PROCEEDINGS

OF THE

Royal Society of Victoria.

VOL. L. (New Series).

PARTS I. and II.

Edited under the Authority of the Council.

ISSUED 29th December, 1937, and 23rd MAY, 1938.

(*Containing Papers read before the Society during the months of January to December, 1937.*)

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ROYAL SOCIETY'S HALL,
VICTORIA STREET, MELBOURNE, C.1.

H. J. Green, Government Printer, Melbourne.

1938.

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PART I.

PART II.

H. J. GREEN, Government Printer, Melbourne.

[Proc. Roy. Soc. Victoria, 50 (N.S.), Pt. I., 1937.]

Art. I.—*On some Stromatoporoids from Griffith's Quarry, Loyola, Victoria.*

By ELIZABETH A. RIPPER, M.Sc., Ph.D.

[Read 8th April, 1937; issued separately, 29th December, 1937.]

Contents.

Introduction.

This paper deals with a small collection of stromatoporoids from Griffith's Quarry, Loyola, made by the writer in 1933, and now in the museum of the Department of Geology, University of Melbourne. These stromatoporoids are associated with a rich coral fauna, which has been described by F. Chapman (1914) and placed by him in the Yeringian, being correlated with the Wenlock of Great Britain.

Description of Species.

Family ACTINOSTROMATIDAE Nicholson, 1886 (emend. Stechow, 1922).

Clathrodictyon Nicholson and Murie, 1878.

1878. *Clathrodictyon* Nicholson and Murie, Journ. Linn, Soc., xiv., p. 220.

1886. *Clathrodictyon* Nicholson, Mon. Brit. Strom., Gen. Introd., p. 77.

1936. *Clathrodictyon,* Parks, Univ. Toronto Studies, Geol. Ser., 39, p. 10.

Stromatoporoids in which the coenosteum is usually expanded or laminar, with a basal epitheca and a small area of attachment; built up of horizontal laminae and radial pillars which are confined to one interlaminar space, and which may be formed by the downward inflection of the laminae. Astrorhizae may be present. Skeletal fibre not minutely porous.

Genotype: *Cl. vesiculosum* Nich. & Murie, 1878, Journ. Linn. Soc., xiv., p. 220, pl. II., figs. 11-13. 1889, Nicholson, Mon. Brit. Strom., p. 147, pl. XVII., figs. 10-13; pl. XVIII., fig. 12. Silurian of Europe, North America. *Cl. confertum* Nich. (Mon. Brit. Strom., p. 154, pl. XVIII., figs. 13, 14, 1889) is probably identical with *Cl. vesiculosum.*

Clathrodictyon regulare (von Rosen).

(Pl. I., figs. 1, 2.)

1867. *Stromatopora regularis* von Rosen, "Ueber die Natur der Stromatoporen," etc., p. 74, pl. ix., figs 1-4.
1887. *Clathrodictyon regulare* Nicholson, Ann, Mag. Nat. Hist., ser. 5, xix., p. 10, pl. ii., figs. 5–6.
1888. *Clathrodictyon regulare* Nicholson, Mon. Brit. Strom., p. 155, pl. xviii., figs. 8-11A.
1908. *Clathrodictyon regulare* Vinassa de Regny, Pal. italica, xiv., p. 182, pl. xxi. (1), figs. 18–20.
1915. *Clathrodictyon regulare* Boehnke, Palaeontographica, 61, p. 168, text-fig. 12.
1934. *Clathrodictyon regulare* Le Maitre, Mém. Soc. Géol. du Nord, xii., p. 39; p. 185, pl. xii., figs. 1-6.

Coenosteum massive or laminar; horizontal laminae and vertical pillars distinct. Laminae 3-5 in 1 mm., pillars 3-4 in 1 mm.

Vertical sections show the skeletal mesh to be rather regular. The horizontal laminae are of a uniform, relatively great thickness (0.1 mm.) throughout the coenosteum, and in some examples are flexed at regular intervals, forming domes. In most examples, however, the laminae are quite uninflected, apart from variations in course consequent on the exterior form of the coenosteum. The vertical pillars are stout, of approximately the same thickness as the horizontal laminae, regularly spaced, and complete, i.e., they traverse the whole space between one lamina and the next.

In tangential sections the vertical pillars appear as isolated rounded cross-sections. Areas of dark-coloured material, at present structureless, mark the position of the horizontal laminae. Astrorhizae are rare and poorly developed, and are more readily distinguished in vertical sections, which sometimes show cross-sections of the horizontal canals. There is apparently no vertical grouping of the astrorhizal systems.

The skeletal structure of this form places it in the group of the species of *Clathrodictyon* containing *C. regulare* and other forms in which the horizontal and vertical elements of the skeletal mesh are sharply differentiated. It is identical with *C. regulare* in the regularity of the mesh, and in the isolation of the radial pillars as seen in vertical section. A very similar form occurring in the Lilydale limestone, of Yeringian age, described under the name of *C. regulare* var. *cylindrifera* Ripper (1933), differs, however, in some important characters. The skeletal mesh is of the same regular type, but the astrorhizae are rare and poorly developed in comparison with the highly organized superimposed systems in the Lilydale form, and the laminae are as a result more usually straight, and but rarely undulating or bent into regular domes. The vertical pillars are more usually isolated so that the "hexactinellid" structure as seen in tangential sections is less perfect than in the Lilydale form. The coenosteum is in addition more usually laminar, and is of small size, while that of *C. regulare* var. *cylindrifera* tends to become massive. The median dark line of the horizontal laminae described by Nicholson has not been observed, but this may be due to the mode of preservation. The laminae also appear to be thicker and less crumpled than in the British form.

Horizon.—Yeringian.

Locality.—Griffith's Quarry, Allot. 131, Loyola.

Figured specimen.—Coll. Dept. of Geology, Univ. of Melbourne, Reg. No. 1599.

Clathrodictyon aff. chapmani Ripper.

(Pl. I., figs. 3, 4.)

1933. *Clathrodictyon chapmani* Ripper, Proc. Roy. Soc. Victoria, xlv. (II.), p. 159, figs. 4, 6c, 6d.

Coenosteum massive, irregularly laminated, composed of well defined horizontal laminae connected by vertical pillars which traverse one interspace only. Laminae 6 in 1 mm., pillars 5 in 1 mm., rather irregularly spaced.

All specimens are somewhat recrystallized, so that the finer details of structure are obliterated. In vertical section the laminae are seen to be straight and fairly regular. They are, however, of variable thickness, some reaching a thickness of 0.1 mm. As these thicker laminae occur in groups at regular intervals (usually of 2 or 3 mm.) and appear, on account of their greater thickness, to be more crowded than the thinner laminae that separate them, the coenosteum has a banded aspect which is well seen on polished surfaces. There is usually no break in the growth of the coenosteum at these points, but some vertical sections show that the lowermost lamina of such a group rests on an irregular surface, suggesting that deposition has been resumed after interruption. The vertical pillars are straight, slender, and usually traverse the whole interlaminar space. They are usually independent, but may be connected by irregular horizontal processes where the interlaminar spaces are wider.

Tangential sections passing through a lamina show the vertical pillars to be connected by processes of equal width, so that an irregular reticulate mesh is developed, in which the individual pillars cannot readily be distinguished. Astrorhizae are rare and poorly developed, appearing in tangential section as groups of highly inclined wall-less canals radiating from a common centre. The canals are inconspicuous in vertical section, where they are recognizable as rounded cross-sections of somewhat greater diameter than the normal interlaminar space.

Tangential sections of this form resemble very closely those of *C. chapmani* Ripper, in which the vertical pillars are similarly connected by processes of equal diameter, giving rise to a characteristic mesh. This is also seen in the otherwise distinct form *C. drummondense* Parks. In vertical section the pillars are sometimes seen to be connected by irregular horizontal processes in the interlaminar spaces but this feature is not nearly as constant as in *C. chapmani*, and the pillars are usually more complete. The horizontal laminae are in addition thicker and more crowded than in *C. chapmani*, where there are but two or three in 1 mm. The astrorhizae are comparatively poorly developed, and the canals, though steeply inclined as in the Lilydale species, are apparently not grouped into the vertical systems which are so characteristic of vertical sections of *C. chapmani*. In view of these differences, therefore, it is advisable, while recognizing its affinities with *C. chapmani*, to regard this form as being distinct.

Horizon.—Yeringian.

Locality.—Griffith's Quarry, Allot. 131, Loyola.

Figured specimen.—Coll. Dept. of Geology, Univ. of Melbourne, Reg. No. 1598.

Family STROMATOPORIDAE Nicholson, 1886.

Stromatopora Goldfuss, 1826.

STROMATOPORA TYPICA von Rosen.

1867. *Stromatopora typica* von Rosen, "Ueber die Natur der Stromatoporen," etc., p. 58, pl. i., figs. 1-3; pl. ii., fig. 1.

1886-1891. *Stromatopora typica* Nicholson, Mon. Brit. Strom., Gen. Introd., pl. i., fig. 3; pl. v., figs. 14, 15; p. 169, pl. xxi., figs. 4-11; pl. xxii., figs. 1, 2.

1915. *Stromatopora typica* Boehnke, Palaeontographica, 61, p. 181, pl. xvii., fig. 7, text-figs. 32, 33.

1929. *Stromatopora typica* Yavorsky, Bull, Com. Géol. Leningrad, xlviii. (1), p. 95, pl. x., figs. 2-7.

1934. *Stromatopora typica* Le Maitre, Mém. Soc. Géol. du Nord, xii., p. 193, pl. xv., fig. 4.

Coenosteum massive, latilaminar, composed of well defined relatively thick radial pillars, 4-6 in 1 mm., and irregularly distributed horizontal laminae.

The available specimens are all fragmentary and much recrystallized, so that the finer details of structure are completely obliterated, and it is impossible to give satisfactory figures. The pillars, which are about 0.1 mm. thick, are the most conspicuous features of vertical sections; they are usually parallel, separated by interspaces equal to their own width, and in better preserved parts of the sections show the porous structure characteristics of the genus. The latilaminae, which are straight or gently curved, and 2-3 mm. wide, are each made up of six or seven horizontal laminae, which are inconspicuous and usually very thin.

Tangential sections show the cut ends of the radial pillars, which are united by processes of almost equal diameter, so that a mesh of the vermiculate type seen in *Stromatopora* is the result. Astrorhizae are abundant and well-developed, the horizontal canals being much branched. The centres of the systems are 2 or 3 mm. apart.

These specimens are in a very poor state of preservation, but are clearly identical with some examples from Wenlock limestone of Great Britain (Nicholson Collection, Brit. Mus. Nat. Hist. Reg. Nos. P5563, P5559, P5561), referred by Nicholson to *Str. typica* von Rosen. This form, while being best placed in the same species, is, however, distinct in some respects from the *S. typica* occurring in Gotland and Esthonia, since the radial pillars are far more distinct, and the laminae are not so thickened. These differences suggest that the British form, with which the Victorian form has been identified, and which may also be associated with the Continental form, e.g., at Lilleshall Quarry, Wenlock Edge, is the less advanced, since the merging of the pillars and laminae into a reticulate skeletal mesh is not so complete, and the form therefore resembles some species of *Syringostroma*, coming particularly close to *S. barretti* Girty. It also has characters in common with *Str. antiqua* Nich. & Mur. of the Niagaran of Canada

Horizon.—Yeringian.

Locality.—Griffith's Quarry, Allot. 131, Loyola.

STROMATOPORA BÜCHELIENSIS (Bargatzky).

1881. *Caunopora bücheliensis* Bargatzky, "Die Stromatoporen des rheinischen Devons," p. 62.

(For further synonymy see Ripper, Proc. Roy. Soc. Vic. xlix., (II.), 1937.)

Coenosteum massive, built up of conspicuous radial pillars, 5 or 6 in 2 mm., which are connected at intervals by horizontal processes of similar breadth. These are rarely united to form laminae. Skeletal fibre porous; skeletal mesh reticulate.

The radial pillars are stout, up to 0.3 mm. broad, and separated by interspaces rather narrower than their diameter. In better preserved parts of the sections the minutely porous structure of the skeletal fibre can be seen, but in general the preservation is very indifferent, so that it is impossible to distinguish finer details of structure, and figures cannot be given. The very slender horizontal processes connecting the radial pillars, called "tabulae" by Nicholson, who considered the interspace to be zooidal tubes, are thus not discernible in vertical sections. Broader processes of essentially the same nature as the pillars are, however, of relatively frequent occurrence.

Tangential sections show a completely reticulate mesh in which the radial pillars are not distinguishable as separate skeletal elements, as they are connected by processes of equal breadth. The mesh is very regular, but is interrupted by the abundant astrorhizal canals. These are relatively short, sometimes branching, and are grouped into indefinite systems. "Caunopora" tubes are not present in the only available specimen, and the skeletal mesh consequently is very similar to that of typical British and European examples of the species. It is in this respect distinct from that of examples from Lilydale, where the species is abundant, since these commonly contain numerous large "Caunopora" tubes, and the skeletal mesh of the coenosteum becomes as a consequence very distorted.

The only other Victorian form with which this species may be confused is *S. lilydalensis* Ripper, in which the skeletal mesh is similarly dominated by the radial pillars. In *S. lilydalensis*, however, the radial pillars are somewhat more crowded and they tend to become divergent, as opposed to their parallel habit in *S. bücheliensis*, so that vertical sections of the Lilydale form are readily distinguishable.

Horizon.—Yeringian.

Locality.—Griffith's Quarry, Allot. 131, Loyola.

Remarks on the Stromatoporoid Fauna.

The stromatoporoid fauna of this limestone is rather poor in species, a collection of 17 specimens yielding only four forms. The difference between it and the Lilydale fauna, which is also placed in the Yeringian, may be due to differences in facies, since the small size and laminar and encrusting habit of many of the coenostea at Loyola suggest that they grew under unfavorable conditions. Of the four species here prescribed, three have already been described from European localities:—

Species.	Horizon.	Localities.
Clathrodictyon regulare (von Rosen) ..	Wenlock ..	Great Britain, Gotland
Stromatopora typica (von Rosen) ..	Wenlock ..	Great Britain, Gotland
Str. bücheliensis (Bargatzky) ..	Givetian ..	Devon, Eifel, Paffrath

and the fourth is closely allied to *Clathrodictyon chapmani* Ripper of the Lilydale limestone. The affinities of a fauna of which so far only four species are known must necessarily be rather indefinite, but the presence of *C. regulare* and *Stromatopora typica* in some abundance suggests that it has something in common with the British Wenlock fauna. A Devonian aspect is given, however, by the occurrence of isolated examples of *S. bücheliensis* and *Stromatoporella* (not described in this paper).

Summary.

The stromatoporoid fauna of the Yeringian limestone of Griffith's Quarry, Loyola, contains as far as at present known four species: *Clathrodictyon regulare* (von Rosen), *C.* aff *chapmani* Ripper, *Stromatopora typica* von Rosen and *S. bücheliensis* (Bargatzky), as well as a *Stromatoporella* not here described. This fauna has little in common with the much larger and more varied fauna of the Yeringian limestone of Lilydale, and the presence in some abundance of *Clathrodictyon regulare* and *Stromatopora typica,* two characteristic Wenlock species, suggests that this limestone should perhaps be placed on a lower horizon than that of Lilydale, which contains a fauna having strong Devonian affinities.

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Vinassa de Regny, P. E., 1908. Fossili de Monti de Lodin. *Palaeontographia italica,* xiv., pp. 171-189.

Yavorsky, B., 1929. Silurian Stromatoporoids. *Bull. Com. Géol. Leningrad.* xlviii. (1), pp. 77-114.

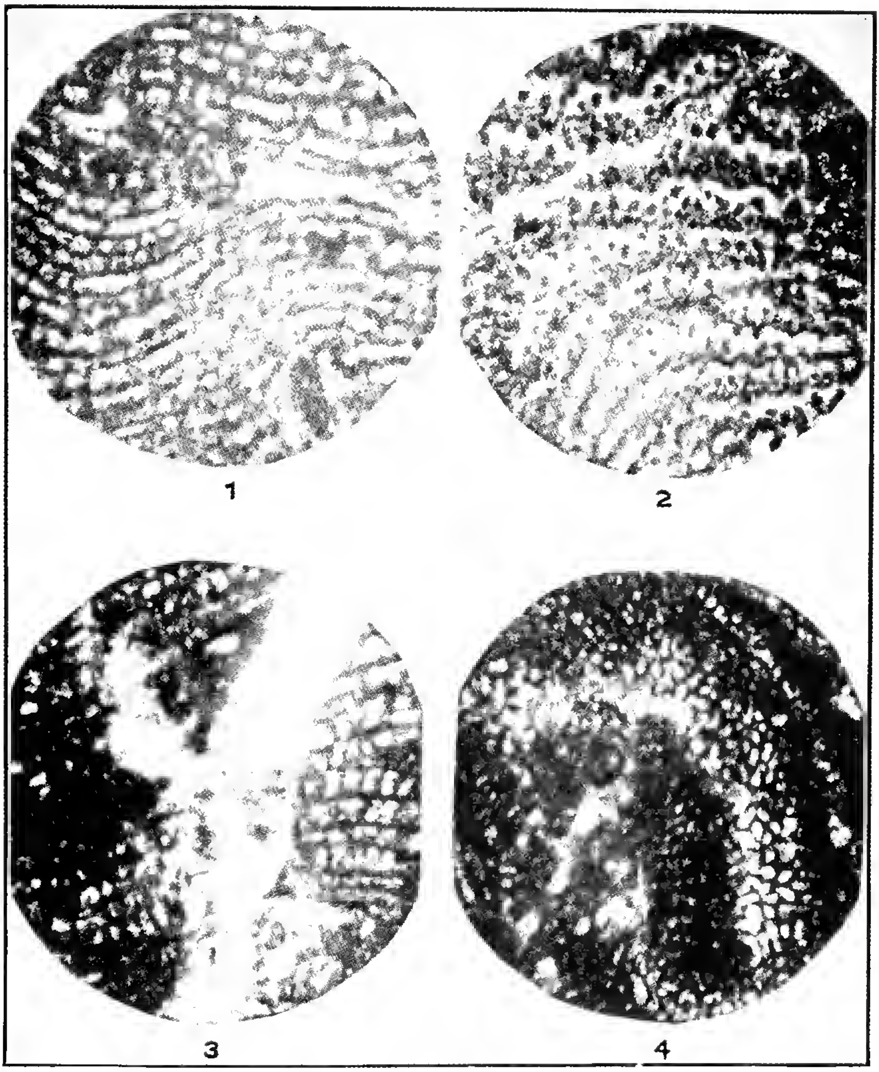
Explanation of Plate I.

Fig. 1.—*Clathrodictyon regulare* (von Rosen). Griffith's Quarry, Loyola. Yeringian. Vertical section. Coll. Dept. of Geology, Univ. of Melbourne, Reg. No. 1599. × 9 approx.

Fig. 2.—Same species. Tangential section of the same specimen. × 9 approx.

Fig. 3.—*Clathrodictyon* aff. *chapmani* Ripper. Griffith's Quarry, Loyola. Yeringian. Vertical section. Coll. Dept. of Geology, Univ. of Melbourne, Reg. No. 1598. × 9 approx.

Fig. 4.—Same form. Tangential section of the same form. × 9 approx.



Loyola Stromatoporoids.

[Proc. Roy. Soc. Victoria, 50 (N.S.), Pt. I., 1937.]

Art. II.—*On the Stromatoporoids of the Buchan District, Victoria.*

By ELIZABETH A. RIPPER, M.Sc., Ph.D.

[Read 8th April, 1937; issued separately, 29th December, 1937.]

Contents.

Introduction.

The Middle Devonian limestones of the Buchan district, Victoria, contain large and varied stromatoporoid faunas which hitherto have been little investigated. Collections were made by the writer in 1933 from five rather widely separated localities within the district, from which no fossils have previously been described: Rocky Camp, Commonwealth Quarries; Citadel Rocks, Murrindal River; near Hicks', Murrindal; Cameron's Quarry, South Buchan; Heath's Quarry. The area has not been geologically mapped in detail, and connecting exposures are lacking, so that little is known of the stratigraphical relations between these five localities. At most of the localities the stromatoporoids are associated with abundant corals. F Chapman (1912) has recorded the occurrence of a few Middle Devonian species from the limestones at Spring Creek, where, however, no stromatoporoids were found, and from localities within the township of Buchan.

Description of Species.

Family ACTINOSTROMATIDAE Nicholson, 1886, emend. Stechow, 1922.

Actinostroma Nicholson 1886.

1886. *Actinostroma* Nicholson, Mon. Brit. Strom., Gen. Introd., p. 75.

Stromatoporoids in which the coenosteum is composed of radial pillars which traverse a number of horizontal laminae. The laminae may be solid or made up of a "hexactinellid" mesh formed by lateral processes given off in whorls from the radial pillars. Skeletal fibre usually not minutely porous. Astrorhizae may be present or absent.

