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Lower Carboniferous Faunas from Wiragulla and Dungog, New South Wales

JOHN ROBERTS

*Geology Department, University of Western Australia, Nedlands, W.A.**

ABSTRACT—The Middle to Upper Viséan (Cu $\text{III}_{\alpha-\beta}$) faunas from Wiragulla and Dungog are examined and their palaeoecology discussed. The stratigraphy of the Wallarobba-Dungog district is briefly considered, including a first description of the Wiragulla Beds which occur between the Ararat and Wallaringa Formations on the eastern limb of the Wallarobba Basin. Species described are: *Chonetes cangonensis* n.sp., *Gigantoproductus tenuirugosus* n.sp., *Inflatia elegans* n.sp., *Echinoconchus gradatus* Campbell, *Athyris wiragullensis* n.sp., *Spirifer osbornei* n.sp., *Kitakamithyris* sp., *Balanoconcha elliptica* Campbell, *Streblopteria* sp., and *Aviculopecten* sp.

Introduction

Marine fossils were first collected in 1960 from the Dungog and Wiragulla localities during geological investigations in the Wallarobba-Dungog district. No previous record of collections from either locality has been found in the literature, although Benson (1921) gave Dungog as a Carboniferous fossil locality. However, a more precise locality was not defined and from a search of the literature it now appears that he referred to several different localities, all of which were south of those dealt with in this work.

Grid references quoted in this paper are taken from the Dungog One Mile Military Sheet. All fossil and locality numbers refer to the palaeontological register at the University of New England, Armidale, N.S.W.

The L.235 Dungog fossil locality is situated 3 miles south of Dungog, three-quarters of a mile west of the main Dungog-Maitland road, and the L.234 Wiragulla locality occurs immediately north-east of Wiragulla railway siding, approximately 4 miles south of Dungog (Text-fig. 1). A northward extension of the L.234 horizon crops out 150 feet stratigraphically above the L.235 Dungog locality.

Both horizons are particularly important because they are contained in stratigraphic sections which extend into the non-marine Wallaringa Formation. The occurrence of *Delepinea aspinosa* (Dun) on both horizons suggests that they can be correlated with one 800 to 1,000 feet above the base of the "Lower Kuttung Series" in the Rouchel Basin (Campbell and Roberts, 1964 in press).

* Present address: Bureau of Mineral Resources, Canberra, A.C.T.

Regional Stratigraphy

The geology of the Gresford district has been considered in a previous paper (Roberts, 1961). Text-figure 2 illustrates the stratigraphic nomenclature of the formations in the Gresford-Dungog district. The stratigraphy of the district is briefly summarized below.

The Bingleburra Formation (approximately 3,000 feet in thickness) consisting of mudstones, siltstones, oolitic and crinoidal limestones and interbedded sandstones and conglomerates, is overlain by the Ararat Formation (1,500 feet in thickness). This formation is composed of calcareous tuffaceous sandstone with minor mudstones and oolitic and crinoidal limestone lenses.

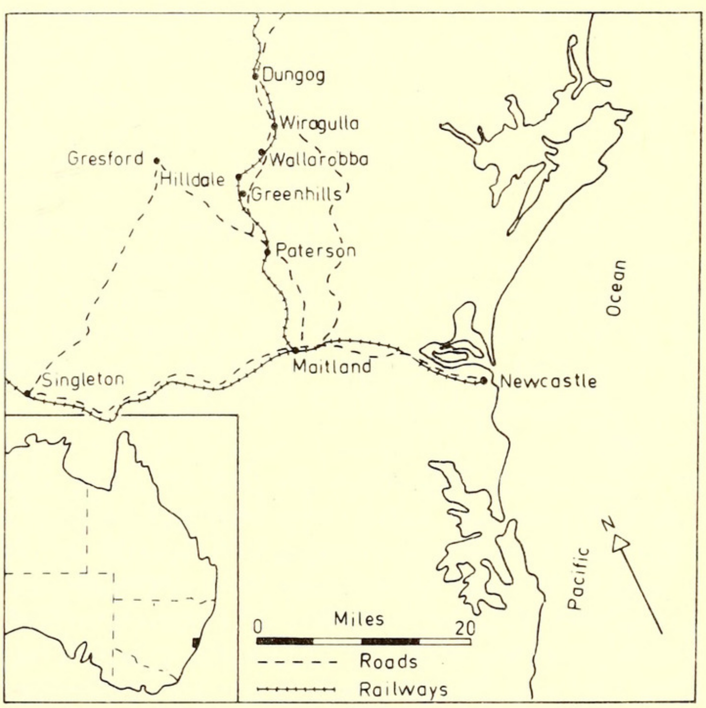

FIG. 1

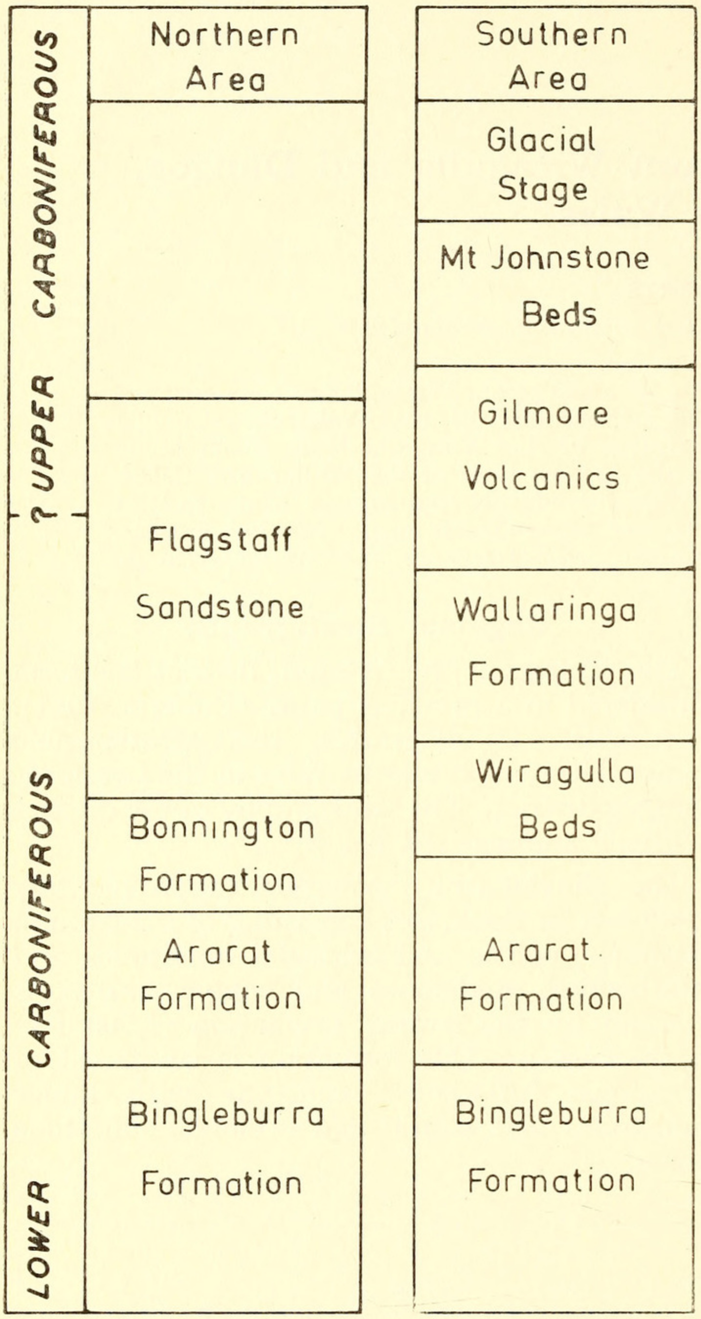

FIG. 2

Following Ararat sedimentation marine conditions continued without interruption in the north of the area, and the Bonnington Formation (400 feet in thickness), consisting of siltstones and mudstones, underlies the coarse tuffaceous Flagstaff Sandstone (5,500 feet in thickness).

To the south, following the deposition of the Ararat Formation, conditions changed in parts to a non-marine environment due to the uplift of a narrow belt stretching from Hilldale to Mt. Ararat (Roberts, 1961). However, away from the influence of the uplift, for example at Wiragulla near Dungog, a thin marine mudstone and siltstone sequence (Wiragulla Beds) is interbedded between the Ararat Formation and the non-marine Wallaringa Formation. The Wallaringa Formation (950 feet in thickness) is overlain by the Gilmore Volcanics, the Mt. Johnstone Beds (Sussmilch and David, 1920) and rocks of the Glacial " Stage " (Osborne, 1922).

Local Stratigraphy

Sediments exposed in the Wiragulla-Dungog district crop out on the eastern limb of the Wallarobba Basin. The geology of the district is illustrated in Text-figure 3 and a stratigraphic section from the eastern limb of the basin given in Text-figure 4.

Rocks of the Bingleburra Formation crop out a short distance north of the area dealt with in this paper and are overlain by those of the Ararat Formation. Faunal evidence suggests that Ararat sedimentation in the Dungog district may have been prolonged compared with that further to the north and that the Ararat Formation is a time-transgressive unit. Faunas containing *Delepinea aspinosa* (Dun) occur in the upper beds of the Ararat Formation and the lower part of the overlying Wiragulla Beds on the eastern limb of the Wallarobba Basin. A fauna in the basal beds of the Bonnington Formation, which overlies the

