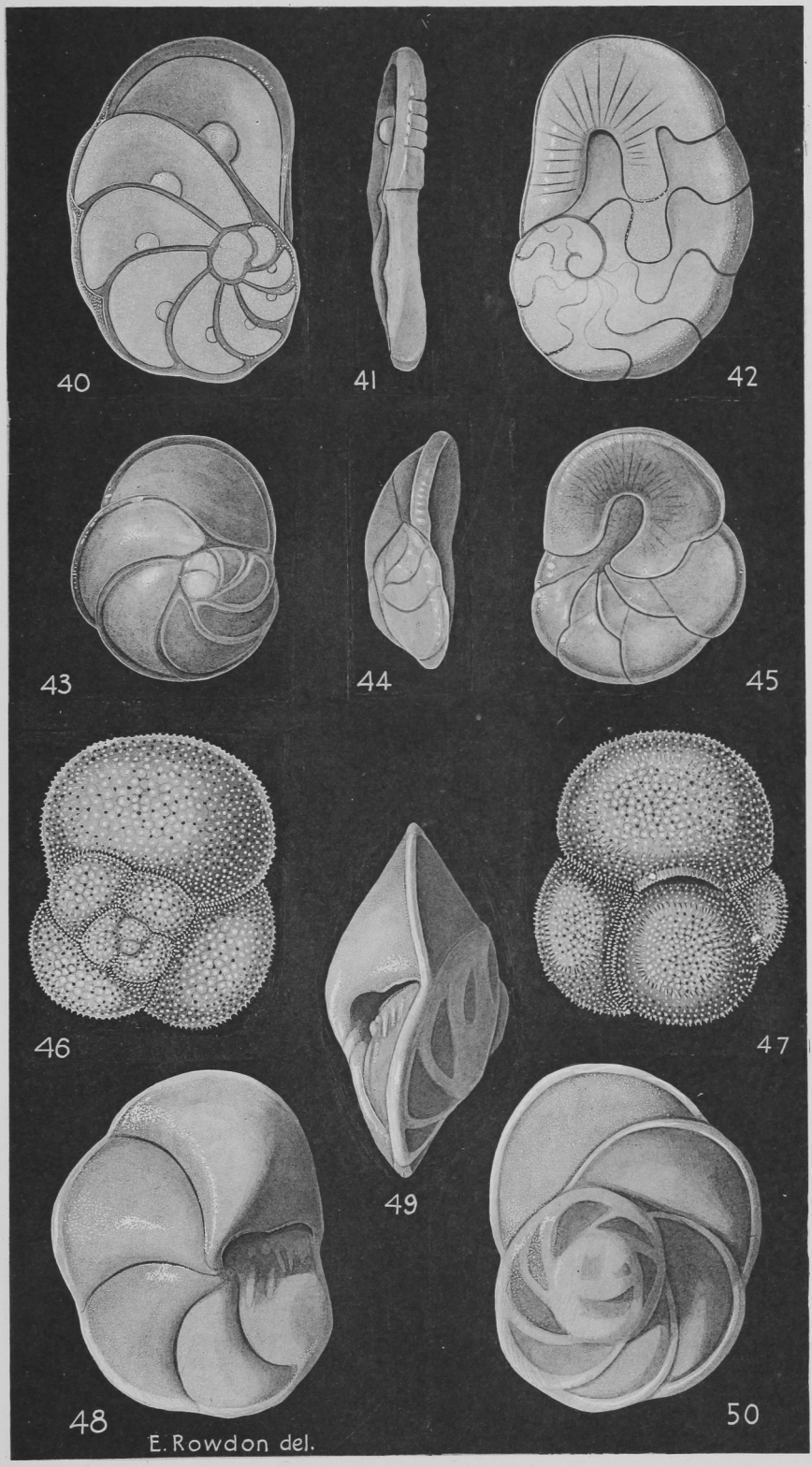

PLATE 6.

Eponides repandus (Fichtel & Moll) 1798

Fig. 51. G.S.M. No. 54675. Ventral view. x 35

Fig. 52. G.S.M. No. 54675. Peripheral view. x 35

Fig. 53. G.S.M. No. 54675. Dorsal view. x 35

Cibicides brevoralis sp. nov.