Horizon.—Cambrian-Devonian. Genotype: *A. clathratum* Nicholson. 1886, Mon. Brit. Strom., Gen. Introd., p. 76; 1886-1889, *Ibid.*, p. 131, pl. i., figs. 8-13; pl. xii., figs. 1-5. Devonian of Europe.

Actinostroma stellulatum Nicholson.

1886. *Actinostroma stellulatum* Nicholson, Ann. Mag. Nat. Hist., Ser. 5, xvii., p. 231, pl. vi., figs. 8, 9.

1889. *Actinostroma stellulatum* Nicholson, Mon. Brit. Strom., p. 140, pl. xiv., figs. 1-8; pl. xv.

1930. *Actinostroma stellulatum* Yavorsky, Bull. unit. Geol. and Prosp. Service, U.S.S.R., xlix. (4), p. 81, pl. ii., figs. 6-9.

Actinostroma stellulatum var. distans, var. nov.

(Pl. II., figs. 1, 2.)

Coenosteum massive, often reaching a large size, composed of latilaminae up to 15 mm. thick, which mark successive stages in its growth; surface gently undulating, with low astrorhizal mamelons; astrorhizae abundant, with branching horizontal canals; separated by distances of 7-8 mm. from centre to centre. Laminae 4-6 in 1 mm., pillars 4-5 in 1 mm.

Vertical sections show a very regular skeletal mesh, made up of stout, slightly inflected horizontal laminae, reaching a thickness of 0.1 mm., and straight, rather thick pillars, which are seen to pass through 12 or 15 laminae in those parts of the sections that are truly vertical. The number of laminae occupying 1 mm. measured vertically varies from 4 to 6, since within the latilaminae, which mark definite interruptions in the growth of the coenosteum, the laminae are periodically crowded. The radial pillars are somewhat more widely spaced (4-5 in 1 mm.) so that the spaces of the skeletal mesh tend to become elongated tangentially. Vertical sections are also characterized by the vertical canals of the astrorhizal systems; these are about 0.2 mm. in diameter, and are in direct connection with the adjacent interlaminar spaces, being marked off only slightly by the faintly upturned edges of the horizontal laminae.

The most conspicuous features of tangential sections are the branching astrorhizal systems and the compact horizontal laminae. Those parts of the sections passing through the interlaminar spaces show the relatively large, rounded cross-sections, sometimes connected by slender processes, but usually isolated, representing the cut ends of the radial pillars, but on passing through a horizontal lamina the section shows the pillars to be united to form a solid plate, which, however, has minute, regularly arranged perforations separated by distances of 0.1-0.2 mm. In places the pillars are seen to be composed of a number of fibres, an appearance which seems to anticipate the porous structure of the skeletal fibre of *Stromatopora* and allied genera.

This form undoubtedly falls into that group of the species of *Actinostroma* in which the coenosteum is made up of regular, isolated pillars and stout, straight or slightly undulating horizontal laminae, i.e., that group of which *A. stellulatum* Nicholson is the most characteristic member. From this European Middle Devonian species the Victorian form is to be separated only by its somewhat coarser skeletal mesh. The laminae are thicker in var. *distans*, and more solid, the pillars being more completely fused than in most European specimens. An example of this species from the Middle Devonian of Gerolstein, in the Eifel district, Germany (Sedgwick Museum, Cambridge, Reg. Nos. A4651, A4662), shows in tangential section a similar alternation of isolated, composite pillars and perforated (and probably porous) horizontal laminae, an aspect which is not so marked in specimens collected by the writer from Lummaton Quarry and other localities in the Torquay district. From *A. stellulatum* var. *italicum* Gortani it is further distinguished by its more regular skeletal mesh, in which, moreover, the interspaces are not elongated tangentially. The skeletal mesh is also more regular and coarser than that of *A. praecursum* Parks, which that author considers to be a Silurian forerunner of the Middle Devonian species. *A. perspicuum* Počta, from the Middle Devonian (Gg3) of Bohemia, is a related form in which, however, the mesh is much less heavy, being made up of remote, thin, regularly arranged laminae and pillars. *A. matutinum* Nicholson, of the Chaleur Group of Quebec (of doubtful Niagaran age), is probably similar, but has a thicker skeletal mesh made up of stout isolated pillars and gently undulating laminae. The Victorian form is thus best described as a new variety of *A. stellulatum* Nicholson.

Horizon.—Middle Devonian.

Locality.—Very abundant in the limestones of Heath's Quarry, Buchan.

Holotype.—Coll. Dept. of Geology, Univ. of Melbourne, Reg. No. 1610.

ACTINOSTROMA CONTORTUM, sp. nov.

(Pl. II., figs. 3-6.)

Coenosteum massive, usually large, composed of irregularly flexed and domed horizontal laminae and straight, but irregularly developed radial pillars; laminae 5-8 in 1 mm., pillars 5-6 in 1 mm.; astrorhizae abundant.

The horizontal laminae as seen in vertical sections are thin, and flexed at more or less regular intervals to form astrorhizal mamelons. They are periodically crowded, so that the number in 1 mm. may vary from 5 to 8. Latilaminae do not occur regularly, but interruptions in the growth of a large coenosteum are not infrequent. The radial pillars are slender and are seen in those parts of the section which are truly vertical to pass through ten or more laminae. Usually, however, owing to the contortion of the laminae, such parts are rare and of small extent, so that the species may even take on the appearance of a *Clathrodictyon*. Five or six radial pillars, with the intervening spaces, occupy 1 mm. The superimposed astrorhizal systems apparently have no vertical canal, and a marked irregularity of the skeletal mesh is observed at the axes of the astrorhizal mamelons.

Tangential sections show the cut ends of the radial pillars, which appear as rounded, apparently isolated cross-sections. It is probable that the radial pillars are composed of a number of fibres, a feature already noted in *A. stellulatum* var. *distans*. The horizontal laminae are compact and are possibly perforated as in *A. stellulatum* var. *distans*. Owing to the great curvature of the laminae in the region of the astrorhizal mamelons, the horizontal astrorhizal canals are inconspicuous, since a very small part of their length lies in any given plane.

This abundant species has little affinity with any described species of *Actinostroma*, and in spite of the poor state of preservation in which it is frequently found, it is readily identifiable. In the abundance of astrorhizal mamelons, and their domination of the skeletal mesh, the species recalls *A. verrucosum* (Goldfuss), but it is separated from that Middle Devonian species by the fine, periodically crowded laminae and the isolated radial pillars, and the generally finer skeletal mesh. The character of the tangential section places it in the group of *A. stellulatum* Nich., from which species it is distinguished by the irregularity of the skeletal mesh and the thinner laminae and pillars. The species is very variable in the amount of the curvature and doming of the horizontal laminae, though the contorted aspect is usually more conspicuous in slightly oblique and naturally weathered surfaces. In addition to the commonly occurring form there may be recognized a finer variety of rarer occurrence, in which the laminae are more evenly spaced and are less flexed, though they are sometimes crumpled at the points of junction with the radial pillars. The upper surface of the coenosteum is covered with small, pointed astrorhizal mamelons, separated by distances of about 1 cm. from centre to centre (Coll. Dept. of Geology, Univ. of Melbourne, Reg. No. 1604, Rocky Camp).

Horizon.—Middle Devonian.

Localities.—Very abundant in the limestones of Rocky Camp, Commonwealth Quarries, but usually in a bad state of preservation. Also present at Heath's Quarry, and near Hicks', Murrindal.

Holotype.—Coll. Dept. of Geology, Univ. of Melbourne, Reg. No. 1611, Heath's Quarry. Figured specimen of finer variety: Reg. No. 1604, Rocky Camp.

Actinostroma compactum Ripper.

(Pl. II., figs. 7, 8.)

1933. *Actinostroma compactum* Ripper, Proc. Roy. Soc. Vic. (n.s.), xlv. (2), p. 153, figs. 5A, 5B.

Coenosteum massive, latilaminar, often reaching large size; upper surface smooth, with abundant branching astrorhizae; horizontal laminae thin, curved or gently undulating, not domed to form astrorhizal mamelons; laminae 5-7 in 1 mm., pillars 5 in 1 mm.

Vertical sections show a skeletal mesh which, though much finer, is closely similar to that of *A. clathratum* Nicholson. The horizontal laminae are thin and appear to be somewhat crumpled, thus resembling those of *A. intertextum* Nicholson. The radial pillars are slender, straight, and pass through a considerable number of horizontal laminae, but usually do not traverse a whole latilamina (a distance of about 5 mm.). The laminae are commonly crowded at intervals within the latilaminae, and the base of each successive latilamina may be marked by a zone of irregularly vesicular tissue up to 0.5 mm. broad. The astrorhizal systems are apparently not superimposed, and no axial canals are seen in vertical sections; rounded cross-sections, somewhat larger than the spaces of the normal skeletal mesh, probably mark the positions of the horizontal astrorhizal canals.

Tangential sections show the skeletal mesh typical of *Actinostroma*. The radial pillars are connected by delicate radiating processes, four or five of which arise from each pillar. Where the section crosses an interlaminar space, the pillars are usually isolated, though even here occasional processes may be seen. Astrorhizae are abundant, but rather irregularly distributed, the distance between the centres of adjacent systems varying between 5 and 10 mm. The horizontal canals reach a length of 2-3 mm., are much branched, and merge gradually into the normal skeletal mesh. Tangential sections of this species come very close to similar sections of *A. intertextum* Nich., but the two species are readily separated by the more regular aspect of the skeletal mesh in vertical sections of *A. compactum*, which has better developed horizontal laminae.

This form is similar in every respect to that described as *A. compactum* from the Lilydale limestone of Yeringian age. The abundant specimens from Heath's Quarry, Buchan, are particularly well preserved, and have yielded further details of skeletal structure, and particularly of the external form of the coenosteum. At Lilydale the species is of much rarer occurrence and the specimens are in a state of preservation that does not show the external characters. The new material, however, is still fragmentary, and no weathered out specimens have been seen, so that the base and mode of attachment of the coenosteum are still unknown.

Horizon.—Middle Devonian.

Localities.—Very abundant at Heath's Quarry. Also present in the limestone of Rocky Camp, Commonwealth Quarries, Buchan.

Figured specimen.—Coll. Dept. of Geology, Univ. of Melbourne, Reg. No. 1617, Heath's Quarry.

Clathrodictyon Nicholson and Murie, 1878.

CLATHRODICTYON REGULARE (von Rosen).

(Pl. III., figs. 1, 2.)

1867. *Stromatopora regularis* von Rosen, "Ueber die Natur der Stromatoporen," etc., p. 74, pl. ix., figs. 1-4.

1937. *Clathrodictyon regulare* Ripper, Proc. Roy. Soc. Vic., 1. (n.s.), 1, p. 2.

(For further synonymy see Ripper, *Ibid.*, 1, (1), 1937, p. 2.

Two examples from the Buchan district, while being referable to this species, differ in some respects from the more typical form occurring at Lilydale and Loyola. The skeletal mesh is very regular and formed by straight or broadly curved, minutely crumpled horizontal laminae, of which four or five occupy 1 mm., and less regularly disposed radial pillars, of which there are a similar number in 1 mm. In the wider spacing of the horizontal laminae, the broadening of the pillars at their upper ends as a consequence of their origin in the crumpling of the laminae, and the arching of the laminae between the pillars, this form is clearly transitional towards *Cl. striatellum* (d'Orbigny), and closely resembles some specimens of *C. regulare* from the Wenlock Limestone of Dudley in the Nicholson Collection, which, however, have a somewhat finer skeletal

TABLE 1.—CHARACTERS OF VICTORIAN SPECIES OF *Actinostroma*, AND OF SPECIES WITH WHICH THEY ARE COMPARED.

Species.	Horizon.	Locality.	Laminae.	Pillars.	Astrorhizae.	Form of Coenosteum.
			mm.	mm.		
1. Group of *A. intertextum* Nich.						
Act. intertextum Nich.	Wenlock .. Zone of *Pentamerus esthonus*	Great Britain .. Esthonia ..	5	5	Abundant .. Not superimposed	Laminar Circular No latilaminae
A. altum Ripper	Yeringian ..	Lilydale, V. ..	1–5	3–4	Probably absent ..	Massive Latilaminar
2. Group of *A. clathratum* Nich.						
A. clathratum Nich.	Givetian	Europe ..	3–4	3–4	Irregular .. Not superimposed	Massive Latilaminar
A. compactum Ripper	Yeringian ..	Lilydale, V. ..	5–7	5–6	Abundant, irregular Not superimposed	Massive Latilaminar
A. verrucosum (Goldf.)	Givetian	Europe ..	4	5	Abundant .. Superimposed	Massive
3. Group of *A. stellulatum* Nich.						
A. stellulatum Nich.	Givetian	Europe ..	6–8	6–7	Abundant .. Superimposed ..	Massive Latilaminar
A. stellulatum var. *distans*, var. nov. ..	M. Devonian ..	Buchan, V. ..	4–6	4–5	Abundant, regular Superimposed ..	Massive Latilaminar
A. stellulatum var. *italicum* Gortani ..	M. Devonian ..	Carnic Alps ..	3–4	4–5	Abundant Superimposed	
A. contortum, sp. nov.	M. Devonian ..	Buchan ..	5–8	5–6	Abundant .. Superimposed ..	Massive Irregular latilaminae
A. perspicuum Pocta	M. Devonian ..	Bohemia ..	3	3	Few ?	
A. matutinum Nich.	Chaleur Gp. ..	Quebec ..	4–6	3–4	Rare	Massive

mesh. The skeletal mesh of these specimens from Buchan, on the other hand, has not the open appearance characteristic of *C. striatellum,* and the pillars are usually solid, rarely showing the hollow cone near their point of origin which is so marked a feature of *C. striatellum.* The pillars in this Victorian form are, however, sometimes tubular, and then appear in tangential sections as rings, a feature which recalls *C. calamosum* Ripper of the Lilydale limestone. It is clear, therefore, that the species *C. regulare, C. striatellum,* and *C. calamosum,* together with *C. clarum* Počta and *C. convictum* Yavorsky, are merely the most conspicuous members of a group which contains all transients between them.

Horizon.—Middle Devonian.

Localities.—Heath's Quarry; near Hicks', Murrindal, Buchan.

Figured specimen.—Coll. Dept. of Geology, Univ. of Melbourne, Reg. No. 1618, Heath's Quarry.

Clathrodictyon confertum Nicholson.

(Pl. III., fig. 3.)

1889. *Clathrodictyon confertum* Nicholson, Mon. Brit. Strom., p. 154, pl. xviii., figs. 13, 14.

1915. *Clathrodictyon confertum* Boehnke, Palaeontographica, 61, p. 170, figs. 15, 16.

Coenosteum massive or laminar; characters of surface unknown: built up of thin crumpled laminae, connected by radial pillars formed largely by their inflection; laminae 6 in 1 mm., pillars 6-7 in 1 mm.

Vertical sections show a very fine, regular skeletal mesh in which the horizontal laminae are the dominant element. They are evenly spaced, and no periodical crowding is seen. No grouping into latilaminae is observable, but the specimens available show only very small fragments of the coenosteum, so that their absence cannot be definitely stated. The laminae are crumpled at regular intervals, forming by downward inflections the somewhat more widely spaced radial pillars.

In tangential section the skeletal mesh is irregularly vesicular, and the cut ends of the radial pillars are not readily distinguishable from the edges of the horizontal laminae. Astrorhizae are apparently not present, though this cannot be definitely asserted, in view of the small extent of the tangential sections.

This species is of rare occurrence in the Devonian limestones of the Buchan area, but it is readily identifiable with examples collected by the writer from Hope's Nose, Torquay, as well as with Nicholson's original specimen (Brit. Mus. Nat. Hist., Reg. No. P5981).

Horizon.—Middle Devonian.

Locality.—Rare in the limestone of Cameron's Quarry, Buchan.

Figured specimen.—Coll. Dept. of Geology, Univ. of Melbourne, Reg. No. 1607.

Clathrodictyon convictum Yavorsky.

(Pl. III., figs. 4-8.)

1929. *Clathrodictyon convictum* Yavorsky, Bull. du Comité Géol. Leningrad, 48 (1), pp. 91, 105, pl. vi., fig. 10; pl. ix., figs. 5-7.

Coenosteum massive, without latilaminae, reaching a large size, built up of thin, undulating, slightly crumpled horizontal laminae and stout radial pillars; laminae 3-5 in 1 mm., pillars 4 in 1 mm.; astrorhizae absent.

The external characters of the coenosteum are not observable in the specimens collected from Buchan, since these are all fragments of large masses. In vertical sections the horizontal laminae are seen to be rather thin and irregularly undulating. They are periodically crowded, there being in those parts of the coenosteum up to 5 in 1 mm., while in other places they are much more remote (2 or 3 in 1 mm.). Definite latilaminae are not present. The laminae are minutely crumpled, and the radial pillars, which may sometimes be incomplete, appear to be formed by their downward inflection, being thus thickened at their upper ends.

Very conspicuous in vertical sections are the thin-walled "Caunopora" tubes, which here probably belong to a form of *Syringopora*. They are abundant, regularly spaced at intervals of 1 mm. or more, reach a diameter of about 0.5 mm., and have thin, funnel-shaped tabulae. Horizontal connecting tubes, 0.2 to 0.3 mm. in diameter, are fairly abundant.

Tangential sections show the cut edges of the thin laminae, in the region of which the rounded cross-sections representing the cut ends of the radial pillars are much enlarged and crowded. Elsewhere the cross-sections of the pillars are small, usually isolated dots, which, however, may occasionally be connected by thin lateral processes. Astrorhizae are apparently absent. The "Caunopora" tubes are seen as abundant round cross-sections, in which the tabulae appear as concentric rings. The section may also occasionally traverse longitudinally the horizontal connecting stolons of the "Caunopora."

In some respects this form shows resemblances to *C. striatellum* (d'Orb.), particularly in the thin, crumpled horizontal laminae and the mode of formation of the radial pillars. The author of the species suggests an analogy with *C. regulare* (von Rosen), but points out the absence of a median line in the laminae. It seems too that the laminae are much more delicate than in *C. regulare*, and the skeletal mesh is rather more irregular. Most Victorian specimens have "Caunopora" tubes resembling the corallites of *Syringopora*, though these reach only half the diameter of those in the Oesel specimens figured by Yavorsky. The skeletal mesh is rather variable, even in different parts of the one coenosteum, and some examples, with more remote horizontal laminae (3-4 in 1 mm.) and very stout radial pillars, which are sometimes tubular, approach *C. calamosum* Ripper of the Lilydale limestone, in which the radial pillars are still obviously formed by the downward inflection of the laminae, but are more often tubular than conical, as they are in *C. striatellum* (d'Orb.) (Coll. Dept. of Geology, Univ. of Melbourne, Reg. No. 1613). A similar form from the Chalonnes limestone of the Ancenis Basin, with pillars which are frequently tubular, has been described and figured by Le Maitre (1934, p. 187, pl. XI., fig. 8), who refers it, however, to *C. striatellum* (d'Orb.).

Horizon.—Middle Devonian.

Locality.—Heath's Quarry, Buchan.

Figured specimens.—Coll. Dept. of Geology, Univ. of Melbourne, Reg. Nos. 1613, 1616 (typical form).

The species also occurs in the Cave Limestone, Goodradigbee River, New South Wales.

CLATHRODICTYON CONVICTUM var. DELICATULA, var. nov.

(Pl. IV., figs. 1, 2.)

Coenosteum massive, of large size, non-latilaminar; horizontal laminae straight or irregularly curved, 7-10 in 1 mm., radial pillars slender, 6-7 in 1 mm.; astrorhizae absent.

The skeletal mesh of this form as seen in vertical and tangential sections is of the same type as that of *C. convictum*, but the laminae are much thinner, more crowded and not so crumpled as in the typical form of the species. Distinct latilaminae are absent, though the laminae are periodically crowded, there being as many as 10 or 11 in 1 mm. in those parts of the coenosteum, and there are interruptions in the deposition of the laminae at irregular intervals. "Caunopora" tubes are abundant, and similar to those in the typical form, but reach a diameter of only 0.2-0.3 mm., while the connecting stolons are still narrower. Tangential sections present a similar appearance, on a smaller scale, to that of corresponding sections of the typical form. Some much smaller examples from Cameron's Quarry have assumed, possibly under unfavorable conditions, a laminar habit, and the coenosteum is built up of irregular latilaminae in which the direction of growth of the laminae is frequently changed. The "Caunopora" tubes are sometimes thick-walled, and up to 0.6 mm. in diameter, and as they grow always at right angles to the plane of the laminae, their course is correspondingly irregular.

Horizon.—Middle Devonian.

Localities.—Rocky Camp, Commonwealth Quarries; Cameron's Quarry, Buchan.

Holotype.—Coll. Dept. of Geology, Univ. of Melbourne, Reg. No. 1606, Rocky Camp.

Clathrodictyon clarum Počta.

(Pl. IV., figs. 3, 4.)

1894. *Clathrodictyon clarum* Počta, Syst. Sil. du Centre de la Bohême, viii. (1), p. 152, pl. 18, figs. 7, 8.