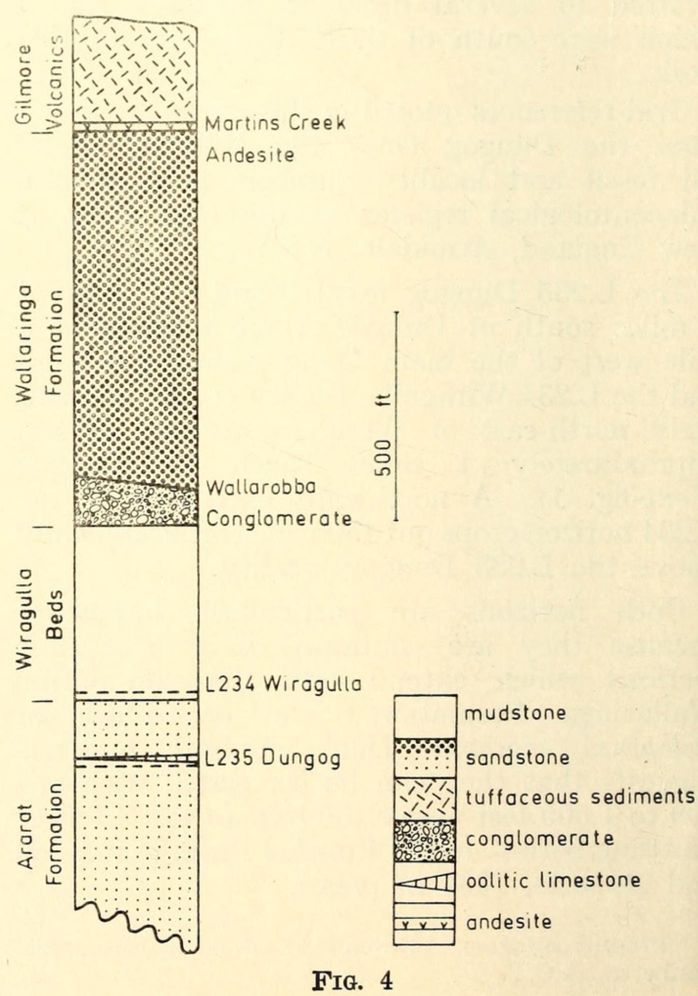

FIG. 4

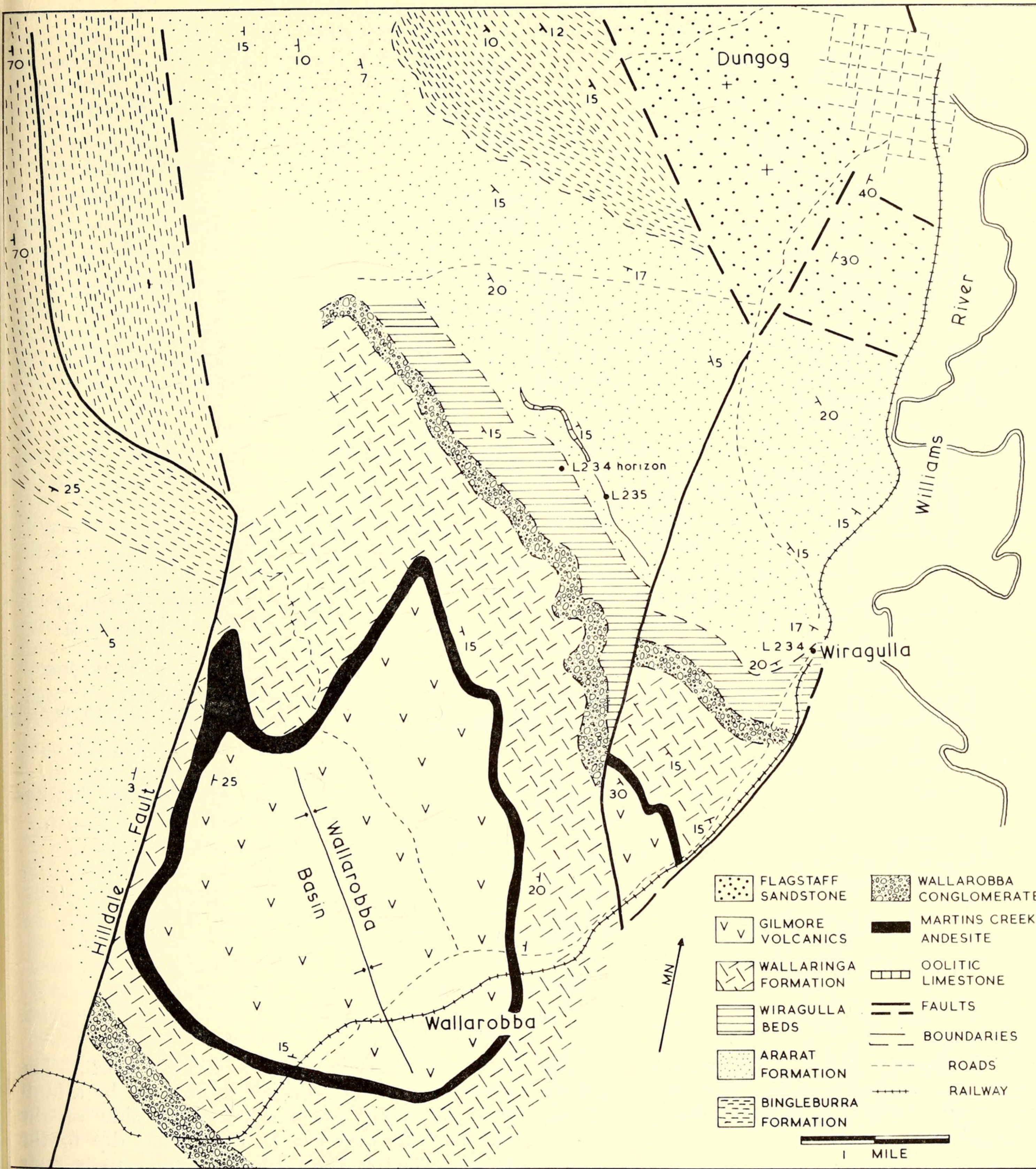

FIG. 3

Ararat Formation in the Lewinsbrook Syncline 10 miles to the north-west, is distinctly older and is more closely related to the Middle Viséan (Cu III$_\alpha$) L.53 Greenhills assemblage (Roberts, 1964).

The Wiragulla Beds occur in an area south of Dungog where they occur between the Ararat and Wallaringa Formations. The Wallaringa Formation crops out strongly on the hills forming the eastern flank of the Wallarobba Basin and is overlain by the Martins Creek Andesite, the basal member of the Gilmore Volcanics. Tuffaceous sandstones belonging to the Gilmore Volcanics crop out in the centre of

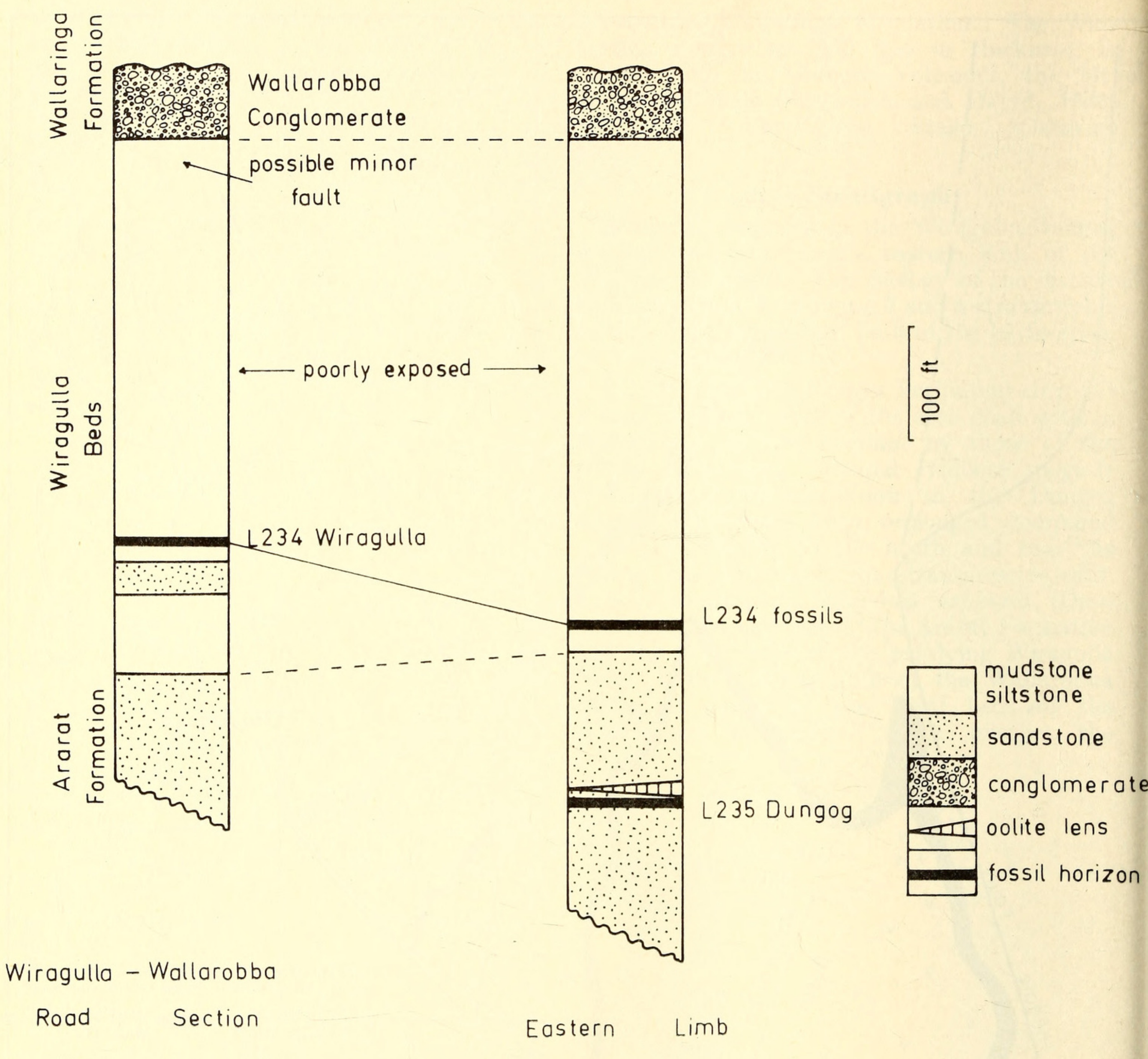

FIG. 5

the Wallarobba Basin. To the north of the basin the coarse marine Flagstaff Sandstone interfingers with and replaces the non-marine Wallaringa Formation.

Wiragulla Beds

The best exposed section of the Wiragulla Beds crops out on the north-western side of the Paterson-Dungog road from 47659862, near the overhead road bridge crossing the North Coast Railway Line, to approximately 47609852 (Text-fig. 5). A small fault causes a slight disruption to the upper parts of this section immediately below the Wallarobba Conglomerate near a roadside quarry at 47609852. The remainder of the section is influenced by a fault running along the south-eastern side of the railway line and has an anomalous dip to the south. The base of the Wiragulla Beds rests on massive sandstones of the Ararat Formation cropping out to the west of the Chichester-Newcastle water pipeline. The upper limits are obscured by the small fault mentioned above, but the beds appear to gradually merge into coarse sandstones at the base of the Wallarobba Conglomerate.

A more poorly exposed section occurs approximately 2 miles north-west of the road section on the eastern limb of the Wallarobba Basin (Text-fig. 5). Here, the Wiragulla Beds conformably overlie the Ararat Formation and pass with apparent regular conformity into the overlying Wallaringa Formation.

Thickness. The thickness of the Wiragulla Beds is approximately 450 feet.

Lithology. For the most part the Wiragulla Beds are composed of distinctive grey to pale fawn mudstones and fine-grained sandstones.

Lateral Variation. (1) The Gresford District. Two occurrences of the Wiragulla Beds are known from the Gresford District, but because of very poor exposures and the complex nature of the regional stratigraphy they have previously been mapped with other formations. (*a*) The L.210 Toryburn fossil locality, found in an isolated outcrop on the bank of McIntyre's Creek, is surrounded by a large area of alluvium and has been included in the Wallaringa Formation in the geological map of the Gresford district (Roberts, 1961). (*b*) A thin sequence of fossiliferous mudstones containing the L.211 fossil locality (Roberts, 1961) underlies massive green sandstones on the south-western side of the Colstoun Basin near the Gresford Fault. These mudstones were previously mapped with the Flagstaff Sandstone, but their stratigraphic position and lithology appear to link them with the Wiragulla Beds.

(2) South-western margin of the Wallarobba Basin. In a newly exposed section in a road cutting across the Wallarobba Range the Wiragulla Beds are missing, and coarse-grained lithic sandstones appear to underlie the Wallarobba Conglomerate conformably. The absence of the Wiragulla Beds, however, can possibly be best explained by the existence, in certain areas, of an unconformity at the base of the Wallaringa Formation. Support for this suggestion comes from the Clarencetown district, where the Wiragulla Beds and faunas characterised by *Delepinea aspinosa* (Dun) are absent from beneath the Wallarobba Conglomerate; instead, the latter member is underlain by a sequence containing a Middle Viséan ($CuIII_{\alpha}$) fauna, the same as that found at L.53 Greenhills (Roberts, 1964), which is definitely older than the $CuIII_{\alpha-\beta}$ assemblages from Wiragulla and Dungog.

The sandstones underlying the Wallarobba Conglomerate in the above section are coarse-grained, contain a high percentage of volcanic rock fragments, and have a dark green chloritic cement. They are usually massively bedded, but exhibit small scale cross stratification on a number of horizons. The lithology changes markedly near the base of the Wallarobba Conglomerate Member from a dark green chloritic sandstone to a pink zeolitic rock. In the lower parts of the western flank of the range the sandstones are accompanied by several thin conglomerate bands.