Fig. 54. G.S.M. No. 54680. Dorsal view. x 64

Fig. 55. G.S.M. No. 54680. Peripheral view. x 64

Fig. 56. G.S.M. No. 54680. Ventral view. x 64

Cibicides perforatus (Karrer) 1864

Fig. 57. G.S.M. No. 54682. Ventral view. x 65

Fig. 58. G.S.M. No. 54682. Peripheral view. x 65

Fig. 59. G.S.M. No. 54682. Dorsal view. x 66

Anomalinoides procolligera sp. nov.

Fig. 60. Holotype. G.S.M. No. 54683 Ventral view. x 55

Fig. 61. Holotype G.S.M. No. 54683. Peripheral view. x 55

Fig. 62. Holotype. G.S.M. No. 54683. Dorsal view. x 55

Fig. 63. Tectotype. G.S.M. No. 54718. Vertical thin section. x 92

Plate 6

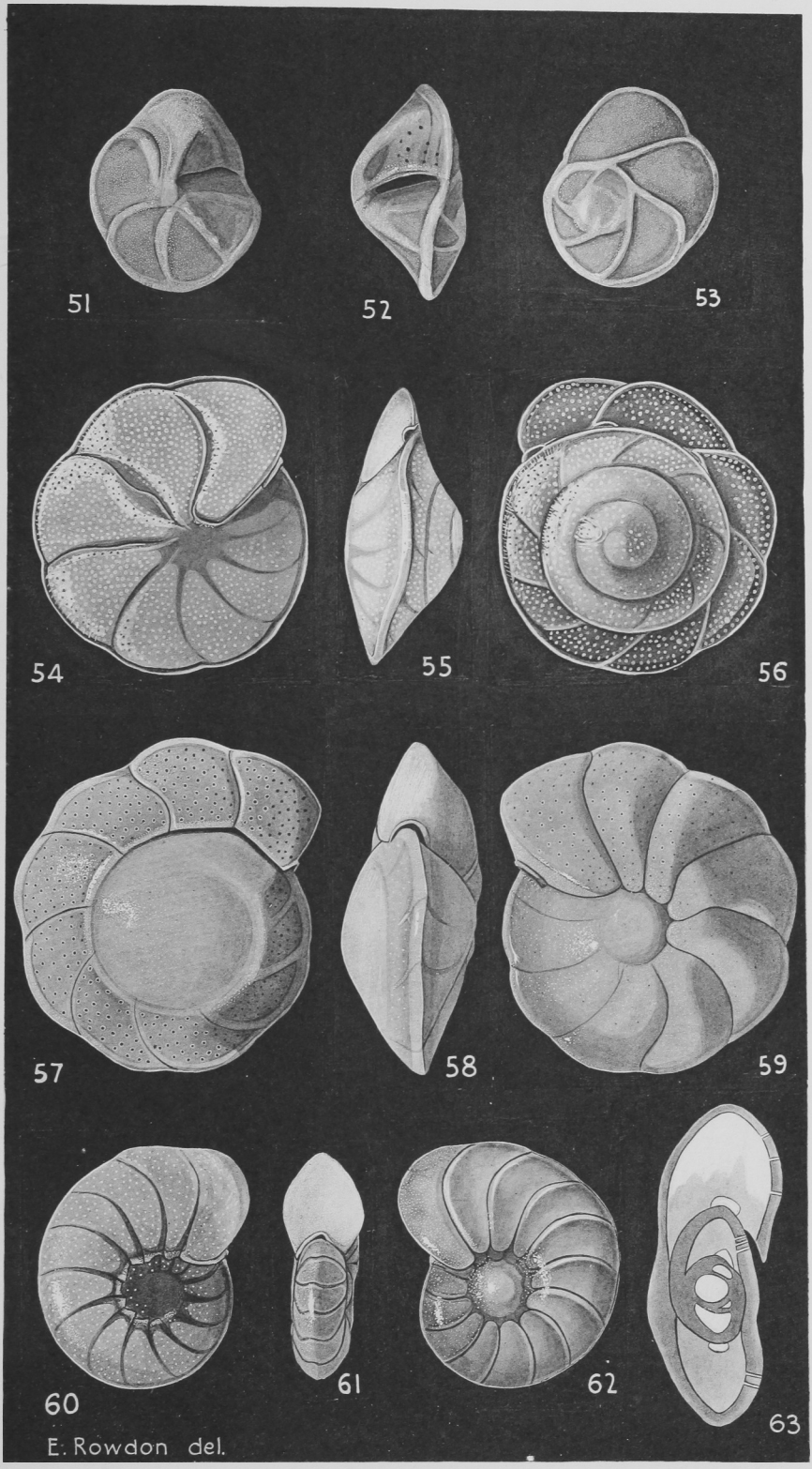

PLATE 7.