1910. *Clathrodictyon clarum* Počta, Sitzungsberichte Königl. Böhm. Gesells. d. Wissenschaften in Prag, No. 12, p. 1, and plate.

1933. *Clathrodictyon clarum* Le Maitre, Mém. Soc. Géol. France (n.s.), ix. (1), Mém. 20, p. 16, pl. iv., figs. 1-5.

Coenosteum massive or laminar, latilaminar, built up of periodically crowded, sinuous laminae and straight radial pillars; laminae 4–6 in 1 mm., pillars 4–5 in 1 mm.; astrorhizae probably absent.

Vertical sections show a fairly regular skeletal mesh which is dominated by the thin, well defined, slightly crumpled horizontal laminae. These are crowded at rather irregular intervals, and in those parts of the coenosteum where they are more widely spaced a distinctly vesicular structure may arise from the development of short subsidiary laminae which may traverse obliquely an interlaminar space, or, failing to reach the lamina next above, form vesicles by joining the lamina from which they originated. The radial pillars are fairly stout, usually complete and strictly at right angles to the laminae which they connect. In parts of the sections they are clearly seen to be formed by the downward inflection of the laminae. Their distribution in the coenosteum appears to be rather irregular, on account of the variable direction of growth of the laminae, which is a characteristic feature of the species. Polished and weathered surfaces thus resemble sometimes those of *Actinostroma contortum*, sp. nov., in which the mode of growth of the coenosteum is precisely similar. "Caunopora" tubes are abundant and regularly distributed through the coenosteum. They are usually of the thick-walled, probably tabulate type, the "*Syringopora*" type having been observed in only one specimen, and reach a diameter of 0.3–0.5 mm. They are separated by an average distance of 1 mm.

Tangential sections show the cut ends of the radial pillars as rounded cross-sections, which are sometimes connected by sinuous processes. These may, in reality, be the cut edges of the subsidiary incomplete laminae. The true laminae appear as very dense areas in the sections, but this is probably an effect of imperfect preservation. Astrorhizae have not been observed in tangential sections.

The specimens of this form are usually recrystallised, so that the banded aspect of the coenosteum, arising from the periodical crowding of the laminae, is intensified by zones in which all structure is lost, and which thus appear to be very dense. Similarly in tangential sections the laminae sometimes appear to be compact and structureless. The "Caunopora" tubes have likewise been affected, so that their walls are excessively thickened, and the presence of tabulae is shown by mere traces The radial pillars in tangential section appear to be structureless and solid, while Počta (1910) in his description of additional features of this species notes the presence of hollow pillars, appearing as circular cross-sections in tangential sections.

This species belongs to the group containing those forms of *Clathrodictyon* which have a regular skeletal mesh, including such species as *C. regulare* (von Rosen), *C. striatellum* (d'Orb.), *C. neglectum* Počta and *C. convictum* Yavorsky. From *C. striatellum* it is readily distinguished by the mode of growth of the coenosteum, the greater crowding of the horizontal laminae and the less obviously conical form of the radial pillars. *C. calamosum* Ripper has stout pillars, formed by the downward inflection of the laminae, but these are usually tubular, as shown in tangential sections, and the skeletal mesh is coarser and less regular. *C. convictum* Yavorsky of the Upper Oesel group of Kattri-pank, Oesel, and present also in the Buchan limestones, is probably the most closely allied species, but the mode of growth of the coenosteum is much more regular, and the pillars and laminae, which are more usually crumpled, are more slender than in *C. clarum*. Finally, in *C. linnarssoni* Nicholson of the Wenlock limestone of Wisby, Gotland, the laminae are more crowded and regularly spaced, and in the general aspect of vertical sections the species marks a passage from the group of which *C. vesiculosum* Nich. and Murie is typical.

Horizon.—Middle Devonian.

Localities.—Rocky Camp, Commonwealth Quarries; near Hicks', Murrindal, Buchan.

Figured specimen: Coll. Dept. of Geology, Univ. of Melbourne, Reg. No. 1605, Rocky Camp.

Family STROMATOPORIDAE Nicholson, 1886.

Stromatopora Goldfuss, 1826, emend. Nicholson, 1886.

STROMATOPORA aff. FOVEOLATA (Girty).

(Pl. IV., figs. 5, 6.)

1895 *Syringostroma foveolatum* Girty, Rep. State Mus. New York, xlviii. (2), p. 295, pl. vi., figs. 8, 9.

1937. *Stromatopora foveolata* Ripper, Proc. Roy. Soc. Vic. (n.s.), xlix. (2), p. 178.

A specimen from the Buchan district shows the same type of internal structure as the form described from Lilydale, but the skeletal mesh is considerably coarser, so that it should probably be regarded as a distinct variety. The coenosteum is massive and composed of straight latilaminae. The radial pillars are stout,

TABLE 2.—CHARACTERS OF VICTORIAN SPECIES OF *Clathrodictyon*, AND OF SPECIES WITH WHICH THEY ARE COMPARED.

Species.	Horizon.	Locality.	Laminae.	Pillars.	Astrorhizae.	Form of Coenosteum.
			mm.	mm.		
Group of *Cl. vesiculosum* Nich. and Mur.						
Cl. confertum Nich.	M. Devonian	Buchan, V. / Torquay, Devon	8	6-7	Small, abundant	Massive or laminar
Cl. linnarssoni Nich.	Wenlock	Gotland	6-8	5-6	Small, superimposed	Laminar
Group of *Cl. striatellum* (d'Orb.).						
Cl. striatellum (d'Orb.)	Wenlock	Europe	5 thin,	4 conical crumpled	Absent	Laminar or hemispherical
Cl. calamosum Ripper	Yeringian	Lilydale, V.	4-5	3-4 tubular	Absent	Massive, non-latilaminar
Cl. convictum Yavorsky	U. Oesel	Oesel	3-5 thin, somewhat crumpled	4 sometimes tubular	Absent	Massive, non-latilaminar
Cl. convictum var. *delicatula*, var. nov.	M. Devonian	Buchan, V.	7-10 less crumpled	6-7	Absent	Massive, non-latilaminar
Cl. regulare (v. Rosen)	Wenlock / M. Devonian	Europe / France / Buchan, V.	6 arched	4 solid	Absent	Laminar / Encrusting or massive
Cl. regulare var. *cylindrifera* Ripper	Yeringian	Lilydale, V.	5-6	3-4	Abundant, superimposed	Massive
Cl. clarum Počta	Ff_2 / M. Devonian	Bohemia / Buchan, V.	4-6 straight	4-5 sometimes tubular	Absent ?	Massive or laminar, non-latilaminar
Group of *Cl. chapmani* Ripper.						
Cl. chapmani Ripper	Yeringian	Lilydale, V.	2-3	Irregular	Abundant, superimposed	Massive
Cl. aff. *chapmani* Ripper	Yeringian	Loyola, V.	6	5	Rare	Massive or laminar

0.1–0.2 mm. thick, and three or four occupy the space of 1 mm. The horizontal laminae are of varying thickness, sometimes being reduced to mere "tabulae", though their average thickness is 0.2–0.3 mm. They are usually arranged in small groups, two or three of which make up a latilamina. The astrorhizae are well developed, superimposed, and are of the same kind as those of the typical form. The horizontal astrorhizal canals, 0.2–0.3 mm. broad, as well as the vertical axial canal, are crossed by tabulae, which always remain at right angles to the course of the canal. The upturned edges of the laminae bounding the horizontal astrorhizal canals, which are abruptly directed upwards as they approach the centre of the system, give a characteristic aspect to vertical sections of this species. The tangential section shows a mesh more completely reticulate than that of the typical form: the radial pillars are not distinctly recognisable, and the laminae are less compact. The example from Buchan thus appears to combine the features of *S. foveolata* and *S. concentrica* Goldf., and may be regarded, from the point of view of the degree of fusion of the horizontal and vertical skeletal elements, as a transient between these two forms.

Horizon.—Middle Devonian.

Locality.—Rocky Camp, Commonwealth Quarries, Buchan.

Figured specimen.—Coll. Dept. of Geology, Univ. of Melbourne, Reg. No. 1609.

STROMATOPORA CONCENTRICA Goldfuss.

(Pl. IV., figs. 7, 8; Pl. IV., figs. 1, 2.)

1826. *Stromatopora concentrica* Goldfuss, Petrefacta Germaniae, p. 22, pl. viii., figs. 5A-C.

1886. *Stromatopora concentrica* Nicholson, Mon. Brit. Strom., Gen. Introd., p. 2, pl. iii., fig. 5; pl. xi., figs. 15-18.

1891. *Stromatopora concentrica* Nicholson, Mon. Brit. Strom., p. 164, pl. xx., fig. 10; pl. xxi., figs. 1-3; pl. xxiv., figs. 9, 10.

1910. *Stromatopora concentrica* Vinassa de Regny, Boll. R. Com. Geol. d'Ital., xli., p. 46, pl. i., fig. 6.

1912. *Stromatopora concentrica* Gortani, Riv. italiana di paleontologia, xviii., p. 123, pl. iv., figs. 6, 7.

1915. *Stromatopora concentrica* Boehnke, Palaeontographica, 61, p. 180, text-figs. 30, 31.

1919. *Stromatopora concentrica* Vinassa de Regny, Pal. Italica, xxiv., p. 113, pl. xi. (vi.), figs 3-5.

1932. *Stromatopora concentrica* Riabinin, Bull. unit. Geol. and Prospecting Service U.S.S.R., li. (58), p. 860, pl. ii., figs. 5, 6.

1934. *Stromatopora concentrica*, Le Maitre, Mém. Soc. Géol. du Nord, xii., p. 197, pl. xiii., figs. 6, 7.

(For further synonymy see Nicholson, 1891.)

Coenosteum massive, latilaminar, latilaminae 2–5 mm. thick; built up of moderately well defined radial pillars and less definite horizontal laminae; pillars 7 in 2 mm.; astrorhizae fairly abundant.

The specimens on which this description is based are all fragments of larger masses, so that the original form of the coenosteum and the characters of the exterior cannot be observed. The coenosteum is made up of rather irregular latilaminae, and more pronounced interruptions in the growth of larger masses occur at irregular intervals. A vertical section of one of the larger specimens shows a marked discontinuity, in which growth was at a standstill long enough to permit the development of a coenosteum of a *Stromatoporella* of the type of *S. curiosa* (Barg.), which varies in thickness between 5 and 10 mm. The skeletal tissue first deposited after this interruption is irregularly vermiculate and a zone 2 or 3 mm. broad is passed through before the formation of the normal skeletal mesh is resumed. This is composed of straight, parallel, stout, rather short radial pillars 0.2-0.3 mm. thick, which are connected at intervals of 0.5 mm. or less by irregular processes of varying thickness. The thinner processes, which may be more crowded, are probably the structures referred to by Nicholson in his description of *S. concentrica* and allied forms as the "tabulae" of the "zooidal tubes." At intervals of 1-2 mm. a sufficient number of broad processes may be present at one level to form an irregular lamina, which, however, is not so readily recognizable as a distinct structure as are the radial pillars. Many of the pillars are cut off above such a lamina, so that a line of spaces, rather broader than the normal interpillar spaces, is developed. It is probable that these were occupied by horizontal astrorhizal canals. The presence in vertical sections of groups of highly inclined canals which converge to a centre, but which appear to lack an axial canal in the strict sense, suggests that the astrorhizal systems are superimposed.

Tangential sections show a vermiculate skeletal mesh in which the radial pillars, not recognizable as distinct skeletal elements, are connected by lateral processes of equal or slightly smaller breadth. The resulting mesh is open in appearance, as the sinuous rows of pillars, connected by these processes are separated by rather broader interspaces. The conspicuous astrorhizal systems, separated by distances of about 15 mm. from centre to centre, are composed of 8 or 9 radiating, branching canals, which may reach a length of 5 mm. or more. The skeletal tissue in some examples is very well preserved, and is seen to be minutely porous and apparently composed of anastomosing fibres (Coll. Dept. of Geology, Univ. of Melbourne, Reg. No. 1615).

Some other specimens from the Buchan district, particularly one from Rocky Camp (Coll. Dept of Geology, Univ. of Melbourne, Reg. No. 1608) resemble in some respects those species of *Syringostroma* in which the skeletal mesh has almost attained the degree of reticulation characteristic of *Stromatopora*. They are probably best regarded as transients between *Stromatopora foveolata* (Girty) and *S. concentrica*, but are included in the latter species since they correspond very well with some specimens placed in that species by Nicholson. The differences do not warrant the isolation of these examples in a distinct species, since the mesh of *S. concentrica* itself varies from specimen to specimen, and the boundaries between such species as the Helderbergian forms of *Syringostroma*, *Stromatopora foveolata* and *S. concentrica* must at best be arbitrary lines drawn across a continuous series of transients.

These specimens are massive in habit and built up of undulating latilaminae about 2 mm. thick. The skeletal mesh is reticulate, but the radial pillars, 0.1-0.2 mm. thick, are recognizable as distinct elements which may pass without interruption through a whole latilamina. Usually, however, they are confined to shorter distances and traverse only one or two of the feebly developed horizontal laminae (sometimes reduced to "tabulae") which are grouped together in the manner typical of *Syringostroma* and *Stromatopora foveolata*. The intervals between the latilaminae are marked in vertical sections by a series of pores, which probably indicate the positions of the astrorhizal canals. Tangential sections show a completely reticulate mesh in which the radial pillars are not recognizable as distinct skeletal elements. In the interlaminar spaces they are united by processes of similar breadth, forming a vermiculate network, and on the plane of a lamina are completely fused to form a structureless plate with occasional small perforations. Astrorhizae are abundant, though rather irregularly placed, and consist of ten or twelve radiating branching canals 2-3 mm. long. They are thus characteristically small and compact, and are usually not superimposed.

Horizon.—Middle Devonian.

Localities.—Citadel Rocks, Murrindal River; near Hicks', Murindal; Rocky Camp, Commonwealth Quarries; Cameron's Quarry; Heath's Quarry.

Figured specimens.—Coll. Dept. of Geology, Univ. of Melbourne, Reg. Nos. 1608 (Rocky Camp), 1615 (Heath's Quarry).

STROMATOPORA CONCENTRICA var. COLLICULATA Nicholson.

(Pl. V., figs. 3, 4.)

1891. *Stromatopora concentrica* var. *colliculata* Nicholson, Mon. Brit. Strom., p. 165, pl. iii., fig. 5.

Coenosteum massive, non-latilaminar, composed of thick, undulating horizontal laminae and straight radial pillars which may traverse a number of laminae; laminae 3-4 in 1 mm., pillars 3 in 1 mm.; astrorhizae rare.

The external characters of the coenosteum are not observable, since all the specimens are fragments, probably of large masses. Vertical sections show a skeletal mesh which combines the features of *Stromatopora* and *Actinostroma*. The horizontal laminae are well defined, evenly spaced, broadly undulating, and reach a thickness of 0.3 mm. They remain distinct from the straight radial pillars, which are rather more slender, and usually traverse a number of interlaminar spaces. The pillars may become broader at their intersections with the laminae, so that a mesh with rounded apertures is produced. Occasional rounded apertures, of rather larger size than the normal apertures of the mesh, are probably cross-sections of horizontal astrorhizal canals. Interlaminar septa are absent. True latilaminae are not present, though occasional interruptions in the growth of the conosteum are marked by narrow zones, about 0.5-1 mm. broad, of irregularly reticulate skeletal fibre in which the mesh is much finer than in the rest of the coenosteum. "Caunopora" tubes have not been observed.

Truly tangential sections of any great extent are difficult to obtain on account of the disposition of the laminae into mamelons. The laminae are solid, with occasional small perforations, and the radial pillars in the interlaminar spaces are usually isolated or connected by narrow lateral processes, forming a coarse, imperfectly "hexactinellid" mesh. Definite astrorhizal canals have not been observed in tangential sections, probably owing to the small areas of such sections that are actually parallel to the planes of the laminae, but irregularities in the arrangement of the radial pillars are probably caused by their presence.

The skeletal mesh of this form corresponds well with that of examples of *S. concentrica* var. *colliculata* in the Nicholson Collection. A specimen from Teignmouth in this collection (Brit. Mus. Nat. Hist., Reg. No. P5874) is identical with the Victorian examples in this respect. Nicholson has not given in the Monograph of British Stromatoporoids a separate figure showing the microscopic structure of the variety, but it must be noted that it is in some respects distinct from that of the typical form. In the extreme distinctness of the two skeletal elements this form comes close to some species of *Syringostroma*, but the laminae are rather too thickened to permit its inclusion in that genus, where the laminae are essentially thin and traversed by thickened pillars. Further, the laminae in this form are more evenly spaced and have not the periodical crowding and arrangement in groups which are so characteristic of those species of *Stromatopora* which are more closely related to *Syringostroma*. In these respects *Stromatopora concentrica* var. *colliculata* may show an advance on the typical form, since there the laminae are still arranged in groups and traversed by pillars which often do not extend beyond the boundaries of such a group.

Astrorhizae are apparently not so abundant nor so conspicuous in the Victorian form as in the European specimens described by Nicholson.

Horizon.—Middle Devonian.

Localities.—Heath's Quarry; near Hicks', Murrindal.

Figured specimen.—Coll. Dept. of Geology, Univ. of Melbourne, Reg. No. 1614, Heath's Quarry.

Stromatopora hüpschii (Bargatzky).

(Pl. V., figs. 5, 6.)

1881. *Caunopora hüpschii*, Bargatzky "Die Stromatoporen des rheinischen Devons," p. 62.

(For further synonymy see Ripper, Proc. Roy. Soc. Vic., xlix., p. 186, 1937.)

Coenosteum massive, irregularly latilaminar, built up of long, straight radial pillars, which are connected at frequent intervals by slender lateral processes; pillars 6 in 2 mm.; astrorhizae irregularly distributed.

The specimens are fragmentary, so that the external characters of the coenosteum are not observable. Vertical sections show a skeletal mesh which is dominated by the well defined radial pillars. These are straight, stout, their average thickness being 0.2 mm., and reach a considerable length, often traversing a whole latilamina, a distance of 5 mm. or more. The pillars are connected by abundant thin lateral processes ("tabulae" of Nicholson), of which there are usually 6 in 2 mm. They occur at different levels in adjoining interpillar spaces ("zooidal tubes" of Nicholson), so that they do not coalesce at certain levels to form laminae. The astrorhizal canals are not observable in vertical sections. "Caunopora" tubes, when present, are of the *Syringopora* type, with funnel-shaped tabulae. They are of small size, reaching a diameter of 0.3 mm., and are connected by horizontal stolons.

In tangential sections the skeletal mesh is completely reticulate, the pillars being united by processes of equal breadth to form a vermiculate network. Occasional irregularities in this network probably indicate the positions of horizontal astrorhizal canals, but these are not very abundant or highly organized. The skeletal fibre in the better-preserved parts of tangential sections is seen to be coarsely porous.

This form, of which only one undoubted specimen is available, differs somewhat from the typical examples of the species, since the skeletal mesh is rather finer, but is very similar to specimens from the Eifel and Büchel, Germany, in the Nicholson Collection (Brit. Mus. Nat. Hist., Reg. Nos. P5881, P5882). These, however, are in the "Caunopora" state, so that the skeletal mesh is a little less regular than that of the Victorian specimens. The radial pillars are long, slender and rather more crowded than in the typical form, and are connected occasionally by processes of similar breadth, but more frequently by thin, curved processes, which are much more abundant than in typical examples. There is no concentration of the processes at certain levels to form horizontal laminae. The German examples are rather better preserved than those from Buchan, but there is no doubt of the identity of the two forms.

Horizon.—Middle Devonian.

Localities.—Citadel Rocks, Murrindal River; Rocky Camp, Commonwealth Quarries.

Figured specimens.—Coll. Dept. of Geology, Univ. of Melbourne, Reg. No. 1601.

Hermatostroma Nicholson.

1886. *Hermatostroma* Nicholson, Mon. Brit. Strom., Gen. Introd., p. 105.

Stromatoporoids in which the coenosteum is massive, usually latilaminar, built up of horizontal laminae and continuous radial pillars, which are readily distinguished as separate skeletal elements within the skeletal mesh; skeletal fibre porous or tabulated; astrorhizae may be present.

Genotype.—*H. schlüteri* Nicholson, Mon. Brit. Strom., p. 105, pl. III., figs. 1, 2; pl. XXVIII., figs. 12, 13; wood-cuts, figs. 1, 16, 29, 30, 31, 32, 1886-1892. Middle Devonian of Hebborn, Paffrath district, Germany.

Hermatostroma episcopale Nicholson.

(Pl. V., figs. 7, 8.)

1892. *Hermatostroma episcopale* Nicholson, Mon. Brit. Strom., p. 219, pl. xxviii., figs. 4-11.

1934. *Hermatostroma episcopale* Le Maitre, Mem. Soc. Géol. du Nord, xii., p. 198, pl. xv., figs. 5, 6; pl. xvi., figs. 1, 2.