Fossil Localities

The stratigraphic positions of the fossil localities discussed in this paper are illustrated in diagrammatic stratigraphic sections from the eastern limb of the Wallarobba Basin (Text-figs. 4, 5).

L.235 Dungog occurs in a calcareous sandstone and impure limestone at grid reference 47439880, on the top of a ridge three-quarters of a mile west of the Dungog-Maitland road. Stratigraphically this horizon occurs 130 feet below the top of the Ararat Formation. The fossil bed can be traced some distance north and south of the L.235 collecting point and its lateral extent is shown in Text-figure 3.

L.234 Wiragulla is found in pale fawn fine-grained siltstones cropping out on the roadside opposite the large gates of Wiragulla railway siding (grid reference 47659861) and in the railway cutting immediately north-east of the siding. L.234 occurs towards the base of the Wiragulla Beds, its stratigraphic position being shown in Text-figure 5. A northward extension of the L.234 horizon has been found approximately 150 feet stratigraphically above L.235 Dungog.

The stratigraphic sections on the eastern limb of the Wallarobba Basin have enabled the L.234 and L.235 horizons to be placed in a sequence extending upwards into the Wallarobba Conglomerate Member of the Wallaringa Formation, the Basal unit of the Kuttung Group.

Dungog and Wiragulla Faunas

The following is a list of all identifiable species collected during the present investigation. Those forms described in this paper are marked with an asterisk.

L.235 Dungog.
- *Fenestella* sp.
- *Leptagonia* cf. *L. analoga* (Phillips)
- **Chonetes cangonensis* n.sp.
- *Delepinea aspinosa* (Dun)
- **Gigantoproductus tenuirugosus* n.sp.
- **Echinoconchus gradatus* Campbell
- *Waagenoconcha delicatula* Campbell
- *Inflatia simplex* (Campbell)
- *Pustula* sp.

Unispirifer striatoconvolutus (Benson and Dun)
Voiseyella anterosa (Campbell)
Kitakamithyris sp.
**Balanoconcha elliptica* Campbell
**Aviculopecten* sp.
**Streblopteria* sp.
Diodontopteria delicata Roberts
Tentaculites sp.
Straparolus sp.

L.234 Wiragulla.
Fenestella sp.
Conularia sp.
Schizophoria verulamensis Cvancara
Delepinea aspinosa (Dun)
**Inflatia elegans* n.sp.
**Spirifer osbornei* n.sp.
**Athyris wiragullensis* n.sp.
**Kitakamithyris* sp.
Stenoscisma laevis Roberts
Diodontopteria sp.
Bellerophon sp.
Straparolus sp.
Tentaculites sp.

L.234 continuation, 150 feet stratigraphically above L.235.
Schizophoria verulamensis Cvancara
Leptagonia cf. *L. analoga* (Phillips)
Schuchertella concentrica Roberts
Delepinea aspinosa (Dun)
**Chonetes cangonensis* n.sp.
Waagenoconcha delicatula Campbell
**Echinoconchus gradatus* Campbell
Fluctuaria campbelli Roberts
**Inflatia elegans* n.sp.
**Spirifer osbornei* n.sp.
Unispirifer striatoconvolutus (Benson and Dun)
**Athyris wiragullensis* n.sp.
Cleiothyridina sp.
" *Camarotoechia* " sp.
Stenoscisma laevis Roberts
**Balanoconcha elliptica* Campbell
**Aviculopecten* sp.
Bellerophon sp.

The following species have restricted vertical ranges and in the Gresford-Dungog district are confined to the L.235 and L.234 assemblages: *Delepinea aspinosa* (Dun), *Chonetes cangonensis* n.sp., *Gigantoproductus tenuirugosus* n.sp., *Inflatia elegans* n.sp., *Inflatia simplex* (Campbell), *Spirifer osbornei* n.sp., *Athyris wiragullensis* n.sp., *Balanoconcha elliptica* Campbell, *Aviculopecten* sp., *Streblopteria* sp. These constitute a faunal element which is distinct from the younger assemblages in the district (Roberts, 1963, 1964, 1965).

Age of the Fauna

The age of the Wiragulla-Dungog fauna can be closely estimated as Middle to Upper Viséan (Cu $III_{\alpha-\beta}$). It is younger than the Middle Viséan (Cu II_δ to Cu III_α, Brown, Campbell and Roberts, 1964) fauna from Trevallyn described by Roberts (1965 in press), and the Middle Viséan (Cu III_α) fauna from Greenhills (Hilldale) described by Roberts (1964).

An age closer to Middle Viséan is suggested by the presence of *Schuchertella concentrica* Roberts, *Echinoconchus gradatus* Campbell and *Voiseyella anterosa* (Campbell) in the Greenhills fauna, and *Echinoconchus gradatus* Campbell, *Inflatia simplex* (Campbell), *Voiseyella anterosa* (Campbell) and *Balanoconcha elliptica* Campbell in the Babbinboon fauna from the Werrie Basin. The latter fauna is now considered to be at the latest Middle Viséan in age, this determination being based on the presence of Upper Tournaisian goniatites in the lower part of the Carboniferous sequence in the Werrie Basin (Campbell and Engel, 1963), and on a correlation of the Babbinboon horizon with the Burlington and Keokuk Limestones of North America. Recent work by Collinson, Scott and Rexroad (1962) has shown the Burlington and Keokuk Limestones to be correlated with the Cu $II\gamma$ and Cu II_δ zones, respectively, of Germany.

Two brachiopod relationships may be considered in detail. *Voiseyella anterosa* (Campbell) is morphologically close to *Spirifer mundulus* Rowley from the Lower Burlington Limestone of the Mississippi Valley, U.S.A. (Campbell, 1957). This again suggests a Middle Viséan age.

Gigantoproductus tenuirugosus n.sp. appears to be morphologically similar to *G. dentifer* (Prentice), which ranges from the C_2S_1 zone to the D_2 zone in England and is most common in the D_2 of Derbyshire. In Belgium *G. dentifer* occurs in rocks of V_{3a} age.

Preservation and Palaeoecology

L.235 Dungog. Shelly material is present in all except the extensively weathered portions of the calcareous sandstone and impure limestone constituting this horizon. The weathered portion of the rock is most useful in determining internal structures but is extremely friable. Leaching of unweathered material with hydrochloric acid is a difficult process because of the calcareous nature of the rock.

L.234 Wiragulla. Fossils from this locality are preserved as internal or external moulds in a grey to fawn mudstone. Little trace of shell material has been found.

The following observations give some indication of environmental conditions prevailing during the accumulation of the two fossil beds.

L.235 Dungog.

(1) The L.235 horizon is characterized by an intermixed brachiopod/pelecypod fauna, brachiopods being in the majority. Polyzoa are rare and where found are always fragmentary. Solitary corals are absent.

(2) *Chonetes cangonensis* n.sp. and *Gigantoproductus tenuirugosus* n.sp. always have broken hinge spines, suggesting that the shells had been washed around by current action. However, the external features of the shells examined are well preserved, show no evidence of abrasion, and some forms, such as *Echinoconchus gradatus* Campbell and *Pustula* sp., still retain their delicate external spinose ornament.

(3) A considerable amount of fragmentary shell debris, particularly pieces of *Gigantoproductus tenuirugosus* n.sp. shell, is found in parts of the bed.

(4) Valves of brachiopods and pelecypods are usually found dissociated, having been washed apart after the death of the animal.

(5) The population ranges from juveniles to adults and species of all sizes occur in the one bed. No major sorting appears to have taken place.

(6) Although the bottom sediment apparently had no suitable hard areas where brachiopods possessing a pedicle could anchor themselves, many specimens of the terebratuloid *Balanoconcha elliptica* Campbell have been collected. These show no evidence of having been washed into the bed from elsewhere and presumably attached themselves to other shelly organisms.

The L.235 fauna appears to be near its original position of growth in a shallow sandy marine environment. Occasional stronger currents washed in fragments of *Gigantoproductus tenuirugosus* n.sp. which may have been broken by wave action in a region nearer the shoreline. Despite the disarticulation of the valves, most other species are probably somewhere near their original position of growth because they are unsorted and their surfaces are well preserved and show no indication of abrasion. A rapid burial soon after death may account for the preservation of the delicate ornament on some spinose brachiopods.

L.234 Wiragulla.

(1) Most shells are disarticulated and often have worn external surfaces. Productid brachiopods are stripped of all external spines. Internal features, however, are excellently preserved. Solitary corals are not found in their positions of growth but lie parallel with the bedding planes. Polyzoa are rare.

(2) Portions of the fossiliferous bed contain a mass of broken gastropod fragments, ostracods, broken echinoid plates and spines and crinoid columnals. The sediment accompanying the fragmentary material is noticeably coarser than the remainder of the bed and may have been washed in by stronger current action.

(3) Sorting has taken place to a limited extent and though the population ranges from juveniles to adults the latter predominate.

(4) Wood fragments are common.

(5) The finer sediment contains fragmentary burrows formed by a sub-surface fauna.

The L.234 Wiragulla fauna is not preserved in a living position. The wear shown by the exteriors of the larger productid and spiriferid shells, the disarticulated nature of the valves and the absence of productid spines suggests that currents washed the shells around for a considerable time prior to burial. Fragmentary debris associated with slightly coarser sediment may have been carried in by stronger currents.

Acknowledgements

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SYSTEMATIC PALAEONTOLOGY

Brachiopoda

Suborder CHONETOIDEA Muir-Wood, 1955
Superfamily CHONETACEA Shrock and Twenhofel, 1953
Family CHONETIDAE Bronn, 1862
Subfamily CHONETINAE Bronn, 1862
Genus CHONETES Fischer de Waldheim, 1830

TYPE SPECIES: *Terebratulites sarcinulatus* Schlotheim, 1820, by subsequent designation of Verneuil, 1845.

DIAGNOSIS: An emended diagnosis for the genus has been given by Muir-Wood (1962).

REMARKS: This material is referred to *Chonetes* sensu stricto as redefined by Muir-Wood. The most characteristic features supporting this designation include the two poorly defined septa in the brachial valve, the strong median septum in the pedicle valve and the relatively flat nature of the shell. The transverse form of the shell is the only departure from the characters presented in the emended diagnosis.

Chonetes cangonensis n.sp.

Plate I, figs. 1–10

DIAGNOSIS: Shell flat to slightly plano-convex; twice as wide as long, sub-rectangular in shape with rounded cardinal margins; 20–24 capillae occur per 3 mm. at the anterior margin of the shell. Pedicle valve has 3 or 4 spines on either side of the umbo; median septum extends to the mid-point of the valve. Brachial valve possesses strong socket plates; 2 long divergent spinose septa extend from the muscle field almost to the anterior margin; a median septum has not been observed.

DESCRIPTION:

EXTERNAL. The shell is small, extremely flattened, approximately twice as wide as long, and sub-rectangular in shape. The greatest width occurs a short distance in front of the hinge and the lateral margins and cardinal extremities are well rounded. Capillae are narrow, half as wide as the well rounded separating sulci, and increase by more or less regular intercalation. There are 20–24 papillae per 3 mm. at the anterior margin of the shell. Concentric and radial micro-ornament is absent. The surface ornament becomes weaker on the postero-lateral margins of the shell. The dimensions of the largest shell observed are 10 mm. wide and 6·5 mm. long.