Globigerinoides index Finlay 1939

Fig. 64. G.S.M. No. 54687. Dorsal view. x 75

Fig. 65. G.S.M. No. 54687. Side view. x 75

Fig. 66. G.S.M. No. 54687. Ventral view. x 75

Globigerinoides triloba (Reuss) 1850

Fig. 67. G.S.M. No. 54688. Dorsal view. x 66

Fig. 68. G.S.M. No. 54688. Side view. x 66

Fig. 69. G.S.M. No. 54688. Ventral view. x 66

Globigerinoides bispherica Todd 1954

Fig. 70. G.S.M. No. 54690. Dorsal view. x 70

Fig. 71 G.S.M. No. 54690. Side view. x 70

Fig. 72. G.S.M. No. 54690. Ventral view. x 70

Fig. 73. G.S.M. No. 54689. Ventral view. x 78

Fig. 74. G.S.M. No. 54689. Dorsal view. x 78

Stomatorbina concentrica (Parker and Jones) 1864

Fig. 75. G.S.M. No. 54679. Ventral view. x 36

Plate 7

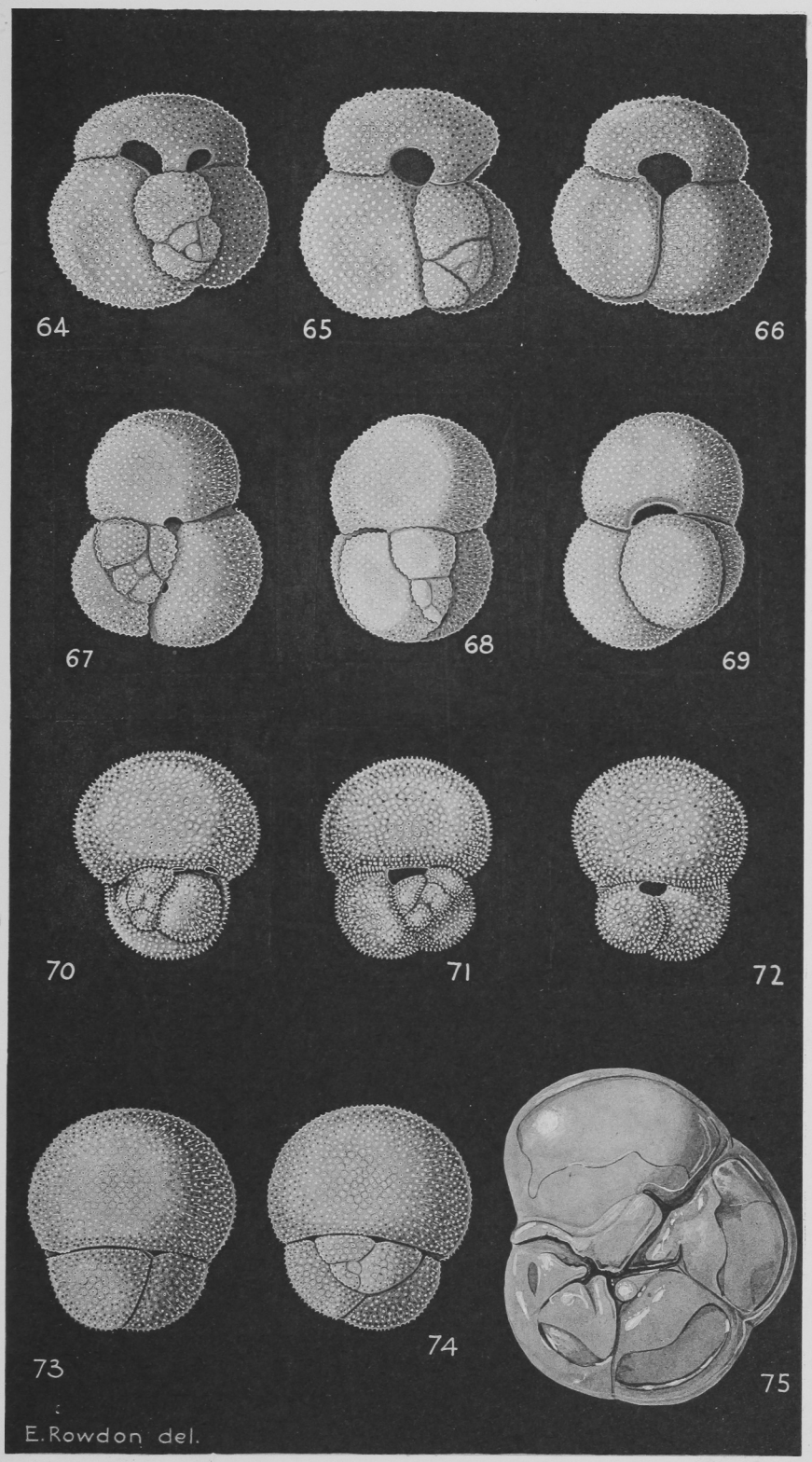

PLATE 8.

Planorbulinella johannae sp. nov.

Fig. 76. Holotype. G.S.M. No. 54694. Dorsal view. x 46

Fig. 77. Holotype. G.S.M. No. 54694. Ventral view. x 46

Fig. 78. Tectotype. G.S.M. No. 54696. Horizontal thin section, semi-diagramatic. x 100