Coenosteum massive, latilaminar, built up of thick, undulating horizontal laminae and stout radial pillars which may traverse several interlaminar spaces; laminae 2-4 in 1 mm., pillars 2-3 in 1 mm.; astrorhizae present, probably not superimposed.

The surface characters of this form are not readily observable, since the large specimen from Heath's Quarry, on which this description is based, is incomplete. Broken surfaces show the laminae to be undulating, forming broad, low mamelons on which the astrorhizal systems, consisting of numerous horizontal canals 1 cm. or more in length, are situated. The radial pillars are very conspicuous on the broken surfaces, giving the laminae a dotted appearance.

TABLE 3.—CHARACTERS OF VICTORIAN SPECIES OF *Stromatopora*, AND OF SPECIES WITH WHICH THEY ARE COMPARED.

Species.	Horizon.	Locality.	Laminae in 2 mm.	Pillars in 2 mm.	Astrorhizae.	Form of Coenosteum.
1. Group of *Str. concentrica* Goldf.						
Str. typica v. Rosen	Yeringian ..	Loyola, V.	Irregular	8–12	Abundant ..	Massive
	Wenlock ..	Europe			Branched ..	Latilaminar
Str. foveolata (Girty)	Yeringian ..	Lilydale, V. ..	8	8–10	Abundant ..	Massive
	Devonian ..	Buchan, V.	Thick	Thick	Superimposed	
	L. Helderbergian ..	N. America		Discontinuous		
Str. concentrica Goldf.	M. Devonian ..	Buchan, V. ..	Irregular	7	Conspicuous ..	Massive
	M. Devonian ..	Europe ..	Indefinite		Superimposed ..	Latilaminar
Str. concentrica var. *colliculata* Nich.	M. Devonian ..	Buchan, V. ..	6–8	6	Rare in Victorian form, superimposed	Massive
	M. Devonian ..	Europe	Thick Undulating		European form	Non-latilaminar
2. Group of *Str. hupschii* (Bargatzky).						
Str. hüpschii (Barg.)	M. Devonian ..	Buchan, V. ..	6	6	Rare, indefinite ..	Massive, irregularly latilaminar
	M. Devonian ..	Europe ..	Processes not coalescing to form definite laminae			
Str. aff. *hupschii* (Barg.)	Yeringian ..	Lilydale, V. ..	Indefinite (lateral processes only)	3–4	Absent	Massive
Str. bucheliensis (Barg.)	Yeringian ..	Lilydale, V. ..	..	..	Small	Massive
		Loyola, V.	Indefinite (lateral processes only)	5–5	Branching, not superimposed	
	M. Devonian ..	Europe				
Str. bücheliensis var. *digitata* Nich. ..	Yeringian ..	Lilydale, V.	6	6	Absent	Composed of cylinders
	M. Devonian ..	Europe				
Str. lilydalensis, sp. nov.	Yeringian ..	Lilydale, V. ..	Indefinite	6	Absent	

In vertical section the coenosteum is seen to be composed of well defined horizontal laminae, reaching a thickness of 0.2-0.5 mm. and straight radial pillars of a similar thickness. These are sometimes confined to a single interlaminar space, but usually they traverse several laminae with their intervening spaces. The laminae may be periodically crowded, there being in some places as many as four or five in 1 mm., while in others they may be separated by nearly 1 mm., so that vertical sections have a banded appearance. In the better preserved parts of the specimen the laminae are seen to be composed of two parts, so that they have a median clear line similar to that sometimes seen in *Clathrodictyon regulare* (von Rosen), as well as in some species of *Stromatoporella*. The skeletal fibre is finely vesicular. In those parts of the coenosteum where the laminae are crowded, the interlaminar spaces are occupied by irregularly curved partitions ("interlaminar septa" of Nicholson), which form a coarsely vesicular mesh of a similar type, though on a larger scale, to that found within the better preserved laminae.

Tangential sections show the cut ends of the radial pillars as rounded, isolated cross-sections, in which the vesicular nature of the skeletal fibre is easily recognizable. The laminae are compact, with occasional perforations. The astrorhizae, owing to their large size and rather irregular distribution, are not conspicuous in tangential section.

In its external form this specimen is similar to *Hermatostroma schlüteri* Nich. of the Middle Devonian of the Paffrath district, Germany. It is latilaminar, and splits easily along the latilaminae, producing broadly undulating surfaces on which the ends of the radial pillars appear as conspicuous dots. It differs from this species, however, in the possession of large astrorhizae, and shows further in vertical section abundant "interlaminar septa," which give to such sections a characteristic vesicular aspect. Vertical sections of *H. schlüteri*, on the other hand, show a more open skeletal mesh, without vesicular tissue, though occasional "interlaminar septa" may be present. The skeletal fibre of the Victorian specimen appears in the best preserved parts of vertical sections to be minutely vesicular, and no sign of the extensive canal system characteristic of *H. schlüteri* can be observed. Nicholson notes in describing *H. episcopale*, in which the skeletal fibre is porous but without canals, that the solid appearance of the fibre in *H. schlüteri* may be due to imperfect preservation. An examination of the type specimen of *H. schlüteri* (Brit. Mus. Nat. Hist., Reg. No. P5527) suggests that the canals also are largely the result of an unusual mode of preservation in which the axial regions of the pillars have been infiltrated with dark-coloured material, and some sections of *H. episcopale* (B.M.N.H., Reg. No. P5691) show the beginnings of a similar process, though here the minutely vesicular structure of the skeletal fibre is still obvious. Some traces of this structure, however, are discernible in the less altered parts of vertical sections of *H. schlüteri.*

Horizon.—Middle Devonian.

Locality.—Heath's Quarry.

Figured specimen.—Coll. Dept. of Geology, Univ. of Melbourne, Reg. No. 1612.

Hermatostroma episcopale var. buchanensis, var. nov.

(Pl. V., figs. 9, 10.)

A variant of this species, occurring in the Middle Devonian limestones at Murrindal, near Buchan, appears to be sufficiently distinct for separation as a variety. The skeletal mesh is of the same type as that of *H. episcopale,* but is much more irregular, and usually rather coarser. The coenosteum is massive, with indefinite latilaminae, built up of thick, undulating, widely spaced laminae which may be separated by as much as 1 mm. The laminae have an average thickness of 0.3 mm. and are traversed by radial pillars of a similar breadth. The pillars are quite often restricted to one interlaminar space, and a characteristic appearance is given to vertical sections by the tapering ends of the pillars, which project into an interlaminar space after crossing a number of laminae. "Interlaminar septa" are very abundant, particularly in those parts of the coenosteum where the laminae are very remote, and the skeletal mesh shows, in the interlaminar spaces, a distinct resemblance, on a small scale, to that of *Labechia.*

Tangential sections show no features of special interest. The cut ends of the radial pillars appear as large rounded cross-sections which are isolated in the interlaminar spaces and coalesce on the planes of the laminae, forming dense plates with few perforations. Astrorhizae have not been observed in the tangential sections so far examined. These, however, are necessarily of small extent on account of the irregular mode of growth of the form. It is possible, therefore, that remote and poorly organized systems would not affect the skeletal mesh as seen in such sections.

Horizon.—Middle Devonian.

Locality.—Near Hicks', Murrindal.

Figured specimens.—Coll. Dept. of Geology, Univ. of Melbourne, Reg. Nos. 1602 (vertical section), 1603 (tangential section).

Notes on the Faunas.

The distribution and relative abundance of the stromatoporoid species occurring in the Buchan limestones are indicated below :—

Species.	Localities.				
	Rocky Camp.	Near Hicks'.	Citadel Rocks.	Cameron's Quarry.	Heath's Quarry.
Actinostroma compactum Ripper	*c*	..	..	..	*cc*
A. stellulatum var. *distans*, var. nov.	..	..	..	..	*cc*
A. contortum, sp. nov.	*c*	*x*	..	..	*x*
Clathrodictyon regulare (v. Rosen)	..	*x*	..	..	*r*
C. convictum Yavorsky	..	..	..	..	*x*
C. convictum var. *delicatula*, var. nov.	*r*	..	..	*c*	..
C. clarum Počta	*c*	*x*	..	*x*	..
Stromatopora aff. *foveolata* (Girty)	*r*	..	..	..	..
S. concentrica Goldfuss	*c*	*c*	*x*	*cc*	*fc*
S. var. colliculata Nicholson	*x*	*fc*	..	..	*fc*
S. hüpschii (Bargatzky)	?	..	*x*	..	..
Hermatostroma episcopale Nicholson	..	..	..	..	*r*
Hermatostroma episcopale var. *buchanensis*, var. nov.	..	*fc*	..	..	..

In the above Table—

x indicates the occurrence of a species.
r indicates that it is rare.
fc indicates that it is fairly common.
c indicates that it is abundant.
cc indicates that it is very abundant.

Stromatoporoids are abundant in the limestones at Buchan, but the faunas, while being rich in individuals, usually contain a relatively small number of species, of which one or two may be particularly abundant and lend character to the assemblage.

Citadel Rocks, Murrindal River: The stromatoporoids are here associated with *Syringopora speleana* Eth. fil., of Middle Devonian age. Only two species, *Stromatopora concentrica* Goldfuss and *S. hüpschii* (Barg.), both occurring also in the Middle Devonian limestones of the Torquay district and in the Givetian (Middle Devonian) of the Eifel, Germany, have so far been found.

Near Hicks', Murrindal: The stromatoporoids are associated with "*Cyathophyllum heterophyllum*" of Middle Devonian age. The fauna consists of six forms, four of which have already been described from other regions:

Clathrodictyon clarum Počta	Ff2 (Lower Devonian)	Bohemia.
C. regulare (von Rosen)	Wenlock	Great Britain. Gotland.
Stromatopora concentrica Goldfuss	Givetian	Devon, Eifel.
Stromatopora concentrica var. *colliculata* Nicholson	Givetian	Devon, Eifel.
and one is a variety of		
Hermatostroma episcopale Nicholson	Givetian	Devon.

The remaining species, *Actinostroma contortum*, sp. nov., is most closely allied to *A. stellulatum* Nich. of the Givetian of Devon and the Eifel.

CAMERON'S QUARRY: The fauna here, associated with corals of Middle Devonian type, is a small one, containing only four species, of which three are well-known European forms. *Clathrodictyon confertum* Nicholson is fairly abundant in the Middle Devonian limestones of Torquay, South Devon, and *Stromatopora concentrica* Goldfuss, one of the most frequently occurring forms (five in a collection of nine specimens), is a characteristic species in the Givetian of Great Britain and Germany. *Clathrodictyon clarum* Počta, which is rather rare in this fauna, is abundant in the Lower Devonian of Bohemia. The fourth form, which is fairly abundant, is a variety of *Clathrodictyon convictum* Yavorsky, occurring in the Upper Oesel beds (Upper Silurian) of Kattri-pank, Oesel. As far as can be judged from the few species present, therefore, this fauna has Middle Devonian affinities.

ROCKY CAMP, COMMONWEALTH QUARRIES: The fauna consists of eight species, of which five also occur in other faunas:

Clathrodictyon clarum Počta	Ff2 (Lower Devonian)	Bohemia.
Stromatopora foveolata (Girty)	Helderbergian	New York.
S. concentrica Goldfuss	Givetian	Devon, Eifel.
S. concentrica var. *colliculata* Nich.	Givetian	Devon, Eifel.
S. hüpschii (Barg.)	Givetian	Devon, Eifel, Paffrath.

Of the remaining species, *Actinostroma compactum* Ripper occurs also in the Yeringian limestone of Lilydale, and is of the type of *A. clathratum* Nich., a characteristic Middle Devonian species in Great Britain and Europe. *A. contortum*, sp. nov., has affinities with *A. stellulatum* Nich. of the Middle Devonian of Great Britain and Europe. Of rare occurrence is *Clathrodictyon convictum* var. *delicatula*, var. nov., a variety of a form present in the Upper Oesel beds of Oesel. The presence of this Upper Silurian species of *Clathrodictyon*, *A. compactum* and *Stromatopora* aff. *foveolata*, an intermediate transient in the *Syringostroma-Stromatopora* series, suggests that the limestone at this locality may possibly be on a lower horizon than that of the other localities whose stromatoporoid faunas have been examined, though two of the three most abundant species, *A. contortum* and *S. concentrica*, are of Middle Devonian type. The third, *C. clarum*, occurs in the Lower Devonian of Bohemia, and is also found, in less abundance and associated with stromatoporoid faunas of more definite Middle Devonian affinities, at other localities within the Buchan district.

HEATH'S QUARRY: Stromatoporoids are very abundant, but the fauna is relatively poor in species, owing to the great abundance of certain forms which dominate the assemblage.

The following species occur also in other assemblages (excluding those from Victoria):

Clathrodictyon regulare (von Rosen)	Wenlock	Great Britain. Gotland.
	Coblenzian-Eifelian	France.
C. convictum Yavorsky	Upper Oesel	Oesel.
Stromatopora concentrica Goldfuss	Givetian	Devon, Eifel.
Stromatopora concentrica var. *colliculata* Nicholson	Givetian	Devon, Eifel.
Hermatostroma episcopale Nicholson	Givetian	Devon.

as well as a variety of *A. stellulatum* Nich., which is characteristic of the Givetian of Great Britain and Germany. *A. contortum*, sp. nov. and *A. compactum* Ripper are so far known only from Victoria: the first is fairly abundant at some other localities in the Buchan district, notably at Rocky Camp, where it makes up over 40 per cent. of the assemblage. *A. compactum*, first described (Ripper, 1937) from the Yeringian limestone of Lilydale, is more abundant here than at the type locality, making up 38 per cent. of the assemblage, and is present also, though less abundantly, at Rocky Camp. The whole assemblage probably indicates a Middle Devonian age, despite the presence of forms usually occurring in the Wenlock and the Upper Oesel. These, however, are rare, making up little over 5 per cent. of the fauna. The most abundant forms are *Act. stellulatum* var. *distans*, *A. compactum* and *Str. concentrica* and its variety *colliculata*, which are either themselves typically Middle Devonian, or belong to groups commonly occurring at that horizon.

Summary.

This paper deals with the stromatoporoid faunas of the Middle Devonian limestones of the Buchan district, and the descriptions of species are based on collections made from five localities within the district. Fourteen species and varieties are described, of which the following are new:

Actinostroma stellulatum var. *distans*, var. nov.

A. contortum, sp. nov.

Clathrodictyon convictum var. *delicatula*, var. nov.

Hermatostroma episcopale var. *buchanensis*, var. nov.

The stromatoporoid assemblages have, in the main, definite Middle Devonian affinities, though typical Wenlock species, e.g., *Clathrodictyon regulare* (von Rosen), persist and make up a small proportion of the fauna. The limestone at Rocky Camp, Buchan, may possibly be on a lower horizon than that of the other localities, since it contains a higher proportion of Upper Silurian and Lower Devonian forms, though even here the typically Middle Devonian species predominate and give character to the assemblage.

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Explanation of Plates.

Plate II.

Fig. 1.—*Actinostroma stellulatum* var. *distans*, var. nov. Heath's Quarry, Buchan. Vertical section showing axial canal of an astrorhizal system. Coll. Dept. of Geology, Univ. of Melbourne, Reg. No. 1610. × 8.5 approx.

Fig. 2.—Same species and variety. Tangential section of the same specimen. × 8.5 approx.

Fig. 3.—*Actinostroma contortum*, sp. nov. Heath's Quarry, Buchan. Vertical section. Coll. Dept. of Geology, Univ. of Melbourne, Reg. No. 1611. × 8.5 approx.

Fig. 4.—Same species. Tangential section of the same specimen. × 8.5 approx.

Fig. 5.—Same species. A finer variety. Rocky Camp, Buchan. Vertical section. Coll. Dept. of Geology, Univ. of Melbourne, Reg. No. 1604. × 8.5 approx

Fig. 6.—Same species. Tangential section of the same specimen. × 8.5 approx.

Fig. 7.—*Actinostroma compactum* Ripper. Heath's Quarry, Buchan. Vertical section. Coll. Dept. of Geology, Univ. of Melbourne, Reg. No. 1617. × 8.5 approx.

Fig. 8.—Same species. Tangential section of the same specimen. × 8.5 approx.

Plate III.

Fig. 1.—*Clathrodictyon regulare* (von Rosen). Heath's Quarry, Buchan. Vertical section. Coll. Dept. of Geology, Univ. of Melbourne. Reg. No. 1618. × 8.5 approx.

Fig. 2.—Same species. Tangential section of the same specimen. × 8.5 approx.

Fig. 3.—*C. confertum* Nicholson. Cameron's Quarry, Buchan. Vertical section. Coll. Dept. of Geology, Univ. of Melbourne, Reg. No. 1607. × 8.5 approx.

Fig. 4.—*C. convictum* Yavorsky. Heath's Quarry, Buchan. Vertical section. Coll. Dept. of Geology, Univ. of Melbourne, Reg. No. 1616. × 4 approx.

Fig. 5.—Same species. Vertical section of the same specimen. × 8.5 approx.

Fig. 6.—Same species. Tangential section of the same specimen. × 8.5 approx.

Fig. 7.—Same species. Form showing affinities with *C. calamosum* Ripper. Heath's Quarry, Buchan. Vertical section. Coll. Dept. of Geology, Univ. of Melbourne, Reg. No. 1613. × 8.5 approx.

Fig. 8.—Same species. Tangential section of the same specimen. × 8.5 approx.

Plate IV.

Fig. 1.—*Clathrodictyon convictum* var. *delicatula,* var. nov. Rocky Camp, Buchan. Vertical section. Coll. Dept. of Geology, Univ. of Melbourne, Reg. No. 1660. × 8.5 approx.

Fig. 2.—Same species and variety. Tangential section of the same specimen. × 8.5 approx.

Fig. 3.—*C. clarum* Počta. Rocky Camp, Buchan. Vertical section. Coll. Dept. of Geology, Univ. of Melbourne, Reg. No. 1605. × 8.5 approx.

Fig. 4.—Same species. Tangential section of the same specimen. × 8.5 approx.

Fig. 5.—*Stromatopora* aff. *foveolata* (Girty). Rocky Camp, Buchan. Vertical section. Coll. Dept. of Geology, Univ. of Melbourne, Reg. No. 1609. × 4 approx.

Fig. 6.—Same form. Tangential section of the same specimen. × 4

Fig. 7.—*S. concentrica* Goldfuss. Rocky Camp, Buchan. Vertical section. Coll. Dept. of Geology, Univ. of Melbourne, Reg. No. 1608. × 4 approx.

Fig. 8.—Same species. Tangential section of the same specimen. × 4 approx.

Plate V.

Fig. 1.—*Stromatopora concentrica* Goldfuss. Heath's Quarry, Buchan. Vertical section. Coll. Dept. of Geology, Univ. of Melbourne, Reg. No. 1615. × 4 approx.

Fig. 2.—Same species. Tangential section of the same specimen. × 4 approx.

Fig. 3.—*S. concentrica* var. *colliculata* Nicholson. Heath's Quarry, Buchan. Vertical section. Coll. Dept. of Geology, Univ. of Melbourne, Reg. No. 1614. × 4 approx.

Fig. 4.—Same species and variety. Tangential section of the same specimen. × 4 approx.

Fig. 5.—*S. hüpschii* (Bargatzky). Citadel Rocks, Murrindal River, Buchan. Vertical section. Coll. Dept. of Geology, Univ. of Melbourne, Reg. No. 1601. × 4 approx.