Pedicle valve is slightly convex on the postero-lateral slopes, but flattens anteriorly. The umbo is obsolete. Three or four spines are present along the hinge on either side of the umbo. An extremely faint median sinus may be developed. The cardinal area is flat and less than 0·5 mm. high at the umbo. No details of the delthyrium have been observed.

Brachial valve is flat and has a lower cardinal area than that of the pedicle valve. The fold is generally obsolete.

INTERNAL. Pedicle valve. The median septum is thin, extends from the umbo to the mid-point of the valve and tapers anteriorly to a sharp blade-like ridge. Two faint divergent ridges arise at the base of the septum and run a short distance laterally. They may border the muscle field. No details of the muscle scars or dental apparatus have been observed. The internal surface of the valve is ornamented with aspinose striae which tend to be irregular in the mid-portion of the valve.

Brachial valve. Socket plates are large, arise from the base of the cardinal process, curve laterally and are slightly divergent from the hinge. Two smaller divergent ridges run from near the base of the cardinal process and enclose the muscle field. The muscle field is triangular in shape and deeply depressed below the cardinal process. Individual muscle scars are not preserved. Two slightly divergent spinose septa extend from the base of the muscle field almost to the anterior margin of the valve. The septa are low and may be almost obsolete in some specimens. The internal surface is marked with papillose radial ribs having a density of 10–12 per 2 mm. at the anterior margin. Papillae are coarsest a short distance behind the margins of the valve. No details of the cardinal process have been observed.

REMARKS: A search of both overseas and Australian literature fails to reveal any *Chonetes* species which can be closely compared with *Chonetes cangonensis*. The Lower Carboniferous species *C. failandensis* S. Smith, figured by Muir-Wood (1962), is larger, has a more convex pedicle valve, a more concave brachial valve, a more globular shape and is more coarsely striate.

This species is named after the property "Cangon", situated 2 miles south of Dungog.

OCCURRENCE: *Chonetes cangonensis* has been collected from L.235 Dungog, the type locality, and a continuation of the L.234 Wiragulla horizon, 150 feet stratigraphically above L.235.

MATERIAL: F.7096–F.7108. *Holotype* F.7096a, *paratypes* F.7096b, F.7097, F.7102.

Suborder PRODUCTOIDEA Maillieux, 1940
Superfamily PRODUCTACEA Waagen, 1883
Family GIGANTOPRODUCTIDAE Muir-Wood and Cooper, 1960
Subfamily GIGANTOPRODUCTINAE Muir-Wood and Cooper, 1960
Genus GIGANTOPRODUCTUS Prentice, 1950

TYPE SPECIES: *Productus giganteus* J. Sowerby 1822.

Gigantoproductus tenuirugosus n.sp.

Plate I, figs. 11–19

DIAGNOSIS: Pedicle valve transverse, semi-elliptical and moderately convex; umbonal curvature weak; postero-lateral margins flattened ; hinge-line long and ornamented with a single row of spines ; there are approximately 25 spines on either side of the umbo ; costellae have a density of 10–14 per 10 mm. at a distance of 20 mm. from the umbo. Brachial valve moderately concave and rugose.

DESCRIPTION :

EXTERNAL. Pedicle valve is wider than long, semi-elliptical in shape, inflated medially and has flattened postero-lateral margins. The greatest convexity occurs a short distance in front of the umbo. The umbo is pointed and does not incurve over the hinge. Lateral shoulders slope steeply to the flat lateral margins. The hinge-line is the widest part of the shell and is ornamented by a single row of closely spaced spines which increase in strength laterally. Approximately 25 spines are present on each side of the umbo. The trail is weak, the venter evenly rounded and the fold and sinus obsolete. Costellae are well defined and are twice as wide as the intercostal troughs. The costellae become broader towards the margins of the shell, increase by random intercalation and have a density of 10–14 per 10 mm. at a distance of 20 mm. from the umbo. They become wavy on the postero-lateral margins of the valve. Fine concentric growth lines are especially prominent along the cardinal margins in front of the row of spines. They commence a short distance in front of the hinge, but become rapidly obsolete on the venter and rarely cross the valve.

Brachial valve is moderately concave, the umbo is depressed below the hinge-line and the postero-lateral margins are flat. Rugae are well defined on the lateral margins and produce a wrinkled appearance across the body of the valve. Costellae are similar to those on the pedicle valve except that occasional bifurcations as well as irregular intercalations take place.

INTERNAL. Pedicle valve. Diductor scars are coarsely striate and are situated in sub-quadrate pits. These are widely separated by longitudinally striate adductor scars. The muscle field is restricted to the posterior portion of the valve and is surrounded by an area of shallow linear pits. The pits grade into impressions of the external ornament towards the anterior margin.

Brachial valve. The median septum is long, well defined, broad posteriorly, tapers anteriorly and extends to the mid-point of the valve. Adductor scars are small, triangular, and occur at the posterior margins of the brachial process. The brachial processes are roughly triangular, longitudinally striate and give rise to poorly defined linear brachial ridges. The cardinal process appears to be quadrilobate externally.

MEASUREMENTS : *Gigantoproductus tenuirugosus* has been described from fragmentary material and consequently cannot be measured accurately. The dimensions of the species can be seen in Plate I.

REMARKS : Because only a small number of poorly preserved specimens are at present available for study the internal morphology of the species is incompletely known. Detailed comparisons are therefore difficult to make.

The closest species appears to be *G. dentifer* (Prentice, 1949, p. 249–257, pl. 11, figs. 2*a–c*, pl. 12, figs. 2*a–b*) which ranges from the C_2S_1 zone to the D_2 zone of Derbyshire, England. *G. tenuirugosus* has a similar shape, but is distinguished by its coarser costate ornament.

The morphologically close specimens of *Productus hemisphaericus* Sowerby described by Davidson (1858, p. 144–145, pl. 40, figs. 4–8) and Delépine (1928, p. 28–29, pl. 4, fig. 53) have been shown by Prentice (1949) to belong to *G. dentifer* ; they are from Warfdale, Yorkshire, England, and the V_{3a} of Belgium, respectively.

Several other forms referred to *Productus hemisphaericus* Sowerby are externally similar to this species and may belong to *Gigantoproductus* ; viz. those described by Krenkel (1913, p. 41–42, pl. 2, fig. 1) from the Utsch-Turfan district of Tian-Shan, and Reed (1927, p. 45, pl. 9, fig. 3) from Ta-shih-wo, Yun-nan.

This species is named from the Latin *tenuis*—slight and *rugosus*—wrinkled, which refer to the small rugae on the lateral margins of the shell.

OCCURRENCE : *Gigantoproductus tenuirugosus* has been collected only from L.235 Dungog.

MATERIAL : F.7122–F.7137. *Holotype* F.7122, *paratypes* F.7123, F.7127B, F.7133.

Family MARGINIFERIDAE Stehli, 1954
Subfamily COSTISPINIFERINAE Muir-Wood and Cooper, 1960
Genus INFLATIA Muir-Wood and Cooper, 1960

TYPE SPECIES : *Productus inflatus* McChesney, 1860.

REMARKS : This material differs from the type species, *Inflatia inflata* (McChesney), in the possession of more narrow adductor muscle scars in the pedicle valve, a shorter hinge, the absence of a fold and sinus and the shorter median septum in the brachial valve. Features which are comparable with those of the type species are the size, profile, external ornament and the arrangement of spines ; the internal morphology of both valves is generally similar in both species.

Inflatia elegans n.sp.
Plate II, figs. 1–18

Diagnosis : Two small spines present along hinge-line of pedicle valve ; costae have a density of 13–15 per 10 mm. on anterior portion of trail ; sinus absent ; greatest width occurs at mid-region of valve ; pedicle valve musculature moderately developed. Brachial valve bears prominent geniculation and extensive trail ; fold absent ; median septum short for the genus, blade-like anteriorly and extends to mid-point of valve.

Description :

external. Pedicle valve is globose, strongly inflated and convex, with the greatest convexity occurring at the umbo and at the commencement of the trail. The visceral disc is gently convex. The umbo is narrow, strongly incurved and extends a short distance behind the hinge-line. Greatest width occurs at the mid-region of the valve. The hinge-line is straight and the postero-lateral margins are flattened but not auriculate. The flanks and the trail are steep and pronounced. In gerontic individuals a flat lip-like extension on the anterior of the trail may extend up to 7 mm. in front of the general trail base and rests against a similar marginal modification of the trail of the brachial valve. Ornament is moderately reticulate and in adult specimens up to 10 rugae occur on the visceral disc. On the anterior portion of the trail the costae have a density of 13–15 per 10 mm. They increase by bifurcation and intercalation. Two small spines are commonly developed on the hinge-line and occasionally two or three additional spines are situated towards the mid-portion of the valve. A median sinus is absent.

Brachial valve is geniculate, has a high concave trail and lateral margin and a shallowly concave visceral disc. On a valve 32 mm. wide and 28 mm. long the trail is 13 mm. high. The greatest concavity occurs at the junction of the trail and the visceral disc and on the posterior shoulders which slope upwards from the depressed visceral region. Gerontic individuals possess a marginal flange on the trail formed by an abrupt geniculation of its anterior-most tip. The pointed umbo is depressed below the level of the hinge. Lateral and postero-lateral regions are flattened, but the extremities are non-auriculate and meet the hinge at right angles. Fourteen to fifteen concentric ribs are present on the visceral disc and the radial ornament has the same density as that on the opposite valve. The brachial valve is aspinose and a median fold is absent.

internal. Pedicle valve. Diductor scars are triangular in shape, slightly impressed into the shell, commence indistinctly a short distance in front of the umbo and become rapidly broader and flabellate anteriorly. They have irregular but well-differentiated lateral margins. The posterior portions of the diductor scars, the most weakly impressed regions of musculature, are ornamented with fine concentric filae. The remainder of the muscle field is marked by low branching ridges which are sometimes continuous with the internal ornament of the valve. Adductor scars are narrow, elongate, commence a short distance behind the posterior margins and terminate behind the anterior margins of the diductor scars. They are usually elevated above the floor of the valve on narrow platforms, but in some cases are shallowly impressed into the shell. In the first instance they are divided by a median furrow and in the second they are separated by a weak median ridge originating from a small apical callus ; the median ridge occurs only in gerontic individuals. Dendritic markings occur on the posterior portions of the adductor scars. Muscle scars are poorly defined in juvenile specimens. A distinct ginglymus extends across the hinge and is divided by the umbonal cavity. The hinge-line is thickened and a weak marginal ridge cuts across the postero-lateral extremities and traverses the trail, in most cases becoming obsolete towards the front of the valve. The internal ornament varies from a densely pitted region adjacent to the muscle field, to an area of parallel longitudinal striations which extends anteriorly from the muscle field and becomes indistinct towards the marginal ridge.