Planorbulinella plana (Heron-Allen & Earland) 1924

Fig. 79. G.S.M. No. 54695. x 66

Fig. 80. G.S.M. No. 54695. Peripheral view. x 66

Globigerinoides rubra (d'Orbigny) 1839

Fig. 81. G.S.M. No. 54691. Oblique dorsal view. x 66

Fig. 82. G.S.M. No. 54691. Side view. x 66

Fig. 83. G.S.M. No. 54691. Dorsal view. x 66

Fig. 84. G.S.M. No. 54691. Ventral view. x 66

Globoquadrina dehiscens (Chapman, Parr & Collins) 1934

Fig. 85. G.S.M. No. 54692. Ventral view. x 65

Fig. 86. G.S.M. No. 54692. Peripheral view. x 65

Fig. 87. G.S.M. No. 54692. Dorsal view. x 65

Plate 8

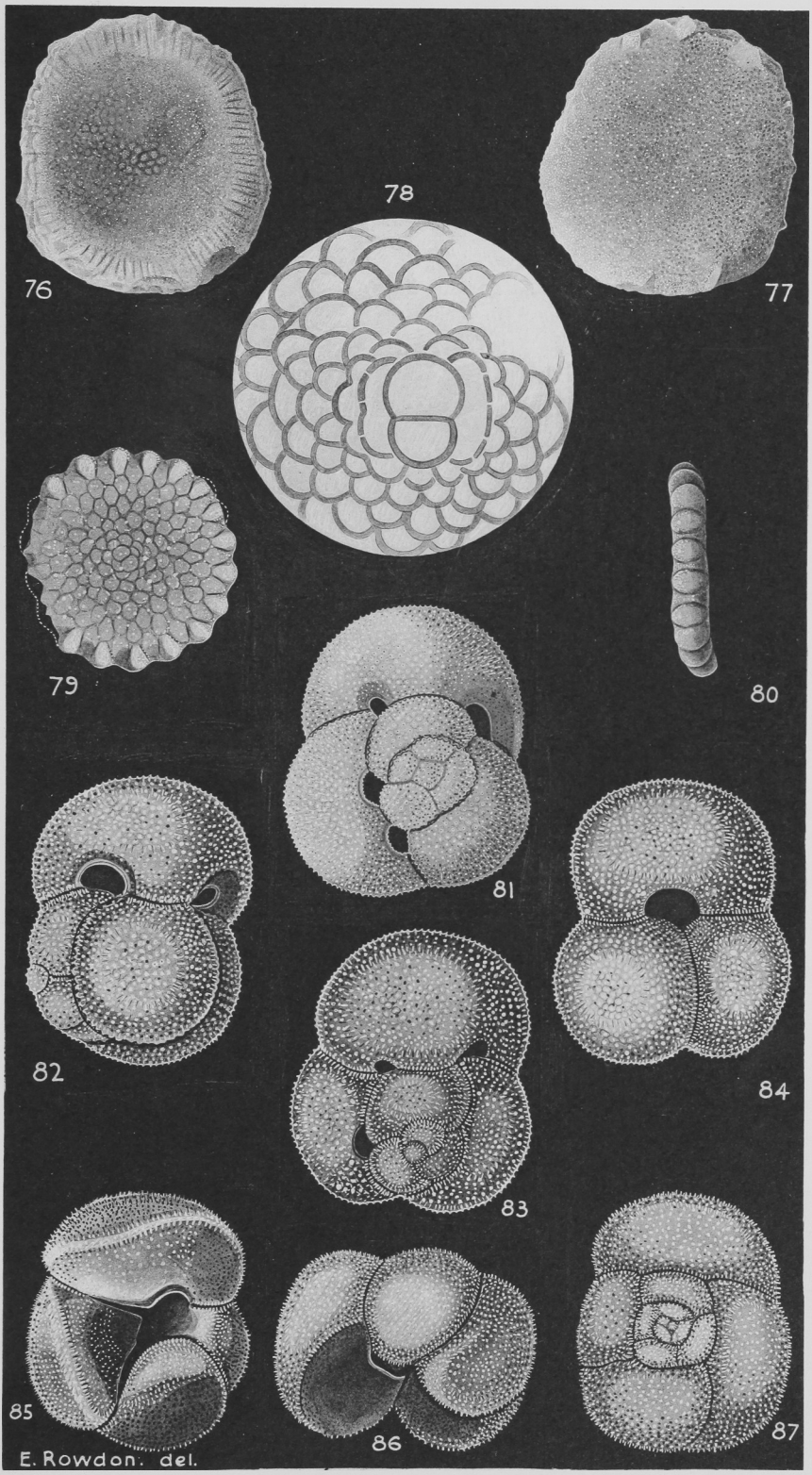

PLATE 9.

Hofkerina semiornata (Howchin) 1889

Fig. 88. G.S.M. No. 54697. Ventral view. x 33

Fig. 89. G.S.M. No. 54697. Peripheral view. x 33

Fig. 90. G.S.M. No. 54697. Dorsal view. x 33

Astrononion australe Cushman & Edwards 1937

Fig. 91. G.S.M. No. 54698. x 64

Fig. 92. G.S.M. No. 54698. Peripheral view. x 64

Astrononion sp.

Fig. 93. N.M.V. No. P.16012. Peripheral view. x 80

Fig. 94. N.M.V. No. P.16012. x 80

Astrononion centroplax sp. nov.

Fig. 95. Holotype. G.S.M. No. 54702. x 65

Fig. 96. Holotype. G.S.M. No. 54702. Peripheral view. x 65

Fig. 97. Paratype. G.S.M. No. 54704. Oblique view. x 65

Elphidum (Parrellina) centrifugalis sp. nov.