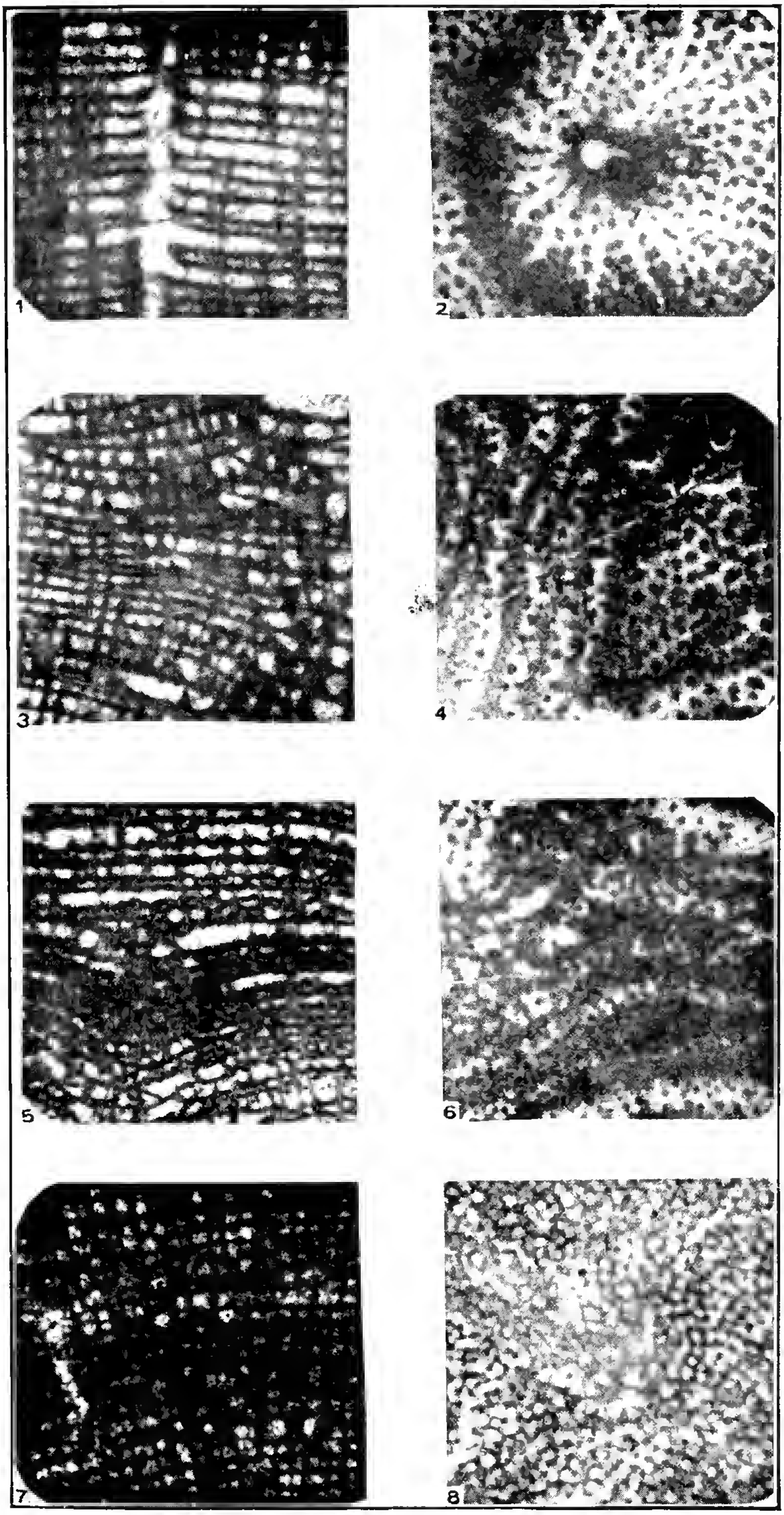
Fig. 6.—Same species. Tangential section of the same specimen. × 4 approx.

Fig. 7.—*Hermatostroma episcopale* Nicholson. Heath's Quarry, Buchan. Vertical section. Coll. Dept. of Geology, Univ. of Melbourne, Reg. No. 1612. × 4 approx

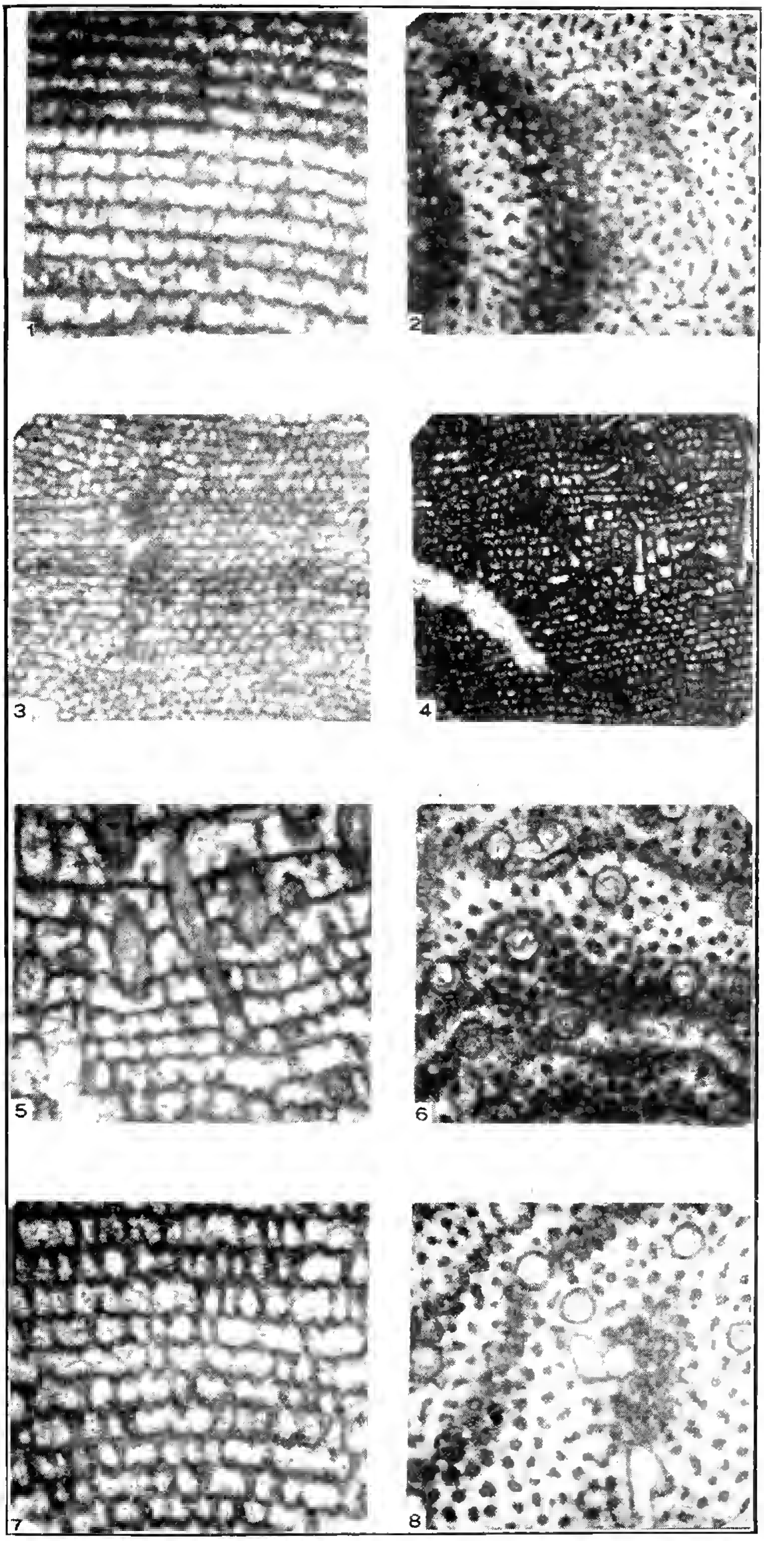
Fig. 8.—Same species. Tangential section of the same specimen. × 4 approx.

Fig. 9.—*H. episcopale* var. *buchanensis,* var. nov. Near Hicks', Murrindal, Buchan. Vertical section. Coll. Dept. of Geology, Univ. of Melbourne, Reg. No. 1602. × 4 approx.

Fig. 10.—Same species and variety. Tangential section of another specimen from the same locality. Coll. Dept. of Geology, Univ. of Melbourne, Reg. No. 1603. × 4 approx.



Buchan Stromatoporoids.



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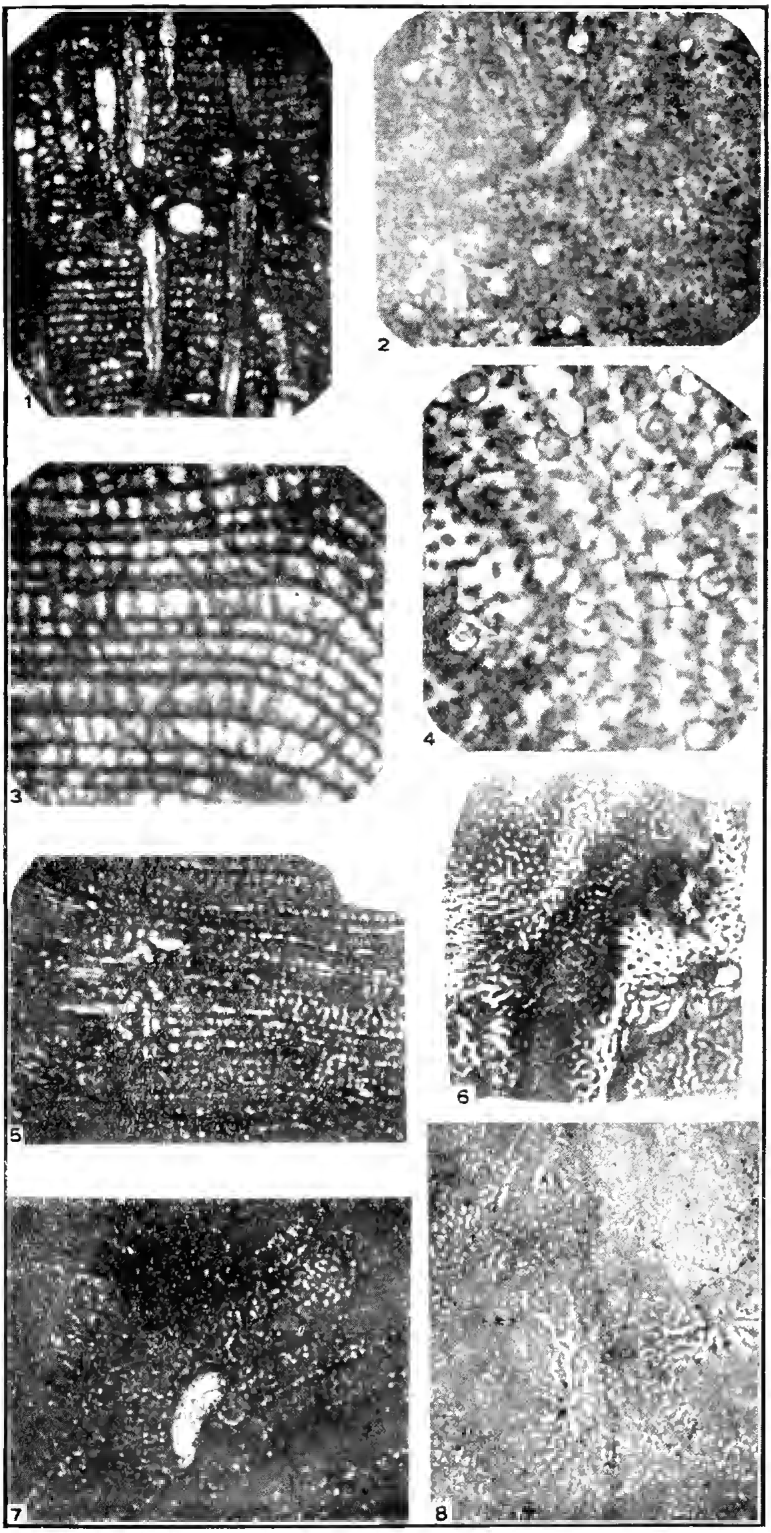

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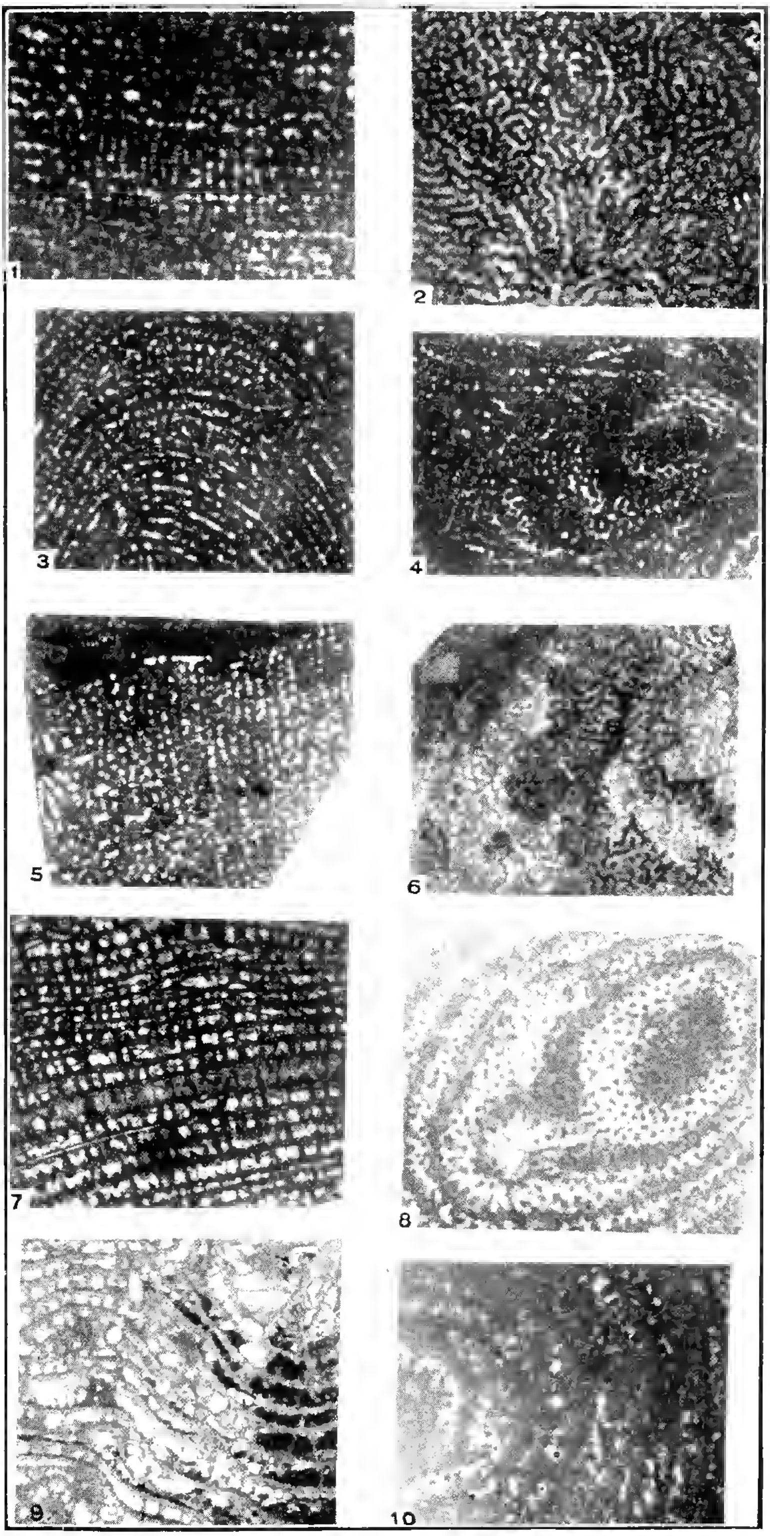

Buchan Stromatoporoids.

[Proc. Roy. Soc. Victoria, 50 (N.S.), Pt. I., 1937.]

Art. III.—*Orthite in Some Victorian Granitic Rocks.*

By GEORGE BAKER, M.Sc.

[Read 8th April, 1937; issued separately, 29th December, 1937.]

Introduction.

A search for the cerium-bearing epidote mineral known as orthite or allanite in Victorian granitic rocks, subsequent to its discovery in the You Yangs granite (1), has revealed its presence in granitic rocks occurring at Tynong, Mt. Eliza, South Morang, Zumstein's Crossing in the Grampians, Selby, Yackandandah, Mt. Wycheproof, Maude, Junction of the Mitta Mitta River and the Bundarrah River, Stawell, Dergholm, and Tarnagulla. The majority of these outcrops present evidence of having been contaminated by assimilation. The orthite crystals are of microscopic size and occur too sparsely for chemical analysis.

Mode of Occurrence.

The orthite is not of common occurrence, and most of the crystals so far observed are found in granitic rocks containing xenoliths or basic clots and schlieren. The greatest concentration occurs in basic schlieren at the You Yangs, where orthite locally constitutes 3.5 per cent. of the rock, and sometimes occurs in groups of three or four crystals wedged between biotite and hornblende (fig. 12). In the granitic rocks, the orthite would represent only a small fraction of 1 per cent., and it usually occurs as more or less idiomorphic, isolated crystals. Biotite is moulded around many of the orthite crystals, and a few lie in contact with sphene and hornblende. Several occur independently of the ferromagnesian minerals and are surrounded by quartz or felspar.

The following table indicates the distribution of observed crystals of orthite in Victorian granitic rocks. The minerals listed as associated minerals are those which are most frequently found in direct contact with the orthite crystals. Biotite, quartz, and felspar are omitted from the list because, being the important essential minerals of the rocks in which the orthite occurs, they are commonly found associated with many of the orthite crystals.

A total of 409 rock sections from the University collection was examined for orthite, this number representing about 100 different localities of granitic rocks in Victoria. Of the total number, 178 sections were from rocks collected from the thirteen localities listed in the table, but only 43 of them were found to contain orthite. The totals for each rock type examined are as follows:—Granites, 147 sections, granodiorites (including the

TABLE I.

	Location.	No. of Slides Examined.	No. of Slides with Orthite.	No. of Orthite Crystals.	Associated Minerals. Hornblende.	Sphene.	Epidote.	Xenoliths.
Granites.	You Yangs	38	9	23	x	x	..	x
	Dergholm	5	1	1	x	x	x	x
	Stawell	4	4	17	..	..	..	..
	Mitta Mitta Bundarrah River Junction ..	2	1	1	..	..	x	..
	Maude	2	1	3	..	x	..	..
	Mount Wycheproof	2	1	1	..	..	x	..
	Tynong	8	2	8	x	x	..	x
Granodiorites.	Tarnagulla	2	2	3	x	x	..	..
	Mount Eliza	2	1	1	x	x	..	x
	South Morang	3	1	1	x	x	..	x
	Zumstein's Crossing, Grampians	2	1	2	x	x	..	x
	Selby	2	1	2	x	x	..	x
	Yackandandah	1	1	2	..	x	x	x
Basic Schlieren.	You Yangs	5	5	34	x	x	..	x
	Tynong	1	1	4	x	x	x	x
Xenoliths.	You Yangs	99	11	17	x	x	..	

so-called adamellites), 111 sections, xenoliths, 145 sections and basic schlieren, 6 sections. Out of a total of 120 crystals of orthite observed, one-third occurred in the basic schlieren of the You Yangs. Granites contained four times as many crystals as granodiorites. Ninety-six of the crystals occurred in rocks containing sphene and hornblende, whilst You Yangs rocks contained augite in addition. Five were in rocks containing sphene but no hornblende, and the remaining nineteen in rock types which possessed neither sphene nor hornblende, the Stawell granite being outstanding amongst such examples. Epidote was neither common nor widespread in the orthite-bearing rocks.

Description of Victorian Orthites.

Orthite is a monoclinic mineral, and it possesses very variable physical, chemical, and optical properties. The crystals vary in size from 0.2 mm. to almost 3 mm., and are commonly prismatic, being sometimes elongated along the direction of the c-axis (fig. 4). In cross section, some appear diamond-shaped (figs. 6 and 10), others are sub-ovoidal (fig. 9), or more or less irregular (fig. 7). Some of the orthite crystals in the granite and xenoliths from the You Yangs have been corroded in contact with biotite and hornblende (figs. 2 and 6), and others in contact with quartz and felspar (fig. 1). Sometimes the corrosion is restricted to one visible face of the crystal (figs. 3, 5, and 8). The largest and best developed crystals are found in basic schlieren from the You Yangs (1), where an occasional lens-shaped form is present (fig. 18).

The colour varies from colourless, pale yellowish-brown, pale green, greenish-brown, and deeper shades of brown to red. The deep red colouration of some altered crystals appears to be due to ferric oxide, since hematite occurs along cracks and cleavages, and outlining the other minerals in rocks which contain red orthite. Fresh cores and remnants in orthite crystals, such as those indicated by dotted areas in figures 3, 13, 14 and 20, are pleochroic from greenish-brown to reddish-brown.

Iddings records strong basal cleavage in fresh orthite (5), but no traces of cleavage were observed in any of the Victorian examples. The irregular cracks which traverse most crystals (figs. 2, 3, 7, 10, and 22), may represent (100), (110), and (010) cleavage traces, as is stated to be the case by Michel-Lévy and Lacroix in some of the French occurrences (11). Occasionally the cracks are curved as in fig. 19.

Simple twinning, with the twin plane parallel to (100), has been observed in three crystals, one of which possesses a marked "composition seam" (fig. 20), similar to that described by Hobbs (4, p. 226).

Zoning occurs parallel to the outline of the crystal form as in figs. 16 and 17, but it is often "chevron-shaped" as indicated in figs. 4. 13, 14, 20. and 23. Lacroix figures orthite crystals with zoning similar to the "chevron type" from an amphibole gneiss at Geffren-en-Roscoff (8, p. 139), and Hobbs figures similar examples from the hornblende granite of Ilchester, U.S.A. (4, p 226). Michel-Lévy and Lacroix state that nearly all of the orthite crystals from Pont Paul in France, are zoned (11), so it appears that zoning is a common characteristic of the mineral orthite.

In the Victorian granitic rocks fresh and partly altered remnants of orthite are frequently zoned by much more altered material, the nature of which is uncertain. Clarke considers that the altered material in allanite consists of carbonates of the cerium group (2), but Watson records only slight traces of carbonates in the outer zones of weathered allanite (13). The alteration zones in some of the Victorian occurrences are quite rust-coloured (fig. 17), and in others, these zones consist of indeterminable "earthy" material (figs. 4 and 5).