Brachial valve. The adductor scars are differentiated into posterior and anterior pairs. Posterior adductor scars are large, round to ovoid in shape, elevated anteriorly, impressed posteriorly and are strongly dendritic. Anterior adductor scars are lacrimate to rectangular in shape and occur towards the front of, and are partially enclosed by, the divergent posterior pair. They are pointed posteriorly, have well rounded anterior margins and can be either impressed into the shell or, more commonly, be elevated on platforms above the floor of the valve. The anterior adductor scars are smooth, but at least one case of obsolete dendritic ornament has been observed. The cardinal process is short, bilobate internally, trilobate externally and is buttressed by strong lateral ridges and a median septum. The internal lobes are convex and well rounded, diverge posteriorly and are separated from one another by a deep narrow groove. Externally the lateral lobes are convex, diverge from a smaller peg-like central lobe and are separated from it by a narrow angular furrow. The median septum extends to the mid-point of the valve. It is low, broad and well rounded posteriorly, becomes narrow towards its mid-length and increases in strength towards the anterior extremity, developing into a high blade-like projection. A narrow groove divides the posterior and medial regions of the septum, while the anterior portion is carinate. Brachial ridges arise from the front of the muscle field at the junction of the anterior and posterior adductor scars. They run for a short distance laterally, parallel with the hinge, and then swing anteriorly, enclosing the ovoid to kidney-shaped brachial discs in hook-like curves. Brachial ridges have a variable strength and are usually moderately elevated along their length from the muscle field to the margins of the brachial discs. The ridges are highest on the inner margins of the hooked curves where they surround the elevated discs. In several instances the brachial ridge is not differentiated from the brachial disc, while in some valves, notably juveniles, brachial markings are absent. Brachial discs are smooth or are marked with concentric striae. A smooth region on the floor of the valve extends along the anterior side of the brachial ridges between the brachial discs and the muscle field. The lateral ridges are concave when viewed from the posterior of the valve, rapidly lose strength laterally and fail to reach the lateral margins. A faint groove arises from the lateral margins, extends around the trail and fits into a marginal ridge on the pedicle valve. The groove becomes deep in gerontic forms. The internal ornament is differentiated into three regions ; the first, behind the brachial impressions and on either side of the muscle field, is marked with deep randomly oriented pits ; the second region, between the brachial impressions and the marginal furrow, with radially

Measurements (in mm.) :
Pedicle Valve

Specimen Number	Length	Length of Curvature*	Width	Height	Diductor Muscle Field		Adductor Muscle Field	
					Length	Width	Length	Width
F.6941 ..	37	47	38	15	16	25	11	3·5
F.6943 ..	26	43	33·5	13·5	11·5	22	10	3
F.6942 ..	30	53	37	16	15	27	13	6
F.6930 ..	32	45	33	—	—	—	7	3
F.6932 ..	33·5	42	31	11	—	—	7	2·5
F.7004 ..	30	35	35	13	—	—	8	3

Brachial Valve

Specimen Number	Length	Width	Adductor Muscle Field		Length Median Septum	Distance between outer margins of Brachial Ridges
			Length	Width		
F.6982a ..	30	34 est.	7	8	11	20·5
F.6984 ..	27 est.	33 est.	8	10	13	22
F.6985 ..	29	32	6	7	13	22
F.6986 ..	23	25	8	8	14	21
F.6987 ..	27	30	8	9	16	25
F.6988 ..	23	28	—	—	13	—
F.6989 ..	—	31	7·5	8·5	14	23·5
F.6990 ..	24	28·5	6	10	12	20
F.6993 ..	27	24	8	7	15·5	23
F.6995 ..	24	25	5	7	15	21
F.6997 ..	23	28	6	7	12	22
F.6999 ..	25	28	8	7	14	21·5

* The length of curvature is measured from the umbo, around the curvature of the valve, to the mid-point of the anterior margin.

arranged strips of pustules ; and the third, on the trail, with spines which gradually grade into a smooth region anteriorly.

Remarks : Variation within the species is mostly dependent on age. Gerontic individuals become highly globose and inflated, develop a recurved marginal flange on the trails of both valves and have a less distinct external ornament. As expected, juvenile specimens show poor development of muscle scars and brachial markings, but some large specimens also exhibit these features and are distinct from most shells of comparable size. Details of the variation within the musculature of both valves are described above.

The species referred to *Dictyoclostus simplex* by Campbell (1957, p. 57–60, pl. 13, figs. 1–8), from Babbinboon in the Werrie Basin, N.S.W., now appears to belong to *Inflatia*. *I. elegans* is readily distinguished from this species by way of its larger size, more globose shape, longer trail and spinose posterior margin. Internally *I. elegans* is characterized by shorter marginal ridges buttressing the cardinal process, a shorter median septum and better defined brachial markings. The morphology, but not the size, of the adductor muscle scars and brachial markings in the brachial valve is closely comparable in both species. These structures are larger in *I. elegans*.

Inflatia inflata (McChesney), figured by Muir-Wood and Cooper (1960, pl. 55, figs. 1–5), from the Chester Series of Oklahoma, is distinguished from *I. elegans* by its wider hinge-line, stronger adductor scars in the pedicle valve, a longer median septum in the brachial valve and the possession of a fold and sinus.

The specific name is taken from the Latin *elegans*—elegant.

Occurrence : *Inflatia elegans* has been collected from the type locality, L.234 Wiragulla, and from a locality 150 feet stratigraphically above L.235 Dungog.

Material : F.6922–F.7004. *Holotype* F.6985, *paratypes* F.6941–F.6943, F.6956, F.6958, F.6980–F.6982a.

Family ECHINOCONCHIDAE Stehli, 1954
Subfamily ECHINOCONCHINAE Stehli, 1954
Genus ECHINOCONCHUS Weller, 1914

Type species : *Productus punctatus* J. Sowerby, 1882.

Remarks : *Echinoconchus* has been redefined by Muir-Wood and Cooper (1960, p. 243–244), who made the provisional note that the genus is still imperfectly understood. They have retained the *Echinoconchus elegans* and *E. punctatus* groups within the genus, thus supporting Campbell's (1956) contention that there was no basis for their separation as proposed by Chao (1927, p. 53).

A row of hinge spines occurs on the brachial valves in the Dungog material. If these spines were present in other species of the *E. elegans* group they could perhaps clarify the interpretation of the genus. However, a review of the relevant literature, including Grober (1909), Krenkel (1913), Weller (1914), Thomas (1914), Hayasaka (1924), Chao (1927), Delépine (1928), Paeckelmann (1931), Sutton (1938), Muir-Wood (1948) and Sarycheva and Sokolskaya (1952), does not reveal rows of hinge spines to be present on the brachial valves of any other species. The quality of many of the photographs illustrating the above works is poor and should a revision of *E. elegans* group species show such spines then this criterion could be used in the separation of the *E. elegans* and the *E. punctatus* groups.

Echinoconchus gradatus Campbell

Plate V, figs. 6–8

Echinoconchus gradatus Campbell, 1956, J. Paleont., 30, p. 474–476, pl. 49, figs. 14–18.

Echinoconchus gradatus Campbell, 1957, J. Paleont., 31, p. 62.

Remarks : The material from L.235 Dungog differs from the type specimens in only one feature, the possession of one or two rows of spines along or nearly parallel with the hinge-line of the brachial valve. The spines are much larger and longer than those ornamenting the shell, have circular bases, become stronger laterally and curve towards the umbo. One or two spines occur near the junction of each concentric rib with the hinge. The apparent absence of these spines in the type material may be due to the poor preservation of the Babbinboon material.

Occurrence : *Echinoconchus gradatus* is now known from L.35 Babbinboon, the type locality, L.53 Greenhills, L.235 Dungog and the extension of the L.234 Wiragulla horizon, 150 feet stratigraphically above L.235.

Material : F.7022–F.7037.

Suborder SPIRIFEROIDEA Allen, 1940, emend. Muir-Wood, 1955
Superfamily ROSTROSPIRACEA Schuchert and Le Vene, 1929
Family ATHYRIDAE Davidson, 1884
Subfamily ATHYRINAE Waagen, 1883
Genus ATHYRIS McCoy, 1884

Type species: *Terebratula concentrica* von Buch, 1834.

Remarks: This genus has been adequately discussed by a number of authors. Weller (1914, p. 464–465) presented a detailed diagnosis, and a brief summary has been given by Cooper (1944, p. 333). No details of the spires or jugum have been observed in the present material.

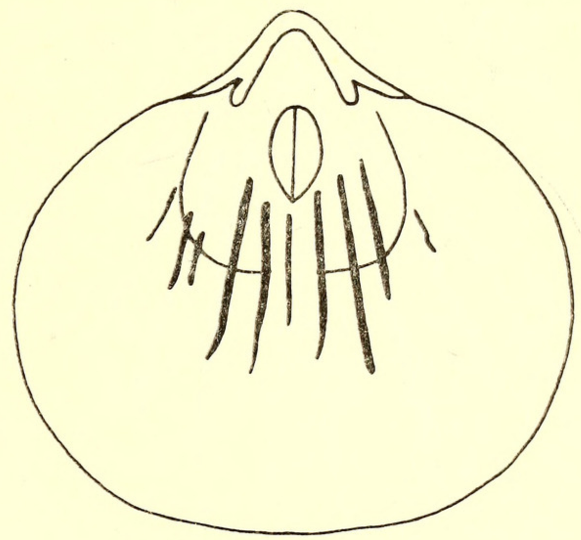

Fig. 6

Athyris wiragullensis n.sp.
Plate III, figs. 4–10

Diagnosis: Shell globular to sub-elliptical in shape, ornamented by closely spaced concentric lamellae, some of which are produced into regularly spaced outgrowths; these are less well developed on the brachial valve; fold and sinus obsolete, commissure rectimarginate. Pedicle valve interior possesses heart-shaped adductor scars and round to ovoid diductor scars; radial pallial markings prominent. Hinge-plate thickened laterally; brachial adductor scars long, narrow, separated by low myophragm; linear pallial markings well developed.

Description:

external. Pedicle valve is globular to sub-elliptical in outline, has a pronounced and slightly incurved umbo and is most convex at the mid-region of the valve. The lateral shoulders slope evenly to the rounded lateral margins. The hinge-line is curved and the palintropes, when viewed from the posterior of the shell, are barely concave. A faint sinus may occur on the anterior-most portion of the shell, but the commissure is usually rectimarginate. Concentric lamellae are closely spaced and have a density of 20 per 5 mm. towards the anterior margin of the valve. Wider, more prominent lamellae are regularly produced every 3 mm. No details of the foramen have been observed.

Brachial valve is less convex than the pedicle valve, is slightly more elliptical in shape and has a weaker umbo. Lateral shoulders slope evenly to the margins. The fold is obsolete to absent. The ornament is similar to that of the pedicle valve except that the large lamellose flanges are less regularly developed. Fifteen concentric lamellae per 5 mm. have been measured on the anterior of one brachial exterior.

internal. Pedicle valve. The pedicle cavity is short, well rounded, tapers posteriorly, becomes deeper anteriorly and in most cases has an undivided floor. Teeth are large, recurved and are supported on stout peg-like dental plates which are confined to the antero-lateral margins of the pedicle cavity. Transverse striations ornament the region behind the teeth, the anterior portion of the pedicle cavity and the inner margins of the dental lamellae. Adductor scars occur as a heart-shaped impression in front of the pedicle cavity and between the posterior of the diductor scars. They are most strongly impressed posteriorly and are divided by a median line which expands anteriorly into a narrow ridge and extends to the front of the diductor muscle field. Diductor scars are round to sub-ovoid, poorly impressed, have well rounded posterior margins and less well defined, broadly rounded anterior extremities. Faint linear vascula genitalia arise from the muscle field and project radially towards the margins of the valve (Text-fig. 6). In addition, an obsolete radial system of vascular markings has been observed around the margins of most pedicle valves. A small number of genital pits occurs in the postero-lateral regions of the valve.