Fig. 98. Holotype. G.S.M. No. 54705. x 41

Fig. 99. Holotype. G.S.M. No. 54705. Peripheral view. x 41

Fig. 100. Paratype. G.S.M. No. 54706. x 45

Plate 9

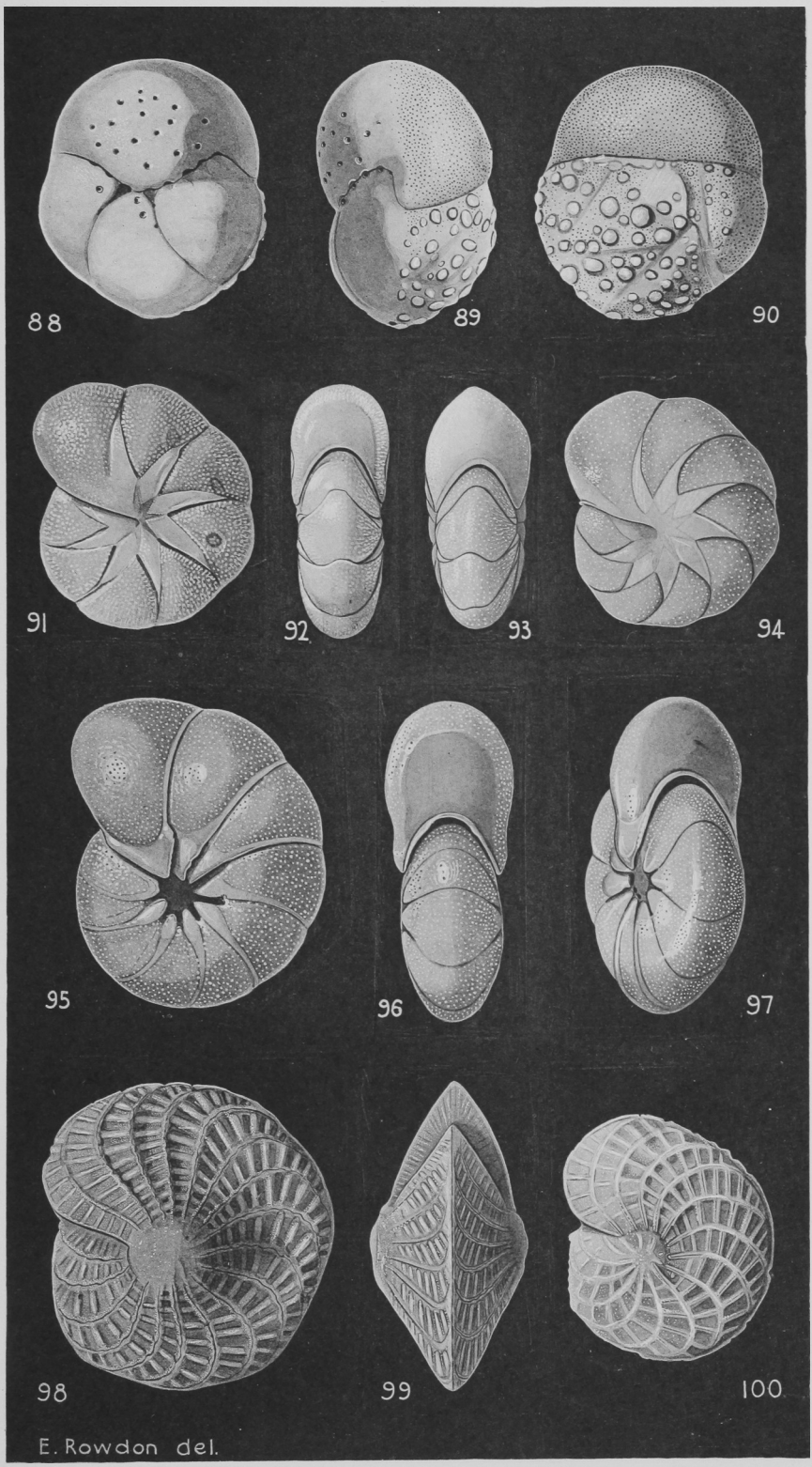

PLATE 10.

Notorotalia crassimura sp. nov.

Fig. 101. Holotype. G.S.M. No. 54708. Dorsal view. x 36

Fig. 102. Holotype. G.S.M. No. 54708. Peripheral view. x 36

Fig. 103. Holotype. G.S.M. No. 54708. Ventral view. x 36

Notorotalia howchini (Chapman, Parr & Collins) 1934

Fig. 104. G.S.M. No. 54710. Ventral view. x 43

Fig. 105. G.S.M. No. 54710. Peripheral view. x 43

Fig. 106. G.S.M. No. 54710. Dorsal view. x 43

Lamarckina airensis sp. nov.

Fig. 107. Holotype. G.S.M. No. 54711. Dorsal view. x 68

Fig. 108. Holotype. G.S.M. No. 54711. Peripheral view. x 68

Fig. 109. Holotype. G.S.M. No. 54711. Ventral view. x 68

Lamarckina glencoensis Chapman & Crespin 1930

Fig. 110. N.M.V. No. P.16013. Dorsal view. x 61

Fig. 111. N.M.V. No. P.16013. Peripheral view. x 61

Fig. 112. N.M.V. No. P.16013. Ventral view. x 61

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Plate 10