The pale coloured peripheral zones in orthite crystals from Tynong, Stawell, and the You Yangs, often contain dendritic inclusions of black iron oxide (figs. 3 and 21), and other crystals possess an outer fringe of similar material (fig. 11), which appears to have been derived from the alteration of fresh orthite. Other inclusions in the orthite consist of needles and stout prisms of apatite (figs. 1, 5, 18, and 19), rounded grains of diopside (fig. 1), rutile (fig. 20), and zircon (figs. 1, 5, 12, and 16). The apatite and zircon themselves contain smaller inclusions. Mennell has recorded similar inclusions from the granites of Northern Rhodesia (10, p. 3), and Iddings and Cross record inclusions of sphene in addition (6, p. 110).

Small rounded crystals of orthite are frequently enclosed by biotite (fig. 15), and rarely by hornblende (fig. 9). Michel-Lévy and Lacroix have recorded allanite crystals enveloped by biotite in the granite of Pont Paul, and state that pleochroic haloes are produced as intense as those formed by zircon (11, p. 67). This also applies to the Victorian examples, where haloes are always developed when orthite is in contact with biotite, and only in rare occurrences is a halo produced in hornblende (fig. 9), even though this mineral is often observed in contact with orthite. The haloes indicate the presence of one or more radio-active elements, and their width, which is 0.04 mm., would be due to Thorium C_2 according to Joly (7).

The variable composition of orthite is revealed in the optical characters of some U.S.A. examples according to Watson (14, p. 7), and optical examination shows that the Victorian occurrences are similarly variable. Crystals extinguish up to an angle of 45°. In one crystal from the You Yangs, a fresh inner core has an extinction angle of 30°, whilst the somewhat altered outer zone extinguishes at 15°. The refractive index varies with the degree of alteration, being much lower in the altered examples than in the fresh pleochroic portions. When very much altered, crystals of orthite become isotropic, as in some of the Mitta Mitta River-Bundarrah River junction, You Yangs, and Zumstein's Crossing examples. The fresh pleochroic cores and zones have a low birefringence, and they are biaxial and negative.

In general, the Victorian orthites conform with Watson's conclusion that isotropic allanite represents the altered form of the original crystalline mineral (14, p. 7). Larsen obtained results which indicate that birefringent crystalline allanite was secondary in some specimens, and derived from the isotropic form (9). He describes allanite crystals from U.S.A. as consisting of three minerals, a pale sensibly isotropic mineral, a weakly birefringent portion, pleochroic in green and yellow with a slightly higher refractive index, and a third more strongly birefringent with a still higher refractive index. In these variations, he considers that the oxidation of the iron present is probably an important factor These three variations are represented in the Victorian examples of orthite, where in some crystals the iron has separated out as oxides and hydrous oxides in the altered outer zones (fig. 21).

Epidote—Orthite Association.

Dana classifies orthite in the epidote group, with which it is isomorphous, and in which it may be enclosed as a nucleus (3). Iddings refers to the intergrowth of orthite and epidote in parallel orientation in some of the U.S.A. granites, and he states that the two minerals are pyrogenetic (5). Mennell records zoned orthite surrounded by epidote in a granite from Kaloma in Northern Rhodesia (10).

Orthite has been observed in association with epidote in two Victorian granitic rocks. In the Yackandandah granodiorite, two well developed crystals are fringed at the ends with small prisms of pale green epidote (fig. 22). These fringes appear to be marginal alteration products of orthite. In the muscovite granite from Mount Wycheproof, a small rounded crystal of orthite is enveloped by a narrow continuous rim of epidote, which may perhaps be due to alteration similar to that recorded by Iddings and Cross (6, p. 111). On the other hand, both the orthite and the epidote may be pyrogenetic in origin. In other Victorian examples showing less definite epidote-orthite associations, the epidote is an alteration product of the orthite, but instead of having clearly defined prisms of epidote produced as in the Yackandandah occurrence, the angles of the crystals consist of a fine-grained mixture of orthite and epidote (figs. 10 and 19), showing mottled polarization colours. In such examples, the interiors of the orthite crystals have become almost isotropic.

The Origin of the Orthite.

Clarke states that orthite is widely diffused as a primary accessory mineral in many igneous rocks (2), and Dana records it in albitic and common felspathic granites (3). On the other hand, Watson states that orthite may be formed by contact metamorphism (13, p. 465), and he records it as locally abundant in marginal facies of some Montana, U.S.A. granitic batholiths at contacts with sediments. He considers that when formed as a product from the consolidation of a molten magma, the mineral is invariably in small grains and crystals of microscopic size. Mennell regards the orthite in the granites of Northern Rhodesia as a normal product of consolidation on account of the idiomorphic nature of the crystals in contact with mica, and he records associated minerals as sphene, hornblende, and abundant epidote (10, p. 4).

The orthite crystals in the granitic rocks of Victoria are of microscopic dimensions, and are idiomorphic towards biotite, hornblende, sphene, quartz, and felspar, so that according to Watson's and Mennell's statements, they would be formed as primary accessories from the consolidation of a molten mass. This may apply to some of the Victorian occurrences, but not to all of them.

Some of the orthite crystals contain inclusions of zircon, apatite, and rutile, so that the orthite crystallized after these accessory minerals. Since it is idiomorphic towards the other constituents, its position in the order of crystallization in these examples, is between that of the accessory and ferromagnesian minerals. The orthite therefore appeared early in the sequence of consolidation, this being in agreement with Hobbs' statement that allanite is one of the earliest separations from the magma (4, p. 228). Iddings and Cross record sphene as an inclusion in allanite, and state that the inclusions are found in such connection as to indicate contemporaneous growth (6, p. 110). In Victorian examples, sphene is only observed moulded on orthite crystals (figs. 7 and 12), so that the orthite crystallized before sphene.

In foreign xenoliths of igneous origin in the You Yangs granite (1), orthite includes grains of diopside which have been produced as a result of reconstitution processes within the xenoliths. The crystals of orthite in this granite are therefore probably xenocrysts obtained from the xenoliths. In the basic schlieren in the Tynong granite, hornblende, biotite, and sphene are plentiful and some orthite is present, but in portions of this granite which show little or no evidence of contamination, hornblende and orthite are wanting, and sphene and biotite subordinate in amount compared with their occurrence in the schlieren. It therefore appears that the sphene and ferromagnesian minerals were developed as a result of contamination, and became strewn about through parts of the granite. Since the orthite is intimately associated with these minerals, it may also have resulted in like manner, and so would be assigned a contamination mode of origin. Where orthite occurs in contaminated granitic rocks, but has not been observed in the xenoliths associated with them, it may be that the orthite crystals developed in the granite magma only after it had become contaminated by the addition of foreign material. Orthite that occurs in granitic rocks showing no evidence of contamination is most probably a primary accessory mineral. Examples of such are the granites of Stawell, Mount Wycheproof, and the outcrop at the junction of the Mitta Mitta River and the Bundarrah River, and in them, zonal alteration of orthite is subordinate, and crystals are much smaller than those developed in granitic rocks which provide definite evidence of contamination by assimilation.

In the Tynong and You Yangs granites, it has been shown that sphene, hornblende, and biotite may arise from contamination processes, and that, since orthite is intimately associated with these minerals, it also may develop from similar processes. Several other Victorian granitic rocks which possess sphene, hornblende, and biotite thought to have been derived by assimilation of foreign material, were examined for the mineral orthite and found to contain no trace of it. In addition, examination of several sections of the contaminated granites of North-Eastern Victoria (12), and basic clots from the Maldon and Pyramid Hill granites, failed to reveal orthite; neither was it observed in the granite itself from these last two localities: such rocks are free from hornblende and contain very little sphene. From the foregoing evidence, the conclusion is that although orthite is commonly associated with hornblende, sphene and biotite in some of the Victorian granitic rocks which have suffered contamination, the presence of these minerals does not necessarily imply the presence of orthite.

The variability in the composition of the orthite is probably due to the chemical attack of the magma, which resulted in embayment of crystal contours, zonal alteration, partial or complete destruction of internal structure and decolouration from leaching out of iron. The zones with a rust-like appearance in some of the orthites may have developed as a result of successive pauses during crystal growth. An already formed crystal may have been partially decolourized by leaching out of iron, and the oxides so formed deposited in the peripheral zone of the crystal. Continuation of crystallization may then build up the crystal, and the newly formed zone may again be subjected to leaching with the deposition of another rust-like zone in the periphery of the crystal. Repetition of these processes would result in the development of three or four alternating zones of rust-like material and pale coloured orthite. The same processes may have resulted in the production of those crystals which possess fresh pleochroic cores and remnants alternating with pale coloured orthite, but in them, leaching was not complete.

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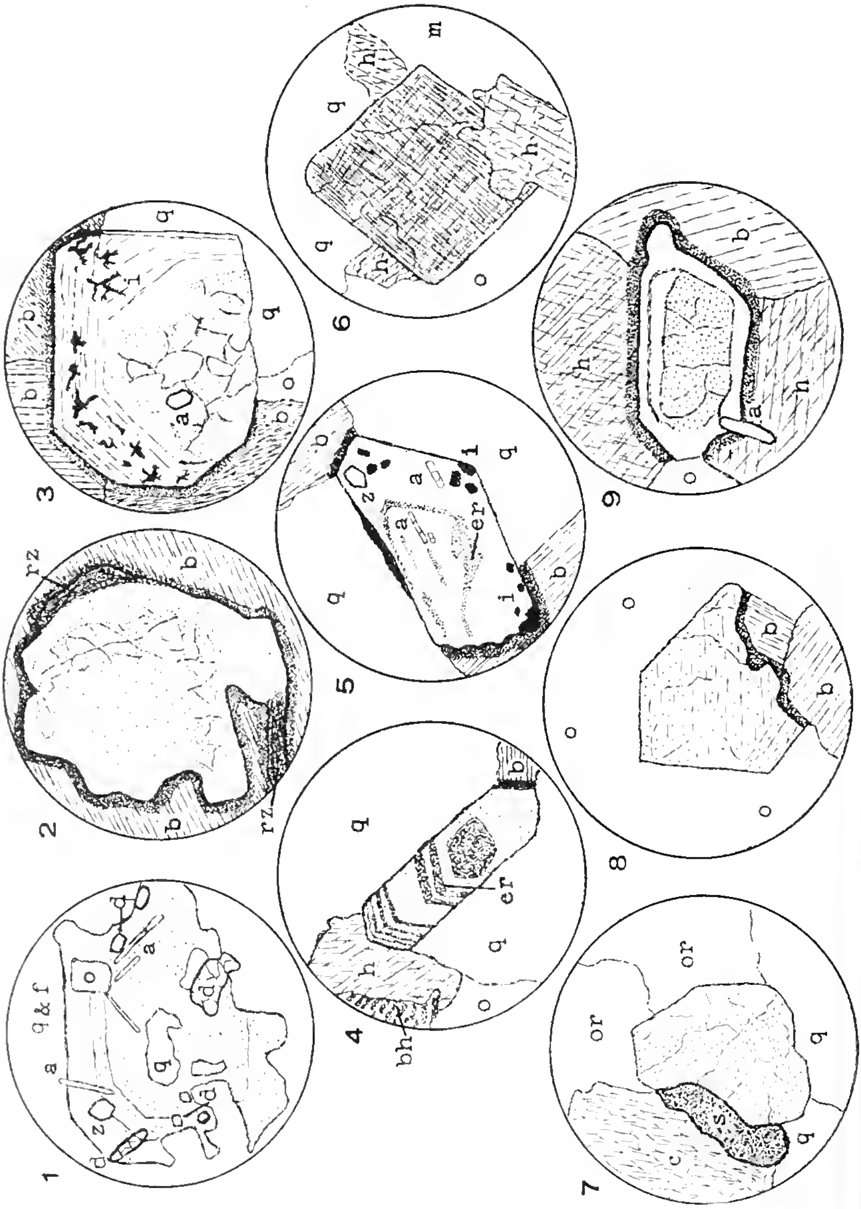
Explanation of Figures.

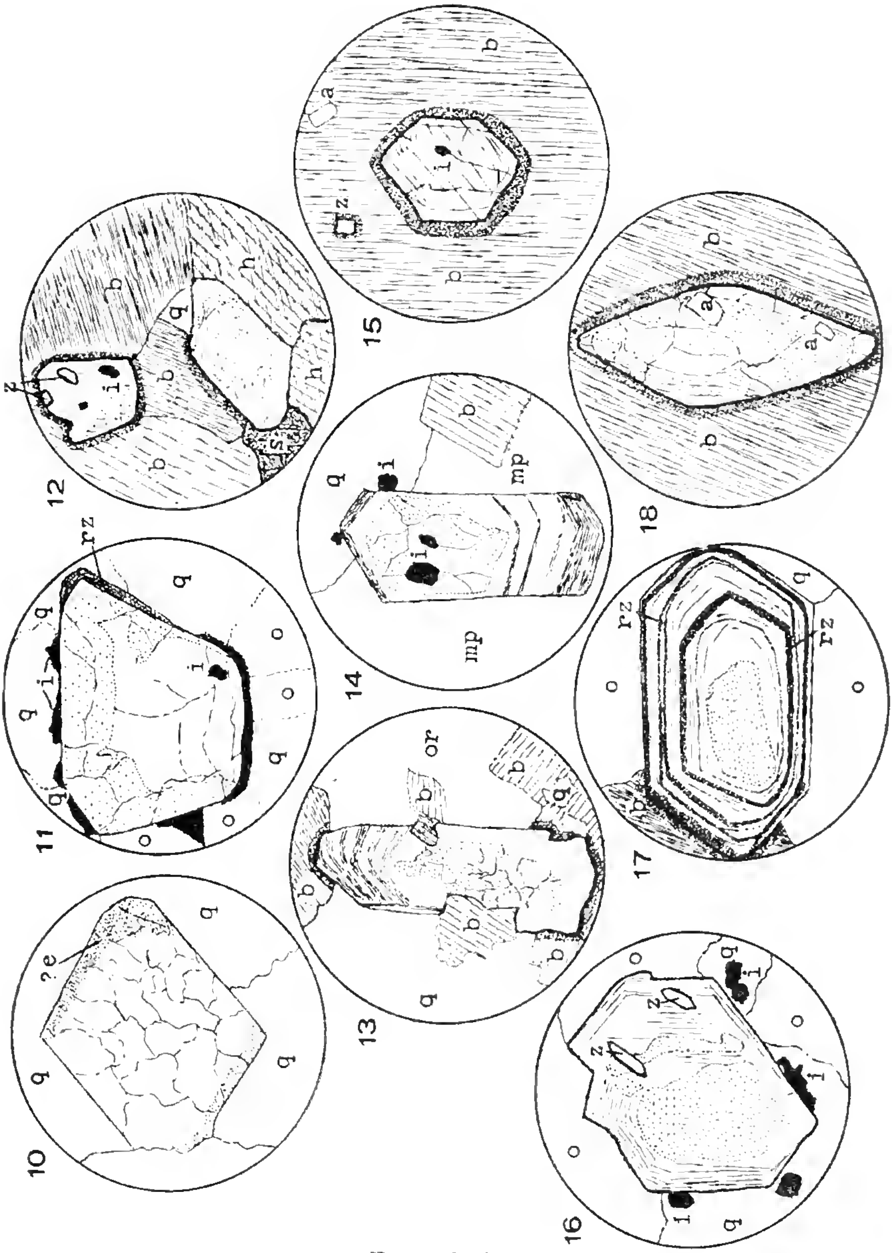
SKETCH MICROSECTIONS OF ORTHITE SHOWING FORM AND MINERAL ASSOCIATIONS. a — apatite, z — zircon, q — quartz, f — felspar, d — diopside, b — biotite, i — iron oxides, o — oligoclase, m — microcline, bh — biotite dactylitic with hornblende, h — hornblende, c — chlorite, s — sphene, or — orthoclase, e — epidote, mp — microperthite, r — rutile, rz — rust-coloured zone, er — "earthy" material, ?e — polarizing aggregate, probably of epidote.

1. Inclusions of diopside, apatite and zircon in crystal corroded in contact with quartz and felspar. Xenolith, You Yangs. × 75.
2. Corroded crystal with cracked pleochroic remnants, included in biotite, and possessing an outer rust-coloured zone and a pleochroic halo against biotite. Granite, You Yangs. × 75.
3. Dendritic inclusions of iron oxide in the outer zones of a crystal showing (001), (100) and (110) faces, with one edge imperfectly developed. Basic schlieren, You Yangs. × 35.
4. "Chevron-like" zoning of "earthy" material in prismatic crystal. Pleochroic against biotite, but non-pleochroic against hornblende. Basic schlieren, You Yangs. × 35.
5. "Earthy" products and inclusions in prismatic crystal showing ragged termination. Basic schlieren, You Yangs. × 35.
6. Red-coloured, diamond-shaped crystal, non-pleochroic against hornblende. Granite, You Yangs. × 75.
7. Irregular-shaped crystal associated with sphene and chlorite. Granite, Maude. × 75.
8. Stumpy prismatic crystal with ragged contact and pleochroic against biotite. Granodiorite, South Morang. × 75.

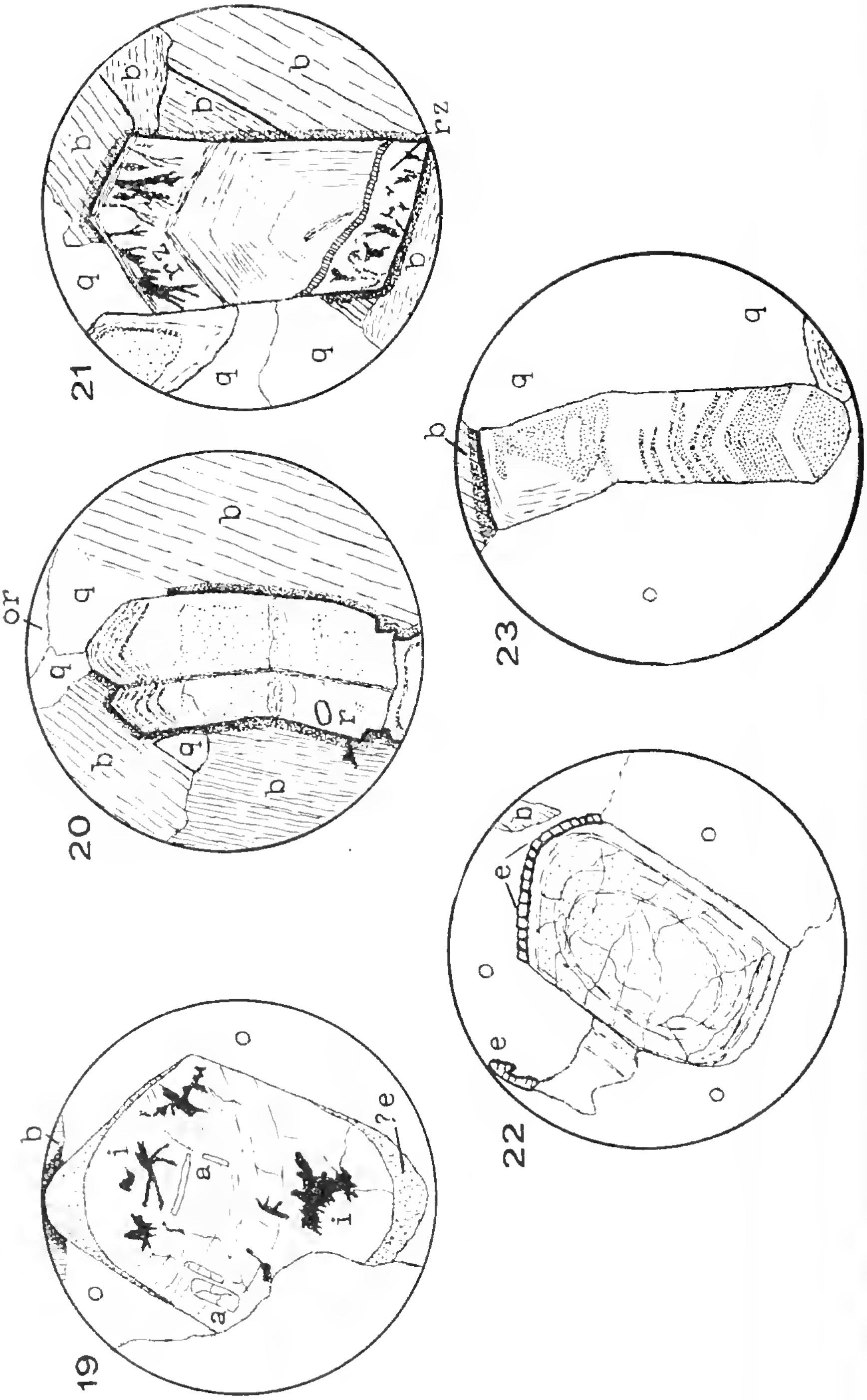
9. Brown pleochroic core surrounded by a green outer rim, and enclosed by hornblende and biotite, with pleochroic haloes against both. Granodiorite, Mt. Eliza. × 75.
10. Diamond-shaped crystal with irregular cracks and more highly birefringent marginal material (probably epidote decomposition products). Granite, You Yangs. × 75.
11. Isotropic core surrounded by a birefringent apprregate, with an incomplete fringe of iron oxides. Xenolith, You Yangs. × 75.
12. Two orthite crystals associated with hornblende, sphene and biotite, in a ferromagnesian clot. Granite, You Yangs. × 35.
13. Pleochroic core with irregular cracks in prismatic crystal showing "chevron-like" zoning in the paler coloured outer zones. Granite, You Yangs. × 35.
14. Prismatic crystal associated with iron oxide, set in microperthite and with "chevron-like" zoning. Granite near contact with xenolith, You Yangs. × 35.
15. Small crystal with pleochroic halo, completely enclosed in a large biotite plate. Granite near contact with xenolith, You Yangs. × 75.
16. Pleochroic remnants of fresh material in zoned crystal. Granite near contact with xenolith, You Yangs. × 35.
17. Prismatic crystal with red interior and rust-coloured zones parallel to the external form. Granite near contact with xenolith, You Yangs. × 75.
18. Lens-shaped crystal with halo, completely enclosed in biotite. Basic schlieren, You Yangs. × 75.
19. Cross section of a crystal with curved cracks, dendritic iron oxide, isotropic centre and birefringent angles. Basic schlieren, You Yangs. × 75.
20. Twin crystal showing "composition seam" and "chevron-like" zoning. Basic schlieren, You Yangs. × 35.
21. Dendritic iron oxide in outer zones of a prismatic crystal, with parallel zoning and pleochroic haloes against biotite. Broken outer zone at bottom of crystal indicates that such zones are three dimensional. Basic schlieren, You Yangs. × 35.
22. Prismatic crystal with irregular protuberance and a fringe of epidote at one end. Granodiorite, Yackandandah. × 35.
23. "Chevron-like" zoning of fresh pleochroic material in prismatic crystal. Granite, Tynong. × 75.