Brachial valve. The hinge-plate has a round apical perforation and extensively thickened lateral margins which form the inner supports of the sockets and are also produced anteriorly to form crurae. Sockets are deeply impressed, divergent, are narrow towards the umbo, broaden antero-laterally and, with the exception

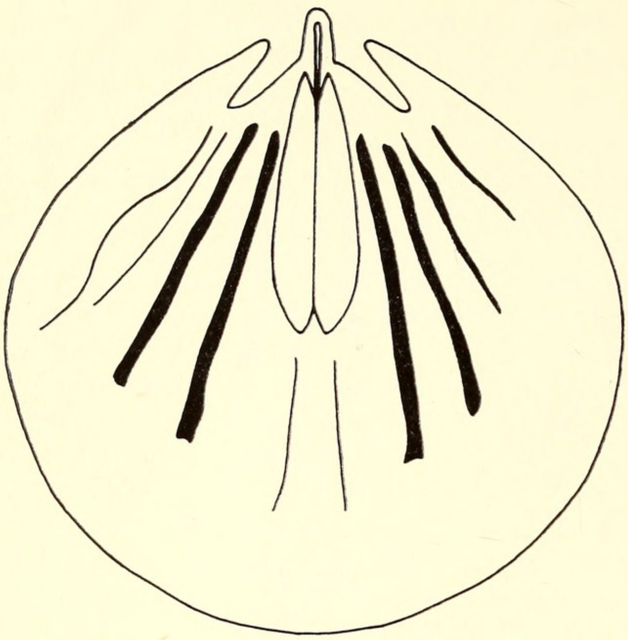

Fig. 7

of one longitudinal groove, have a rounded floor. Adductor scars are narrow, elongate and have well impressed and pointed posterior extremities. They expand medially, taper anteriorly, have rounded anterior margins and are divided by a narrow myophragm extending to the front of the muscle field. The myophragm commences from beneath the hinge-plate, is relatively strong posteriorly and weakens anteriorly. Two well defined pairs of divergent vascular trunks originate towards the postero-lateral margins of the adductor scars (Text-fig. 7). Faint vascular markings are present around the margins of the valve. One specimen exhibits an evenly crenulate furrow which, except for a divergence at one side, runs parallel with the growth lines. The regularity and the position of the furrow suggests that it was formed by the mantle, but its precise function is unknown (see Text-fig. 8).

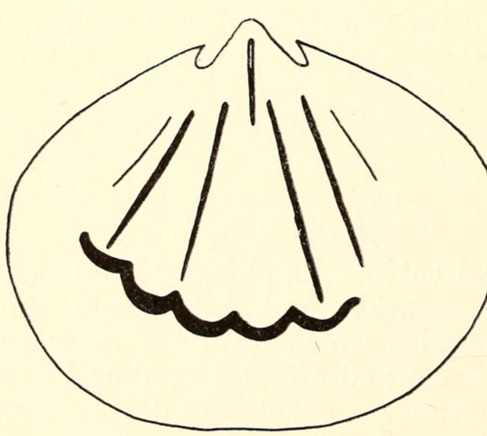

Fig. 8

Measurements (in mm.) :
Pedicle Valve

Specimen Number		Length	Width	Muscle Field Length	Muscle Field Width (median)
F.7006	..	23	27	8·5	11
F.7007	..	21	23·5	7·5	9
F.7008	..	21	26	—	—
F.7015	..	24	30 est.	10	14
F.6982b	..	16·5	20	6·5	8

Brachial Valve

Specimen Number		Length	Width	Muscle Field Length	Muscle Field Width (median)
F.7005	..	32	35	17	5·5
F.7009	..	20	24	—	—
F.7010	..	20·5	21·5	10	2
F.7011	..	22	25	—	—
F.7012	..	20·5	23	10·5	4

Remarks : The globose shape and almost total obsolescence of the fold and sinus distinguishes *Athyris wiragullensis* from most overseas Carboniferous *Athyris* species.

Certain specimens of *Athyris planosulcata* (Phillips) from Bolland, Derbyshire, England, described by Davidson (1857, p. 80, pl. 16, figs. 4, 5, 12) resemble this species in shape, style of ornament and the lack of a prominent fold and sinus. However, because the internal morphology of *A. planosulcata* is unknown a detailed comparison cannot be made.

A. membranacea de Koninck (1887, p. 89–90, pl. 19, figs. 1–4) has a similar ornament and profile to *A. wiragullensis,* but is distinguished by the possession of a uniplicate commissure and a marked sinus in the pedicle valve. The internal details of the Belgian species are unknown. *A. membranacea* occurs in the T_1 of Tournai, Belgium.

This species is named after the small railway siding, Wiragulla, situated a short distance from the L.234 locality.

Occurrence : *Athyris wiragullensis* is known from the type locality, L.234 Wiragulla, and the extension of this horizon 150 feet stratigraphically above L.235 Dungog.

Material : F.7005–F.7015, F.6982b. *Holotype* F.7005, *paratypes* F.7006, F.7008.

Superfamily SPIRIFERACEA Waagen, 1883
Family SPIRIFERIDAE King, 1846
Subfamily SPIRIFERINAE King, 1846
Genus SPIRIFER Sowerby, 1816

TYPE SPECIES : *Conchyliolithus Anomites striatus* Martin, 1793 (by suspension of the rules of the International Commission on Zoological Nomenclature).

Spirifer osbornei n.sp.

Plate III, figs. 11–15 ; Plate IV, figs. 1–11

DIAGNOSIS : Shell wider than long ; commissure weakly uniplicate ; ornament of 60–80 costae crossed by concentric growth lamellae. Radial micro-ornament completely obsolete. Pedicle valve strongly convex with high concave cardinal area ; adminicula are well developed in juveniles but are obscured by a posterior thickening in mature specimens ; the callus almost entirely fills the delthyrium ; the muscle field is sharply pointed in juveniles aad becomes large, sub-quadrate and impressed in later stages of growth. Brachial valve less convex with low inclined cardinal area ; distinct posterior and anterior adductor scars present in mature forms.

DESCRIPTION :

EXTERNAL. The shell is large, unequally biconvex, wider than long and triangular in shape. The greatest width occurs at the hinge-line or between the hinge and the mid-length of the shell. Cardinal extremities appear to be mucronate in juvenile growth stages but become pointed or bluntly rounded in adults. The commissure is weakly uniplicate. Costae are broadly rounded, widen anteriorly and are twice as wide as the separating sulci. The costae increase by bifurcation. On a shell 44 mm. wide and 30 mm. long there are from 60–80 costae around the commissure, their density being 10 per 10 mm. on the median anterior portion of the shell. Concentric growth lamellae are particularly well developed on the lateral extremities. No radial micro-ornament has been observed on well preserved shells.

Pedicle valve is most strongly convex around the umbo, which is incurved over the apex of the delthyrium. The slightly concave lateral shoulders slope steeply to the flattened postero-lateral margins. In older individuals the front of the valve becomes flattened and may form a trough-like flange, especially at the median sinus. The sinus originates at the umbo, where it is shallow and sub-quadrate in section, becomes broader and more rounded anteriorly and is extended into a shallow lingual extension at the front of the valve. In some cases it is weakly developed or almost absent. The cardinal area is high, most concave immediately beneath the umbo and is ornamented with horizontal growth striations. The delthyrium is narrow, triangular and extends to the tip of the umbo ; the delthyrial angle ranges between 40° and 50°. The pattern of sinal costation has not been observed.

Brachial valve is less convex than the pedicle valve. The umbo barely overhangs the hinge and the most convex region occurs at the mid-point of the valve. Lateral shoulders slope gently from the fold to the flattened postero-lateral margins. The fold is low, broadly rounded, commences at the umbo and extends to the anterior margin. A low inclined cardinal area occurs along the hinge-line.

INTERNAL. Pedicle valve. The muscle field is rectangular to elliptical in shape, deeply impressed posteriorly and is level with the floor of the valve anteriorly. Diductor scars are pointed or rounded at both ends and are ornamented with parallel longitudinal striations or with a prominent radiating dendritic pattern originating from a point at their mid-length. The lateral portions of the diductor scars are sometimes elevated above the remainder of the muscle field. Adductor scars are narrow, linear, occur between the diductor scars and are separated by a low myophragm. In some instances they expand into a broader platform on the mid-region of the muscle field. Traces of the curving adminicula occur around the postero-lateral margins of the muscle field. The dental lamellae are almost obscured by the heavy thickening on the umbonal region of the valve, run down the sides of the delthyrium and support strong divergent teeth at their extremities. A callus fills the apex of the delthyrium. An area of genital pits occurs adjacent to the muscle field and extends down the cardinal area. Vascula genitalia trunks are narrow, linear, radially directed and branch from the pitted area. A narrow trunk of vascula media arises from the base of the muscle field and runs towards the anterior margin.

Brachial valve. Two pairs of adductor scars are situated on the posterior portion of the fold and extend to the mid-point of the valve. Both pairs are divided by a sharp myophragm which arises a short distance in front of the umbo and runs to the termination of the muscle field. Posterior adductor scars are smooth, have a divided sub-circular shape, are rounded posteriorly and sharply pointed anteriorly. Two pallial trunks branch from the front of the posterior adductor scars. The anterior adductor scars are elongate, taper posteriorly, have wider, broadly rounded or straight anterior extremities and are slightly impressed into the shell. They are marked with a dendritic or striate pattern. Sockets are divergent, taper posteriorly and broaden anteriorly. Crural plates are wedge-shaped, support the inner margins of the sockets and extend into the umbo on either side of the cardinal process. In older individuals they reach the floor of the valve. The cardinal process is composed of 25–30 thin vertical lamellar plates arranged in a V-shaped pattern. Faint genital pits are present on the postero-lateral shoulders. From each region extremely narrow branching vascula genitalia trunks run to the lateral margins of the valve.

MEASUREMENTS (in mm.) :
Pedicle Valve

Specimen Number	Length	Width	Muscle Field	
			Length	Width
F.7038 ..	38	43	18	11
F.7039 ..	30	41	15	8
F.7040 ..	42	48 est.	16	10
F.7041 ..	30	42	16·5	11
F.7042 ..	—	43	14	10
F.7043 ..	—	52	22	18
F.7062 ..	45	59	—	—

Brachial Valve

Specimen Number	Length	Width	Muscle Field	
			Length	Width
F.7049 ..	38	46	15	8
F.7050 ..	29	44	—	—
F.7056 ..	25	36	10	4
F.7058 ..	35	48	16·5	9

VARIATION WITHIN THE SPECIES :

Pedicle valve. Variation occurring throughout the morphogeny of the species is shown by changes in the apical thickening, adminicula and the muscle field. In juveniles the muscle field is narrow, elongate, sharply pointed posteriorly, tapers anteriorly and is surrounded posteriorly by strong adminicula. No apical thickening is present. With increasing age the valve thickens along the hinge, especially at the umbo, and shell material encloses the dental lamellae and posterior portions of the adminicula. The muscle field becomes broader and more impressed, but still remains markedly elongate and pointed posteriorly. Mature forms, such as described above, show only traces of the adminicula on the postero-lateral margins of the muscle field because of the increased apical thickening and have larger and more deeply impressed muscle scars. Gerontic individuals are massively thickened posteriorly, show no traces of adminicula and have a somewhat less impressed, but larger sub-quadrate muscle field.

Brachial valve. Young specimens possess undifferentiated adductor scars in the form of the elongate sub-rectangular anterior pair. Mature individuals, as described above, have two clearly defined pairs of muscle scars. Crural plates are small in juveniles but become stronger in older specimens and extend to the floor of the valve on either side of the cardinal process.

REMARKS : The pattern of sinal costae has not been observed because of the poor preservation of the external moulds.

Spirifer osbornei is in many ways comparable with *S. lirellus* Cvancara (1958, p. 873–876, pl. 112, figs. 1–7, 11) from Barrington, N.S.W. It is distinguished from *S. lirellus* by the possession of a more massively thickened pedicle valve, a micro-ornament of concentric growth lines but apparently no radial lirae, a coarser costate ornament, a less pronounced umbo on the brachial valve and a weaker median sinus on the pedicle valve.

The external ornament of *S. osbornei* resembles that of *S. suavis* de Koninck, described by Vaughan (1915, p. 42, pl. 6, fig. 7), from the T_{2b} (Upper Tournaisian) of Belgium. However, because the internal details of the Belgian species are unknown a closer comparison cannot be made. The material used in the original description of *S. suavis* de Koninck (1887, p. 118, pl. 27, figs. 28–33) is distinguished from this species by its more pronounced fold and sinus, the stronger nature of the uniplicate commissure and its greater convexity. Demanet (1958) has recorded *S. suavis* from the Tn_{2a}, Tn_{2c}, Tn_{3b} and Tn_{3c} of Belgium.

Spirifer logani Hall, described by Weller (1914, p. 363–364, pl. 56, figs. 1–3 ; pl. 57, figs. 1–3) from the Keokuk Limestone, Mississippi Valley, U.S.A., is much larger, has a more convex brachial valve, a more pronounced fold and sinus, a lower pedicle valve with a less incurved umbo, is less thickened at the apex of the pedicle valve and has a wider delthyrium.

Spirifer cf. *S. liangchowensis* Chao, described by Maxwell (1954, p. 48–49, pl. 6, figs. 7–10) from the Neil's Creek Clastics, Mt. Morgan, Queensland, is comparable in internal details with *S. osbornei*. These similarities include the morphology of the adminicula and muscle field in the pedicle valve (in specimens of adult age of *S. osbornei*) ,and the median ridge in the brachial valve. However, *S.* cf. *S. liangchowensis* is distinguished by its more convex brachial valve, curved area on the pedicle valve and the possession of coarser flattened costae which increase by bifurcation and intercalation and are separated by narrow intercostal grooves.

Spirifer aff. *S. liangchowensis* Chao, described by Yanagida (1962, p. 96–98) from Akiyoshi, Japan, is distinguished by its coarser costae, which bifurcate up to three times along their length, and extremely slender adminicula. No mention of the morphogenetic variation in shell thickness has been made, but Yanagida noted that the apical portions of the pedicle valve are extremely thickened. The brachial valve of the Japanese form has not been described.

Spirifer liangchowensis Chao (1929, p. 6–9, pl. 1, figs. 1–7) is distinguished by its greater convexity and incipient fasciculate external ornament.

This species is named after the late G. D. Osborne, one of the early geological workers in the Hunter Valley, N.S.W.

OCCURRENCE : *Spirifer osbornei* is known from L.234 Wiragulla, the type locality, and the extension of this horizon, 150 feet stratigraphically above L.235 Dungog.

MATERIAL : F.7038–F.7082, F.7020b. *Holotype* F.7038, *paratypes* F.7020b, F.7041, F.7043, F.7044, F.7047, F.7049, F.7062, F.7070.

Subfamily PHRICODOTHYRINAE Caster, 1939

Genus KITAKAMITHYRIS Minato, 1951

TYPE SPECIES : *Kitakamithyris tyoanjiensis* (Minato), 1951.

REMARKS : This genus has been adequately discussed by Maxwell (1961) and Roberts (1965).

Kitakamithyris sp.

Plate III, figs. 1–3

DESCRIPTION :

EXTERNAL. The shell is sub-elliptical in shape, equally biconvex and has well rounded cardinal margins. It is ornamented with concentric lamellae bearing coarse biramous spine bases which have a density of 5 per 5 mm. at the anterior margin of the shell. There are approximately 8 concentric lamellae per 10 mm. on the same region of the shell. The lamellae are marked with concentric growth lines.

Pedicle valve is wider than long and is most convex at the tip of the incurved umbo. Lateral shoulders slope evenly from the apex. The median sinus is completely obsolete. No details of the delthyrium have been observed.

Brachial valve has almost the same convexity as the pedicle valve. The umbo is blunt and barely incurved over the cardinal area. The region of greatest convexity occurs immediately in front of the umbo. Lateral slopes are flatter than on the pedicle valve and the fold is almost entirely obsolete.

INTERNAL. Pedicle valve. The muscle field is divided by a prominent median septum extending almost half the length of the valve. The septum is triangular in cross section, highest near the umbo and becomes broader and lower anteriorly. Elongate adductor scars are situated on the steep sides of the median septum. Diductor scars are pointed posteriorly, expand anteriorly as far as the tips of the adminicula and then curve rapidly inwards, terminating at the tip of the median septum. They are slightly impressed into the shell and are marked by regular or wavy longitudinal striations. Adminicula extend three-quarters the length of the median septum, or one-third the length of the valve, and diverge at 25° to 30°. Internal

MEASUREMENTS (in mm.) :
Pedicle Valve

Specimen Number	Length	Width	Muscle Field Length	Muscle Field Width	Length Median Septum	Angle of divergence of Dental Lamellae
F.7017 . .	30	36	13	8	15·5	25°
F.7016 . .	20	30	13	7	13	30°

Brachial valves are fragmentary and cannot be measured.

ornament consists of longitudinal striae having a density of 10 per 5 mm. at the anterior margin. In addition, an area of irregular crenulations and incipient genital pits occurs adjacent to the muscle field.

Brachial valve. Adductor scars are elongate and narrow for their entire length and extend approximately two-thirds the length of the valve. A low knife-like myophragm arises from a small callus situated a short distance in front of the umbo and extends to the anterior margin of the muscle field. Sockets are shallow divergent depressions and are supported on their inner margins by large crural plates. The crural plates buttress the sides of the cardinal process and on some specimens reach the floor of the valve. The V-shaped cardinal process is composed of approximately 20 thin vertical lamellar plates. Internal ornament consists of fine radiating striae.

Remarks: Too few specimens are available to warrant the designation of a new specific name. However, this material is readily distinguishable from all previously described eastern Australian *Kitakamithyris* species.

K. rouchelensis (Campbell) (1955, p. 380–381, pl. 18, figs. 16–17) from Rouchel Brook, N.S.W., has a similar shape and ornament, but is distinguished by the possession of shorter adminicula and a longer median septum in the pedicle valve and the presence of a fold and sinus on the exterior of the shell.

K. uniplicata (Campbell) (1955, p. 377–379, pl. 18, figs. 1–9) is characterized by a more transverse shape, the presence of a fold and sinus and has a greater number of lamellae and spines ornamenting the shell. In the interior of the pedicle valve the median septum and adminicula are less equal in length. *K. uniplicata* has been collected from L.35 Babbinboon, L.233 Trevallyn, L.53 Greenhills and Glen William, Clarencetown.

K. triseptata (Campbell) (1955, p. 379–380, pl. 18, figs. 10–15) from Babbinboon, Trevallyn and Greenhills, has shorter, more widely divergent adminicula and a longer median septum in the pedicle valve, a shorter myophragm in the brachial valve and a greater density of spine bases on the external ornament.

K. campbelli (Cvancara) (1958, p. 870–872, pl. 111, figs. 14–20, 23, 25) from Barrington, N.S.W., has a weak fold and sinus, a slightly denser spinose ornament, a longer median septum in the pedicle valve and sub-parallel sockets in the brachial valve.

K. globosa Maxwell (1961, p. 101, pl. 20, figs. 25–26) from Old Cannindah, Queensland, is distinguished by its more globular shape, more closely spaced concentric lamellae and greater biconvexity.

Occurrence: *Kitakamithyris* sp. is known only from L.234 Wiragulla.

Material: F.7017–F.7021.

Suborder TEREBRATULOIDEA Muir-Wood, 1955

Superfamily TEREBRATULACEA Waagen, 1883

Family DIELASMATIDAE Schuchert and Le Vene, 1929

Genus BALANOCONCHA Campbell, 1957

Type species: *Balanoconcha elliptica* Campbell, 1957.

Remarks: Campbell distinguished *Balanoconcha* from *Dielasma* King by the absence of dental lamellae. He remarked in a footnote (p. 86) that work by Stehli (1956) had confirmed this distinction.

Balanoconcha elliptica Campbell

Plate V, figs. 12–18

Balanoconcha elliptica Campbell, 1957, J. Paleont., 31, p. 86–88, pl. 15, figs. 13–15.

Remarks: Except for the absence of a median ridge in some pedicle interiors and a slight difference in the distribution and density of the punctae, the L.235 Dungog specimens are identical with the type material.

Punctae are less dense in this material, approximately 300 punctae occurring per square mm. on the median portion of the shell compared with 400–450 per square mm. on the same region of the type material. The punctae are always oriented in regular wavy concentric rows compared with their usual irregular orientation in the Babbinboon specimens. Campbell noted that only some areas in the type material exhibited a regular linear arrangement of punctae.

Pallial markings are more strongly defined in the brachial valve, but this feature may vary with differing preservations.

Sockets are divergent, well rounded, pointed posteriorly, broaden antero-laterally and are supported on their inner margins by strong socket ridges. These were not previously described.

Occurrence: *Balanoconcha elliptica* is known from L.35 Babbinboon, the type locality, L.235

Dungog and an extension of L.234 Wiragulla 150 feet stratigraphically above L.235.

MATERIAL: F.7083–F.7095, F.7138.

Pelecypoda

Subfamily STREBLOCHONDRINAE Newell, 1937

Genus STREBLOPTERIA McCoy, 1851

TYPE SPECIES: *Streblopteria laevigata* (McCoy).

REMARKS: Newell (1937, p. 87–88) presented a definition of the genus and attempted to unravel McCoy's original description. The genus at present remains in a confused state and the author is unable, through lack of suitable material, to add further to Newell's remarks.

Three features of this material are not in exact accordance with Newell's diagnosis. Firstly, the anterior auricle is longer than the posterior auricle; secondly, the anterior auricular sulcus on the left valve is not especially prominent; and thirdly, the valves are slightly less gibbous than those of the type species. In spite of these differences, reference to *Streblopteria* is supported by the lack of body ornament, the morphology of the posterior auricle and the shape of the shell.

Streblopteria sp.

Plate V, figs. 9–11

DESCRIPTION:

EXTERNAL. The shell is smooth, acline and has valves of almost equal convexity. The hinge-line is approximately half as long as the shell. A moderately defined anterior umbonal fold contrasts with the weak posterior umbonal fold. The umbo is pointed and projects a short distance over the hinge-line. The posterior auricle is a continuation of the shell margin, is well differentiated from the body of the shell on the right valve, but is less well defined on the left valve. It joins the hinge at an angle of approximately 120° and is half as long as the anterior auricle. The anterior auricle is well defined and has a rounded extremity. On the right valve it is convex, separated from the umbonal shoulder by a deep narrow groove and is ornamented with strongly defined radiating costae crossed by regularly spaced concentric ribs. The byssal notch is marked by closely spaced growth lines. On the left valve the anterior auricle is flattened and lies well below the level of the umbonal fold.

INTERNAL details are very poorly preserved, but one specimen exhibits a ridge-like thickening along the inner margin of the posterior auricle.

MEASUREMENTS (in mm.):

Specimen Number		Length	Height	Hinge Length
F.7119	Right valve ..	21	—	11
F.7120	Left valve ..	25	24·5	12

REMARKS: Little can be said on the affinities of *Streblopteria* sp. because of the poor preservation of the available material. This species may be similar to the specimen from near Gresford referred to *Aviculopecten ptychotis* McCoy by Etheridge and Dun (1906, pl. 15, fig. 7), but the absence of an adequate description of this form renders a more detailed comparison impossible. Etheridge and Dun's reference of the Gresford specimen to *A. ptychotis* McCoy is most likely invalid. Newell (1937, p. 115) questionably referred the latter specimen to the genus *Streblochondria*.