Figs. 1-9.



FIGS. 10-18.



Figs. 19-23.

[Proc. Roy. Soc. Victoria, 50 (N.S.), Pt. I., 1937.]

Art. IV.—*Cherty Limestone with* Planorbis, *from the Mount Elder Range, Western Australia.*

By FREDERICK CHAPMAN, A.L.S., F.G.S., etc.

[Read 8th April, 1937; issued separately, 29th December, 1937.]

Contents.

1.—Locality and Occurrence.

The samples examined were collected by Dr. Arthur Wade, F.G.S., in May, 1924, during his explorations in the Kimberley District and in the Northern Territory. Dr. Wade's own reference to the occurrence is as follows (Wade, 1924, p. 29):—

> "On the crests of the Mount Elder Range grey, green, and white cherts rest on the chocolate coloured sandstones. Along the junction the sandstones have a peculiar mammillated struture, due, apparently, to partial solution by meteoric waters. The cherts show evidence of being siliceous replacements of limestone beds. Near Trig. J. 40 the cherts are crowded with *Planorbis hardmani* (Foord) [evidently a *lapsus calami* for "McCoy"], which has been determined as a Tertiary freshwater form. This cairn at the Trig. Station is formed of blocks of this fossiliferous chert. It would appear that these cherts are the residual remains of deposits laid down in an inland lake in Tertiary times. At present they are perched on the crests of hills nearly 1,000 feet above sea level, and over 600 feet above the level of the Ord River. This is an indication and rough measure of the amount of denudation that has taken place in this region since the Tertiary period, which one cannot help regarding as remarkable."

In Hardman's admirable report on the Geology of the Kimberley District (Hardman, 1885, p. 7), we read:—

> "On the other side of the Ord, and about 25 miles to the N.E. is a low range of hills trending N.W. and S.E. for 12

> or 15 miles. The northern extremity of this has been named Mount Elder by Mr. A. Forrest, but the highest point lies near the S.E. extremity; it is marked on the map as J.40, and is 987 feet above sea-level. The main portion of this range is composed of Carboniferous rocks, chiefly sandstones and grits, with ironstones, capping the limestones of the flat country beneath; but at the summit of J.40 there is a small patch of white limestones, soft sandstones and chert, the last containing quantities of a gasteropod shell, which Prof. McCoy, of Melbourne University, has determined to be a new species of *Planorbis*, and which he has named *Planorbis hardmani*. This small outlier, which rests unconformably on the Carboniferous rocks, must therefore be of Upper Tertiary age, and is the only remnant of a formation, which probably, formerly widely overspread this district, but has been long since removed by the forces of atmospheric denudation—in this country of tropical rains and intense heat, exceedingly powerful."

No actual measurements of thickness have been given for this *Planorbis* limestone. Dr. Wade, however, in his Table of General Geological Sequence in the Kimberley Report (1924, p. 9), gives the approximate thickness of the Tertiary formation of that area—including clays with crustacea of Anson Bay, the *Planorbis* cherts of Mount Elder and inland lake deposits—as not more than 50 feet.

2.—Description of the Rock.

A compact shelly chert. Colour, pale ochreous-grey to liver-brown on the fractured surface, relieved by occasional dark, almost black patches. The white to cream-coloured molluscan shells are conspicuous as casts and moulds, often with the shell adhering. They tend to become loose when the rock is broken, due to the partial removal of the original shell. The large shells (*P. hardmani*) range from 4 to 21 mm. in diameter, and there is also a flatter and much smaller form of the genus present (*P.* cf. *essingtonensis*). The original shelly layer of these planorbids frequently lies within the mould and can be dissolved away by a weak solution of hydrochloric acid.

On the surface of one of the chert specimens there occurs a form of *Bullinus* which does not seem referable to any known species.

3.—Its Siliceous Condition with Reference to the "Duricrusts."

The old term, "Desert Sandstone," was coined by Richard Daintree in 1872 for the horizontal beds of coarse grit and conglomerate found on the eastern branches of the Upper Flinders River and elsewhere, and which he regarded as Cainozoic in

Queensland. Since then the name has been used to include various waste deposits of sands, conglomerate, laterites and lake deposits, the results of peneplanation, ranging in age from Triassic to Pleistocene (Bryan, 1928, pp. 25, 26).

The elimination of the name "Desert Sandstone" was proposed by E. C. Saint-Smith (1914, p. 20), on the ground that it included Sandstones of the Trias-Jura, upper sandy beds of the Rolling Downs formation, lateritic cappings of Kaolin sandstones from the same, and the gravel waste from Tertiary fluviatiles. H. I. Jensen in the same year (1914, pp. 5 and 6) shows that the name "Desert Sandstone" had been misapplied to four distinct ages of rocks and in his last division he included fluviatile beds as the *Helix* sandstone of the Barkly Tableland, into which division the *Planorbis* cherts of the Mount Elder Range would fall.

With especial reference to the varied lithological aspects of the so-called Desert Sandstone, Dr. W. G. Woolnough has suggested a very apposite term for these superficial and generally hardened rocks (1927, pp. 17-53), and in his presidential address to the Royal Society of New South Wales for that year, he elaborates his term of "Duricrust." He discusses the phenomenon of an extensive peneplanation of Australia in Post-Cretaceous, possibly Miocene times. This has resulted in extensive areas of certain regions, which are alternately very dry and very wet, being covered with a mineralized deposit formed *in situ*. Lake accumulations formed long before the general peneplanation, on flat-topped hills, have also been subject to a later stage of duricrust formation. Such an instance is that of the fluviatile chert of Mount Elder.

Amongst older formations that have been "case-hardened" by a duricrust the writer has lately described (Chapman, 1933), some Cretaceous glauconitic cherts from Davis River and Spinifex Well, W.A., and containing casts of foraminifera and coccoliths; they were found closely associated with a Nullagine series in this part of Western Australia.

4.—Planorbis Hardmani and Its Affinities: the Other Mollusca Present.

Class GASTEROPODA.

Order PULMONATA.

Family LYMNAEIDAE.

Genus **Planorbis** Geoffroy, 1767.

PLANORBIS HARDMANI (McCoy, M. S.) Wade.

(Pl. VI., Figs. 1, 2.)

Planorbis hardmani McCoy M.S. in Hardman, 1885, pp. 7 and 15.
Planorbis hardmani Wade, 1924, pl. i., figs. 2-4.

Note.—Sir Frederick McCoy does not seem to have given any description of this species named in Hardman's Report; it is therefore a cheironym. Subsequently, Dr. A. Wade figured this fossil, though without description, under the above name; since a figure alone with the name attached satisfies the requirements of nomenclature, Dr. Wade becomes the author.

Description.—Shell large, for an Australian species, discoidal; body whorl evenly rounded on one face and depressed on the other. Inner whorls evolute; umbilicus deeply concave on the side with inflated whorls, and less so on the depressed side. Back rounded, sloping obliquely towards the tumid and umbilicated side. Mouth subquadrate, almost lunate, blunt at one extremity and tapering at the other. Shell thin, consisting of three layers, the inner nacreous, as seen on the fractured rock; the periostracum seems to be preserved as a dark and sometimes silicified skin.

Dimensions of Lectotype.—(Wade's figure, pl. I., top right-hand). Greatest diameter of lectotype, 21 mm. Height of shell, 8 mm. (Wade—"in private collection in London or Natural History Museum"—in litt. 15.5.37.)

Dimensions of Paralectotype, here refigured on pl. VI., fig. 1 (Wade's figure, pl. I., middle fig. of group, slightly under natural size). Height of shell, 6.25 mm. Height of aperture, 7.25 mm. Greatest diameter, 17.25 mm.

(This paralectotype is in the palaeontological collection at Canberra.)

Many smaller examples of this species, deep-whorled in its younger stages, are seen in the matrix, down to 4 mm. in diameter.

Relationships.—Most of the living Australian species of *Planorbis* are smaller, flatter, and more usually carinate. *P. hardmani* resembles the European *P. corneus* Linné, in its large size, deep rounded whorls, wide and deep umbilicus, and in its well-marked growth-lines. *P. hardmani* differs from the European species in having a roundly quadrate aperture, as against the oblique and nearly round one of *P. corneus*. *Planorbis corneus* derives its trivial name from the horny or corneous periostracum, which in that species is of considerable thickness. That the Australian species also possessed this character to a large degree is evident from portions of the shells seen in thin section of the Kimberley rock, and it even retains its characteristic horn-brown colour and conchioline structure amidst the siliceous replacement of the rest of the shell and its infilling.

Other Freshwater Mollusca in the Kimberley Silicified Limestone.

Planorbis cf. essingtonensis E. A. Smith.

Planorbis essingtonensis E. A. Smith, 1882, p. 294, pl. vi., figs. 33-35.

Several examples of a small planorbid occur on the fractured surfaces of the silicified limestone specimens, which can be separated from the young of *P. hardmani* by certain of the following characters:—

The shell is small, flatly discoidal, and so far as visible, not distinctly umbilicated; the whorls of four turns are narrow, with indications of growth-lines, and with rounded contour, making the suturation distinct; aperture very slightly expanded; diameter 3.25 mm.

It agrees with *P. essingtonensis* in its compressed form, character of the spire, number of volutions and absence of carination except in the adult, as well as in dimensions. *P. essingtonensis* came from freshwater lagoons at Point Smith, Port Essington, about 470 miles N.E. of Mt. Elder. Another species of *Planorbis*, found living in many parts of Australia is *P. gilberti* Dunker; this species, however, is more distinctly keeled, and the last whorl suddenly increases in width.

Genus **Bullinus** Oken, 1815.

Bullinus sp. nov.

A mould of a small, shortly turreted species of this genus occurs in this silicified limestone. A wax squeeze indicates a small, roundly ovate shell of four whorls, slight angulation at the shoulder, and deeply impressed sutures; the body whorl shows faint spiral lirae. In some respects it resembles *B. aliciae* (Reeve), but the short spire and more ovate shell proves it to be distinct.

In the study of these mollusca the writer has had the advantage of the experienced assistance of Mr. C. J. Gabriel.

5.—Description of Other Associated Organisms, in Thin Section.

The matrix of this rock, originally a travertine or calcareous lacustrine mud, is still partly calcareous. This mud surrounds the shells of *Planorbis*, filling their outer whorls; in places it is seen to show a laminate, spherical habit, as in the blue-green algae (*Cyanophyceae*). A quantity of fine, granular material is present, probably representing the undigested food of the snails.

The silicification of this rock is extremely interesting; interstices between the calcareous granules and pellets are filled in with chalcedonic or cryptocrystalline silica. The remaining part of the cavity of the *Planorbis* shell is filled with a mosaic of polysynthetic quartz, which presents a striking appearance under crossed nicols. The shells themselves are partly silicified, the inner and outer layers, originally fibrous and conchiolitic, retaining their characteristic horn-brown tint.

Occurrence of Plant Remains.

In a thin slice prepared from the darker and denser part of this chert, I have been able to recognize minute tubular calcareous plants, that are most likely referable to a filamentous alga such as *Cladophora*. Similar plant remains have been described by the writer from opal nodules of Pleistocene age from the Richmond River, New South Wales (Chapman, 1922, p. 169), under the name of *Cladophora richmondiensis*.

There are also traces of charophytes (fragments of stems and nucules (pl. VI., fig. 5)).

Occurrence of Foraminifera.

At the present time the Elder Range lies 160 miles in a direct line from the coast at Cambridge Gulf. The discovery of the existence of minute tests of foraminifera in the fine granular matrix of the freshwater silicified limestone on the plateau of the Ord River Basin points to their possible aeolian origin from a shore-line in early Pleistocene times when the present coast in the vicinity of the Ord River Basin extended farther inland. With regard to the carrying of foraminifera and other minute organisms inland from the marine shore-line, another instance may be cited of foraminifera-bearing dune-sands in the Girnar Hills of India, 30 miles away from the sea (Chapman, 1900, p. 586). The following forms have been identified in the matrix:—

Globigerina sp. near *bulloids* d'Orb. (pl. VI., fig. 3, 4); cf. *Discorbis; Trochammina* sp.; and *Spiroplectammina* sp.

Occurrence of Sponges.

In thin section, particularly of the denser part of the chert, there is evidence of acerate spicules with numerous cross sections of cf. *Spongilla*, a freshwater sponge (pl. VI., fig. 6).

Occurrence of Ostracoda.

In the thin section of this freshwater limestone there occur numerous fragments of ostracods, only one of which, however, can here be identified. This is the freshwater form, *Newnhamia* cf. *fenestrata* King (Henry, 1923, p. 270, pl. XXIV., figs. 1-10). The species at present has a wide distribution, having been recorded from New South Wales, New Zealand, and the Bismarck Archipelago.

Occurrence of Insect Fragments.

In the denser part of the chert, numerous fragments of probable insect remains of an umber brown colour are seen in thin sections (pl. VI., fig. 6).

6.—Evidence of Age.

Ideas as to the probable age of the *Planorbis*-bearing limestones or cherts of the Mt. Elder Range of North-western Australia are somewhat conflicting, but they mostly range about late Tertiary or Pleistocene. L. Glauert expressed the opinion (Glauert, 1926, p. 52) that " The cherty beds of Mt. Elder, East Kimberley containing the gasteropod *Planorbis hardmani* may probably be found to be of Cretaceous age when a more detailed examination of the fossil contents is undertaken ". He does not, however, advance any direct evidence which would support this suggestion.

Dr. Wade's own observations (*loc. supra cit.*) led him to believe that the *Planorbis* cherts were laid down in Tertiary times.

From a general survey of comparative evidence in other parts of the continental peneplain, the most tenable view, coinciding with that expressed in my former, preliminary, report on this collection (Chapman, 1924, p. 3) is that their age is most probably Post-Tertiary (Early or Middle Pleistocene). They are thus practically synchronous with the *Helix* Sandstone of the Bass Strait Islands, in regard to which Sir Edgeworth David came to a similar conclusion in the British Association Handbook, " The Geology of the Commonwealth " (David, 1914, p. 255), where he also linked up the *Helix* limestone of the Cloncurry district in Queensland.

Finally, some good evidence of a Pleistocene duricrust has been discovered in the Eastern Macdonnell Ranges by Dr. C. T. Madigan (1932, p. 98), who, referring to the flat tops that slope gently down the south side of Paddy's Hole Plain, states that limestone rises to 50 feet, covered with spinifex. Dr. Madigan states that " The limestone was found to be formed almost entirely of *Planorbis* shells, and is a freshwater limestone, indicative of lacustrine conditions on the plain in former times. . . . Mr. F. Chapman . . . wrote that the *Planorbis*, while unlike the usual numerous keeled species living in Australian freshwater streams, and lakes, resembled *P. hardmani*, the supposed Pleistocene species of the north-west, though of much smaller dimensions ".

Such fluviatile deposits, always in the vicinity of the present river systems, are apparently synchronous with the bone beds of the King's Creek, Maryvale Creek, the Condamine River, and other localities in Queensland and elsewhere. These have yielded in abundance fossil remains of the large extinct marsupials, sometimes associated with such freshwater molluscs as *Corbicula nepeanensis* (Lesson), *Bullinus truncatus* (Adams), *and Lymnaea vinosa* (Adams and Angas).

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Explanation of Plate. VI.

Fig. 1.—*Planorbis hardmani* Wade. Paralectotype. Lacustrine cherty limestone. Hill J40. Mt. Elder Range, Kimberley District, W. Australia Nat. size.

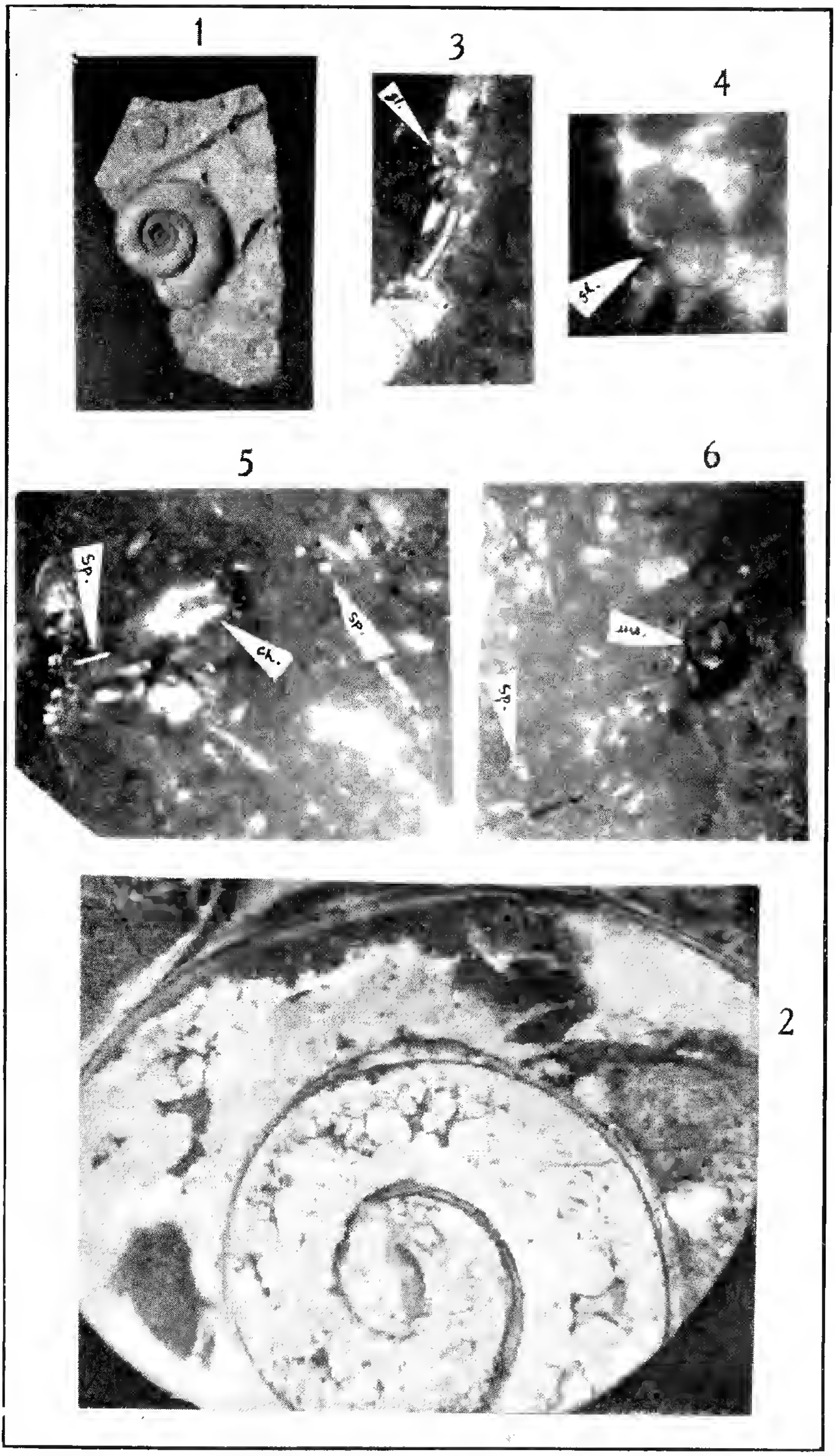
Fig. 2.—*P. hardmani* Wade. Horizontal section of shell in matrix. Shows infilling of calcareous mud and invading polysynthetic quartz. Also shell with three-fold layers. × 18.