OCCURRENCE: *Streblopteria* sp. has been collected from L.235 Dungog.

MATERIAL: F.7118–F.7121.

Family AVICULOPECTINIDAE Etheridge Jr., 1906 emend. Newell, 1937

Subfamily AVICULOPECTININAE Meek and Hayden, 1846 emend. Newell, 1937

Genus AVICULOPECTEN McCoy, 1851 emend. Newell, 1937

TYPE SPECIES: *Aviculopecten planoradiatus* McCoy, 1851, by subsequent designation by Hind (1903).

REMARKS: A detailed account of the morphology and affinities of the genus have been presented by Newell (1937, p. 43–46).

Aviculopecten sp.

Plate V, figs. 1–5

DESCRIPTION:

Left valve is small, acline, higher than long, sub-rectangular in shape and moderately convex. The umbo is narrow, well rounded and projects a short distance over the hinge-line. The hinge-line is straight and approximately two-thirds the length of the shell. A well defined auricular sulcus separates the anterior auricle from the prominent anterior umbonal fold. The auricles are sub-equal. The anterior auricle is triangular, broadly convex and has a rounded anterior extremity. The posterior auricle is weakly differentiated from the posterior umbonal fold and becomes flattened posteriorly. In some cases the postero-dorsal margin of the posterior auricle appears to be extended into a slight projection, but it usually runs at right angles to the hinge. The external ornament consists of narrow rounded costae distributed in three orders. The costae increase by regular intercalation and there are from 40–48 costae of all orders present on the body of a mature valve. They are crossed by regular closely spaced concentric growth lamellae which are particularly prominent on the anterior auricle. The anterior and posterior auricles are both ornamented with six well defined costae. Internal details of the valve are obscured by the impression of the external ornament.

MEASUREMENTS (in mm.) :
Left valve

Specimen Number	Length	Height	Length of Hinge
F.7109a	13	14	—
F.7110	18	16	10
F.7112	14	16	—
F.7116	16	15	9 est.

REMARKS : *Aviculopecten lyelli* Dawson, figured by Bell (1929, pl. 27, figs. 9–15, pl. 28, figs. 1–3), has a comparable shape and style of ornament to that of *Aviculopecten* sp. The Australian species is distinguished by its smaller size and smaller and more convex anterior auricle on the left valve. *A. lyelli* occurs in the Lower Windsor Series (Upper Mississippian) of the Horton-Windsor district, Nova Scotia.

The poor preservation of the Dungog specimens and the lack of right valves prevents the making of further comparisons.

OCCURRENCE : *Aviculopecten* sp. has been collected from L.235 Dungog and an extension of the L.234 Wiragulla horizon, 150 feet stratigraphically above L.235.

MATERIAL : F.7109–F.7117.

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Explanation of Plates

Plate I

Figs. 1–10. *Chonetes cangonensis* n.sp.

1*a*. ×4. F.7097. External mould of pedicle valve; paratype.
1*b*. ×4. F.7097. Rubber cast of pedicle valve exterior; paratype.
2*a*. ×4. F.7096b. Rubber cast of pedicle valve exterior; paratype.
2*b*. ×4. F.7096b. External mould of pedicle valve; paratype.
3. ×4. F.7107a. External mould of brachial valve.
4. ×4. F.7107b. Internal mould of pedicle valve.
5. ×4. F.7102. Internal mould of pedicle valve; paratype.
6. ×4. F.7107c. Internal mould of pedicle valve.
7. ×4. F.7098a. Rubber cast of brachial exterior.
8. ×4. F.7096c. Internal mould of brachial valve.
9. ×4. F.7098b. Internal mould of brachial valve.
10*a*. ×4. F.7096a. Rubber cast of brachial valve interior; holotype.
10*b*. ×4. F.7096a. Internal mould of brachial valve; holotype.

Figs. 11–19. *Gigantoproductus tenuirugosus* n.sp.

11. ×2. F.7135. External mould of brachial valve.
12. ×2. F.7134. External mould of brachial valve.
13. ×1·5. F.7136. External mould of brachial valve.
14. ×1. F.7127b. Rubber cast of pedicle valve exterior; paratype.
15. ×1. F.7122. Rubber cast of pedicle valve exterior showing the row of hinge spines; holotype.
16. ×1. F.7137. Internal mould of pedicle valve; some shell material still remains.
17. ×1. F.7123b. Internal mould of pedicle valve; some shell material still remains.
18. ×1. F.7127c. Rubber cast of pedicle valve exterior showing the costellate ornament.
19. ×1. F.7132a. Rubber cast of brachial valve interior; paratype.

Plate II

Figs. 1–18. *Inflatia elegans* n.sp.

1*a*. ×1. F.6984. Rubber cast of brachial valve interior.
1*b*. ×1. F.6984. Internal mould of brachial valve.
2*a*. ×1. F.6985. Rubber cast of brachial valve interior ; holotype.
2*b*. ×1. F.6985. Internal mould of brachial valve ; holotype.
3*a*. ×1. F.6989. Rubber cast of brachial valve interior ; paratype.
3*b*. ×1. F.6989. Internal mould of brachial valve ; paratype.
4. ×1. F.6986. Rubber cast of brachial valve interior.
5. ×1. F.6999. Internal mould of brachial valve.
6. ×1. F.6987. Rubber cast of brachial valve interior.
7. ×1. F.6982*a*. Rubber cast of brachial valve interior showing long trail ; paratype.
8. ×6. F.6960. Rubber cast of the external face of the cardinal process.
9. ×1. F.6955. Rubber cast of pedicle valve exterior.
10. ×1. F.6959. Rubber cast of pedicle valve exterior ; note the spines along the hinge.
11. ×1. F.6957*a*, *b*. Rubber cast of two young pedicle exteriors.
12. ×1. F.6978. External mould of brachial valve.
13. ×1. F.6977. External mould of brachial valve.
14. ×1. F.6981. External mould of brachial valve ; note the flange on the anterior margin of the trail ; paratype.
15. ×1. F.6980. Rubber cast of brachial valve exterior ; paratype.
16*a*. ×1. F.6943. Internal mould of pedicle valve viewed from the side ; paratype.
16*b*. ×1. F.6943. Internal mould of same valve.
17. ×1. F.6956. Rubber cast of pedicle valve exterior ; paratype.
18. ×1. F.6941. Internal mould of pedicle valve.

Plate III

Figs. 1–3. *Kitakamithyris* sp.

1. ×1. F.7017. Internal mould of pedicle valve.
2. ×1·5. F.7016. Internal mould of pedicle valve.
3. ×1·5. F.7018. Internal mould of brachial valve.

Figs. 4–10. *Athyris wiragullensis* n.sp.

4*a*. ×1·5. F.7007. Internal mould of pedicle valve : paratype.
4*b*. ×1·5. F.7007. Rubber cast of pedicle valve exterior ; paratype.
5*a*. ×2. F.6982*b*. Internal mould of pedicle valve.
5*b*. ×2. F.6982*b*. Rubber cast of brachial valve exterior.
6. ×1·5. F.7006. Internal mould of pedicle valve ; paratype.
7. ×1·5. F.7010. Internal mould of brachial valve.
8. ×1·5. F.7009. Internal mould of brachial valve ; note the crenulate pallial mark.
9. ×1. F.7005. Internal mould of brachial valve ; holotype ; note the linear pallial trunks.
10. ×1·5. F.7012. Internal mould of brachial valve.

Figs. 11–15. *Spirifer osbornei* n.sp.

11. ×1. F.7071*a*. Rubber cast of cardinal regions of both valves.
12. ×1. F.7069. Rubber cast of pedicle valve exterior.
13. ×1. F.7062. Rubber cast of pedicle valve exterior ; old specimen ; paratype.
14. ×1. F.7070. Rubber cast of brachial valve exterior ; paratype.
15. ×1. F.7041. Rubber cast of pedicle valve exterior ; paratype.

Plate IV

Figs. 1–11. *Spirifer osbornei* n.sp.

1.	×1.	F.7056.	Internal mould of brachial valve.
2.	×1.	F.7049.	Internal mould of brachial valve ; older specimen showing two pairs of adductor scars ; paratype.
3.	×2.	F.7020*b*.	Internal mould of juvenile pedicle valve ; note the well-defined dental lamellae and pointed muscle field ; paratype.
4.	×2.	F.7048.	Internal mould of juvenile pedicle valve.
5*a*.	×1.	F.7041.	Internal mould of slightly older pedicle valve showing the pointed muscle field and slightly shorter dental lamellae ; paratype.
5*b*.	×1.	F.7041.	Rubber cast of same pedicle interior ; paratype.
6.	×1.	F.7039.	Internal mould of pedicle valve.
7.	×1.	F.7042.	Internal mould of pedicle valve ; this specimen is older than both numbers 5 and 6, has a more bluntly shaped muscle field and shorter dental lamellae.
8*a*.	×1.	F.7040.	Internal mould of mature pedicle valve ; note the deeply impressed muscle field and the absence of dental lamellae.
8*b*.	×1.	F.7040.	Rubber cast of the same pedicle valve.
9*a*.	×1.	F.7038.	Internal mould of mature pedicle valve showing well-defined pallial trunks and deeply impressed muscle field ; holotype.
9*b*.	×1.	F.7038.	Rubber cast of the same valve ; holotype.
10*a*.	×1.	F.7043.	Internal mould of older pedicle valve showing very broad muscle field ; paratype.
10*b*.	×1.	F.7043.	Rubber cast of same pedicle valve ; note the extensive apical thickening ; paratype.
11.	×1.	F.7044.	Internal mould of pedicle valve of old or gerontic specimen ; note the thickened apical region ; paratype.

Plate V

Figs. 1–5. *Aviculopecten* sp.

1.	×2.	F.7110.	Internal mould of left valve.
2.	×2.	F.7116.	Internal mould of left valve.
3*a*.	×2.	F.7109*a*.	Internal mould of left valve.
3*b*.	×2.	F.7109*a*.	Rubber cast of exterior of left valve.
4.	×2.	F.7109*b*.	Internal mould of left valve.
5.	×2.	F.7114.	Internal mould of left valve.

Figs. 6–8. *Echinoconchus gradatus* Campbell.

6*a*.	×2.	F.7022.	External mould of brachial valve.
6*b*.	×2.	F.7022.	Rubber cast of exterior of brachial valve ; note the rows of spines near the hinge.
6*c*.	×2.	F.7022.	Rubber cast of brachial valve interior.
6*d*.	×2.	F.7022.	Internal mould of brachial valve.
7.	×2.	F.7028.	External mould of brachial valve.
8*a*.	×2.	F.7035.	Rubber cast of pedicle valve exterior.
8*b*.	×2.	F.7035.	Internal mould of pedicle valve.

Figs. 9–11. *Streblopteria* sp.

9.	×1·5.	F.7118.	Internal mould of left valve.
10*a*.	×1·5.	F.7119.	Rubber cast of exterior of right valve.
10*b*.	×1·5.	F.7119.	Internal mould of right valve.
11.	×1·5.	F.7120.	Rubber cast of left valve.

Figs. 12–18. *Balanoconcha elliptica* Campbell.

12.	×2.	F.7138.	Exterior of pedicle valve.
13.	×2.	F.7083.	Internal mould of pedicle valve.
14.	×2.	F.7089*a*.	Internal mould of pedicle valve.
15.	×2.	F.7089*b*.	Rubber cast of brachial valve exterior.
16.	×2.	F.7084.	Internal mould of brachial valve ; note the well developed pallial trunks.
17.	×2.	F.7083.	Internal mould of brachial valve.
18.	×2.	F.7085.	Internal mould of brachial valve.

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