Fig. 3.—Section of *Planorbis* limestone, with a test of *Globigerina* aff. *bulloides* (gl.), measuring 0.114 mm. in diameter. × 44.

Fig. 4.—The above *Globigerina* test (gl.), more highly magnified. × 166.

Fig. 5.—Section of *Planorbis* limestone, showing stems of charophytes (ch.) and freshwater sponge spicules (sp.). × 18.

Fig. 6.—Section of *Planorbis* limestone, with an insect fragment (ins.) and numerous freshwater sponge spicules (sp.). × 28.



F. C. photo.]

Planorbis Limestone.—Mt. Elder, Kimberley, W. A.

[Proc. Roy. Soc. Victoria, 50 (N.S.), Pt. I., 1937.]

Art. V.—*The Igneous Rocks of North-Eastern Benambra.*

By A. B. EDWARDS, Ph.D., D.I.C., and J. G. EASTON.

[Read 13th May, 1937; issued separately, 29th December, 1937.]

Contents.

Introduction

The igneous rocks described in this paper outcrop in the north-eastern portion of the County of Benambra, where it is enclosed by the great right-angle bend of the Murray River. The area comprises the parishes of Adjie, Berringama*, Burrowye*, Canabore*, Colac Colac, Cudgewa, Jemba, Jinjellic, Kancobin*, Koetong*, Thowgla, Tintaldra, Towong, Wabba, Walwa, and Welum'a* (part only of those marked with an asterisk), and is about 36 miles long by 30 miles broad. It has been geologically surveyed by Mr. J. Easton, of the Geological Survey of Victoria, and his contoured geological maps of the several parishes were published in 1920, on a scale of 2 inches to the mile.

Acknowledgments.

Mr. Easton has contributed the field work and general geology, on which the paper is based. Dr. Edwards is responsible for the petrological and theoretical sections, and for the form of the paper.

Our thanks are due to Mr. W. Baragwanath, Director of the Geological Survey of Victoria, for permission to use specimens and thin sections in the collections of the Geological Survey, and a set of seven unpublished rock analyses, made in the Survey Laboratories by Mr. F. F. Field; and to Professor Skeats, for laboratory facilities and the use of specimens and thin sections in the collections of the University of Melbourne.

Topography

As will be clear from the contours of the geological map (Fig. 1), the north-eastern portion of the County of Benambra is a deeply dissected tract of mountainous country, sloping, as a whole, towards the north.

Drainage.

The Murray River dominates the drainage system of the region. Where it enters the area, near the south-eastern corner of the Parish of Thowgla, its valley opens out from a gorge tract (some 25 miles in length), into wide alluvial flats. It takes a northerly course until opposite Tintaldra township, when it bends to the west in a right angle. After passing through the township, it swings sharply again to the north, and continues in that direction for several miles, before taking another right-angle bend to the west. From thence it follows a winding course along the northern boundaries of the Parishes of Walwa and Burrowye, with an average fall of about 3 feet to the mile. It is flanked by rich flats of varying width, at about 700 feet above sea level, which give place inland to increasingly mountainous country.

The tributaries joining the Murray in this part of its course (from the Victorian side), are the Biggera, Jeremal, Cudgewa, Pine Mountain, and Walwa Creeks. The principal of these are Cudgewa Creek, and the two branches of Jeremal Creek, the Thowgla, and Corryong Creeks.

As will be seen from the map (Fig. 1), in the southern parts of their courses these streams flow through Upper Ordovician sediments, and their courses are more or less parallel to the W. of N. strike of the sediments. About the middle of the area, however, they pass from a region of contact metamorphosed sediments into granitic rocks. As a consequence the direction of their courses becomes about 20° E. of N., parallel to the strike of the prevailing joints in the granites, and to the general strike of the quartz-porphyry and diorite dykes which have invaded the granite. This indicates that the present drainage system has developed subsequently to a peneplanation of the whole area and that the granitic rocks of the northern part must have been exposed before it originated.

Consideration of a wider tract of country shows that streams to the east of the area under discussion flow in a north-easterly direction to the Murray (Indi), while streams to the west flow to the north-west. The drainage pattern of Benambra is, therefore, more or less fan-shaped, with a central core of high

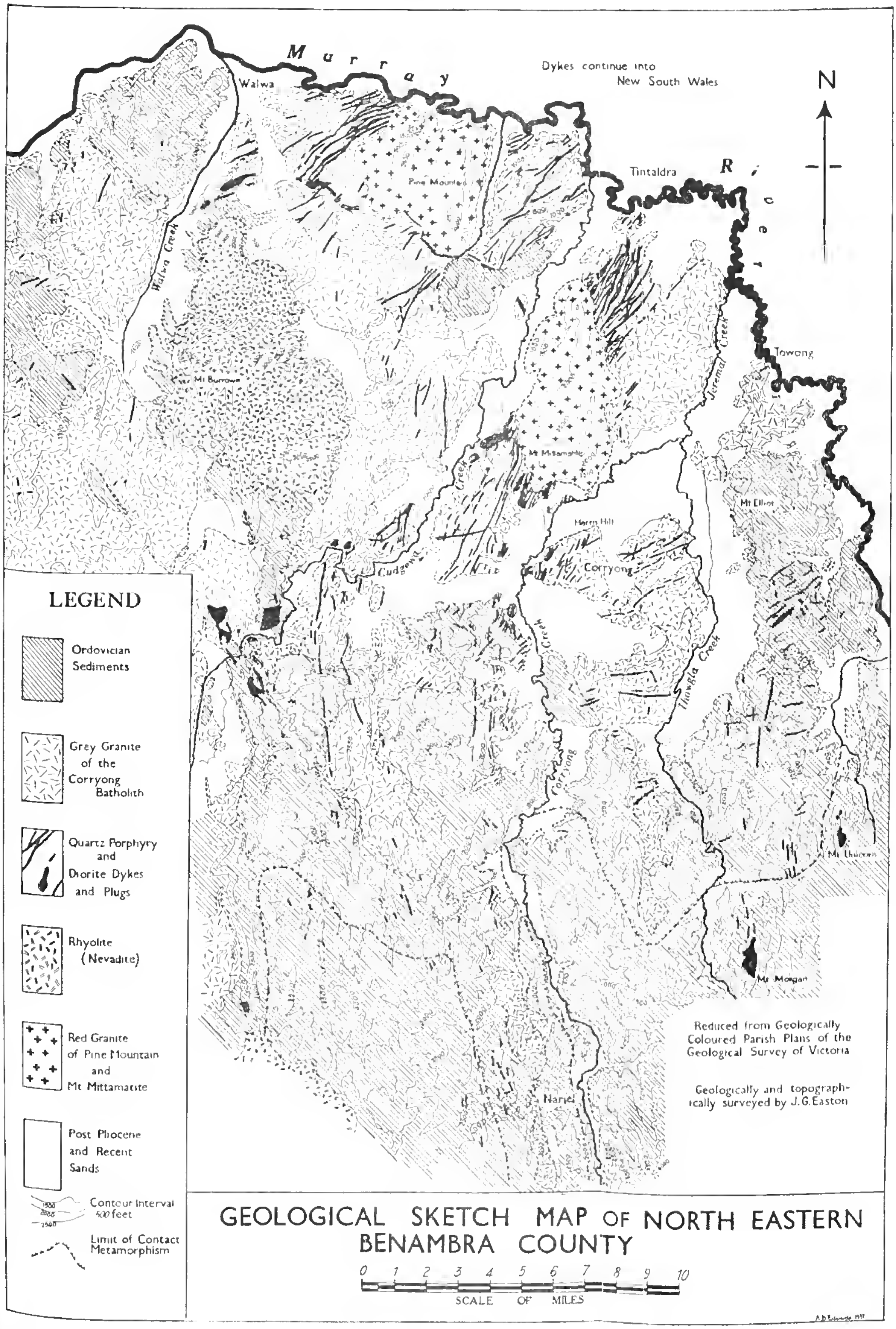

Murray River
Dykes continue into New South Wales
N
Walwa
Tintaldra
Pine Mountain
Walwa Creek
Mt Burrowa
Towong
Jeremal Creek
Mt Mittamatite
Cudgewa Creek
Mt Elliot
Corryong
Corryong Creek
Thowgla Creek
Mt Unicorn
Mt Morgan
Nariel
Reduced from Geologically Coloured Parish Plans of the Geological Survey of Victoria
Geologically and topographically surveyed by J. G. Easton
LEGEND
Ordovician Sediments
Grey Granite of the Corryong Batholith
Quartz Porphyry and Diorite Dykes and Plugs
Rhyolite (Nevadite)
Red Granite of Pine Mountain and Mt Mittamatite
Post Pliocene and Recent Sands
Contour Interval 500 feet
Limit of Contact Metamorphism
GEOLOGICAL SKETCH MAP OF NORTH EASTERN BENAMBRA COUNTY
0 1 2 3 4 5 6 7 8 9 10
SCALE OF MILES

Fig. 1

mountains in the vicinity of Mt. Gibbo (5,763 feet). The immaturity of the streams indicates that the dissection of the pene-plain has occurred recently. It probably began with the Kosciuscko uplift, during the Pliocene (2, p. 91).

Individual Streams.

The Jeremal Creek, which enters the Murray below Towong, (see map) is the largest and longest of the tributaries. It consists of two branches, the Thowgla and Corryong Creeks, which junction about 5 miles above its mouth. The Thowgla, or eastern branch, rises well south of the area, at Mt. Pinnibar (4,100 feet), and the Corryong, or western branch, at Mts. Pinnibar and Gibbo. For about 40 miles they flow in narrow valleys through steep, often precipitous, country. Below Nariel township site, alluvial flats from one quarter of a mile to a mile wide occupy the valley of Corryong Creek. Below Corryong township these flats become still more extensive. Similar flats extend for about 12 miles up Thowgla Creek.

East of Thowgla Creek is Biggera Creek, only 8 miles long. It, rises to the east and west of Mt. Unicorn, and flows with a gentle gradient through normal and slightly metamorphosed Ordovician slates and sandstones to the Murray (Indi) River.

Cudgewa Creek, to the west of Jeremal Creek, rises at Mt. Cudgewa (3,575 feet) in the Parish of Canabore (outside the western limit of the map), and flows north-easterly through granitic country for about 30 miles, joining the Murray below Tintaldra township. It has its source in an alluvial flat of about 60 acres extent, near the summit of the range, at the contact of granite and metamorphic rocks, and falls 900 feet in a distance of three-quarters of a mile, over a series of cascades, before taking a winding course, with intermittent flats and terraces in its upper reaches. From Lucyvale it flows northerly for about 5 miles to Berringama through a fairly wide valley in the granitic rock. There it enters a gorge winding between steep hills, as far as Cudgewa, where the valley widens and flats have developed, which continue until they reach the Murray.

Walwa Creek drains the northern and western slopes of Mt. Burrowye (4,181 feet) a great mass of rhyolite. Its two main branches rise on the eastern and western slopes of this prominent landmark, and converge in gullies, towards Walwa township. Their valleys widen as they pass from the rhyolite into the lower, undulating granite and sedimentary country about the township. The united stream joins the Murray immediately below the township. The total length of the stream, which rises at 4,000 feet, and enters the Murray at about 700 feet above sea-level, is not more than 10 miles.

Between Walwa and Cudgewa Creeks is the short Pine Mountain Creek, which rises at the southern base of the more or less conical mountain of red granite known as Pine Mountain, and flows along the junction of this granite with the earlier, and lower level grey granite, to the Murray.

Mountains and Ranges.

The dissection of the original peneplain into a system of spurs and mountains with innumerable lateral gullies has been further diversified by the presence, especially in the northern part, of a number of conspicuous monadnock features. The main ridges have a northerly trend, and form interfluves between the creeks. Like the creeks they radiate more or less from Mt. Gibbo. The Indi-Thowgla divide, beginning at Mt. Gibbo, and connecting with Mt. Pinnibar, continues in a northerly direction as a series of knobs and saddles gradually decreasing in altitude, with lateral spurs dropping off into the adjoining valleys. The interfluve is formed chiefly of Ordovician sediments, as far as Mt. Elliot, a prominent point 3,000 feet above sea-level, about 4 miles east of Corryong township. There it drops off suddenly into softer granitic rocks, terminating at Towong on the Murray River. The summit of the range is about 1 to 5 chains in width.

West of this is a subsidiary ridge forming the interfluve between the Thowgla and Corryong Creeks. This is a spur which branches off the main Indi-Thowgla ridge at Mt. Pinnibar. It consists of a series of peaks and saddles trending practically due north, and terminating at Corryong. Two of the saddles form conspicuous gaps—Nariel Gap and Green Wattle Gap.

The range forming the western interfluve of Corryong Creek is a branch of the main range which begins in the vicinity of Mt. Gibbo, and follows a north-westerly course towards Mt. Cudgewa. This range trifurcates near the northern head of the Dark River (south of the map). The eastern branch runs almost due north, parallel to the Corryong Creek, to the Colac Colac-Corryong Gap. Mt. Mittamatite, and its erosion shadow, serve as a continuation of this interfluve between the Cudgewa and Jeremal Creeks. The main branch continues beyond Mt. Cudgewa to the vicinity of Shelley railway station, where it bifurcates. The eastern bifurcation connects with Mt. Burrowye, and forms the interfluve between Walwa and Cudgewa Creeks. Between the head of the Dark River and Mt. Cudgewa, the main divide sends off an important spur to Mt. Benambra (4,843 feet), an extensive mass of rhyolite, similar to Mt. Burrowye.

Monadnocks.

The Mt. Benambra rhyolite mass, which just appears in the southern part of the map (Fig. 1), is one of the monadnocks. Other conspicuous monadnocks are Mt. Burrowye, Mt. Mittamatite, and Pine Mountain, in the northern part of the area.

Mt. Burrowye (4,194 feet) is a mass of rhyolite. It rises up like a massive fortress, in a series of cliffs and precipitous slopes, edged with screes, above the surrounding hills of granite and Ordovician sediments. The summit is a dissected plateau. Pronounced jointing can be seen, especially on the north-eastern side, where two well-defined systems of joints strike at N. 60° W. with a dip of 80° N.E., and N. 30° E. with a dip of 65° S.E. The main creeks in this formation conform to the N.E. joints, while the small lateral creeks follow the N.W. set.

Mt. Mittamatite and Pine Mountain are more or less conical bosses or cupolas of red granite, which stand out above the adjacent grey granite. Mt. Mittamatite has a well-defined erosion shadow to the N.E. of it.

There are in addition several smaller and less prominent monadnocks. Mt. Morgan (3,450 feet), east of Thowgla Creek, in the southern part of the area, and Mt. Unicorn (2,910 feet) 5 miles N.E. of it, form noticeable peaks. Both are plugs of quartz-porphyry, surrounded by indurated Ordovician sediments. A number of other small hills, in the Corryong District are also of this character, e.g., Harris Hill, Playle's Hill, and Mt. Sugar-loaf. These have withstood erosion owing to the fact that they are traversed by quartz-porphyry and diorite dykes which are harder than the surrounding sediments. The extra hardness of the dyke rocks, both here and elsewhere, has caused the dykes to stand out as walls across the country.

General Geology.

1. Upper Ordovician Sediments.

The oldest rocks exposed in the area are folded sediments of Upper Ordovician age. Their greatest development is in the eastern and southern parts. They consist of drab yellow, brown and black slates and shales, with siliceous and felspathic sand-stones, and occasional grit beds. Grits and sandstones, composed of quartz and felspar fragments, with some inclusions of black slate are prominent in the Parish of Thowgla, and can be traced for several miles along their strike, which is N. 20–30° W. The folding is open where the beds are competent, with perhaps two anticlines and synclines to the mile; but where the sediments are finely bedded, much closer folding has developed. Marked pitch makes the apparent strikes variable.

Some of the slates are carbonaceous, and contain graptolites. At Reedy Creek these graptolite slates are about 10 chains in width, and graptolites occur in them over a length of 2 miles along the strike. The collections made by Mr. Easton from here, and from other localities within the area have not, as yet, been specifically determined. Earlier collections made by W. H. Ferguson, however, from these and other localities in this region have been examined by the late T. S. Hall, and are classed as Upper Ordovician (14, 15).

After being folded, the sediments were intruded by a granitic batholith. Prolonged erosion has deroofed the higher parts of the batholith, while elsewhere it has reduced the sedimentary cover to a thin metamorphosed roof. An excellent illustration of the effect and degree of the contact metamorphism is afforded by the steep range to the east of Thowgla Creek, in the Parish of Thowgla. Going eastwards from the more easily weathered granite, in which the Thowgla Creek has cut its valley, and which is now hidden under alluvium, across the steep ridge which marks the contact aureole, the succession is from highly micaceous schists to andalusite schists, which grade out into spotted schists containing embryo crystals. These, by degrees lose their nodular appearance, becoming more micaceous, and give place to lustrous phyllites, until, at about a mile from the hidden contact, the strata are normal slates and sandstones. This, of course, gives no indication of the true width of the contact zone, owing to the gentle slope of the underlying granite surface. The true thickness is more adequately indicated by the height of the ridge above the creek level, which is about 500 feet.

Roof pendants, and large xenolithic blocks occur wherever the deroofing of the granite rocks has been only recently accomplished.

2. Igneous Rocks.

Igneous rocks outcrop over a large part of the area, being concentrated in the northern and western parts. They belong to two distinct periods of intrusion (25, p. 107), both later than the folding of the sediments. There are several facies to each period, and their order of intrusion is fairly clearly defined.

(i) *The Corryong Grey Granite.*

The earliest, and most extensive, of the igneous intrusions is a batholith of grey granite which underlies most, if not all, of this part of Benambra, and extends beyond into New South Wales, and Northern and Eastern Victoria for undetermined distances. It is a grey biotite granite, which varies in texture from a fine-grained to a fairly coarse-grained porphyritic rock, with large phenocrysts of felspar. At Corryong it verges on granodiorite, but in other districts, as at Koetong (27, p. 21) is a granite. The rock from Mt. Cudgewa, on the other hand, has been described as granodiorite (3, p. 96). It is always easily distinguished, however, from the later granites proper, both by its appearance, and its chemical composition (see p. 82).

The age of this great intrusion cannot be fixed; but it is assumed that it developed as an aftermath of the (?) Lower Devonian orogeny, during which the sediments were folded.

During the later stages of cooling of this batholith, or subsequently, a series of stanniferous pegmatites and greisens and quartz veins were formed contiguous with its contacts. These occur conspicuously at Walwa (7, 8), Koetong (3), and Mt. Cudgewa (3, 6). Frequently they are rich in tourmaline, as well as cassiterite, and scheelite (9) is developed locally. In the Corryong-Thowgla region these pneumatolytic deposits are replaced by gold-pyrite veins (representing the transition to hydrothermal conditions) (5), and traces of copper (5); while in the neighbourhood of Pine Mountain, hydrothermal lodes of silver-bearing galena and fluorite occur (4). These, however, may be associated with the subsequent red granite of Pine Mountain, since these granites and their associated dykes are rich in both fluorite and tourmaline.

(ii) *Later Granitic Intrusions.*

The second period of igneous activity gave rise to a more limited, but more complex series of contemporaneous intrusions. These, in the apparent order of their development, are:—(*a*) a dyke swarm. (*b*) an extrusion of rhyolite. (*c*) intrusion of two granitic bosses, or cupolas, and associated dykes.

(*a*) *The Dyke Swarm.*

The second period of activity opened with the intrusion of a swarm of acid and intermediate dykes into the Corryong grey granite, and the Ordovician sediments. Approximately 850 dykes have been mapped in this area, and similar dykes occur, though less profusely throughout the County of Benambra (23, 27, 29). Of those mapped, about 50 are granitic dykes, 500 are of quartz-poprhyry, and quartz-felspar-hornblende-porphyrite, and about 300 are of quartz-diorite. These figures do not adequately indicate the predominance of the quartz-porphyry dykes, since they take no account of relative size. The individual granite and diorite dykes can rarely be traced over distances much greater than a mile. The quartz-porphyry dykes, on the other hand, are frequently over a mile in length, and some have been traced in outcrop for over 4 miles. Also they are generally wider than the other types, and show bulges along their strike. Occasionally the quartz-porphyries form plugs. Two such plugs, Mt. Morgan and Mt. Unicorn, stand out as prominent hills. Mt. Morgan forms a peak 3,450 feet above sea level in the Parish of Kancobin. It consists of a central core of quartz-porphyry surrounded by contorted and indurated Ordovician sediments, which indicate that it was intruded under considerable pressure. About 5 miles to the N.E. on the southern boundary of the Parish of Thowgla is Mt. Unicorn, 2,910 feet above sea level, with a similar core of quartz-porphyry surrounded by silicified sediments.

The order of intrusion of the dyke types is from acid to basic, as is clearly shown in Fig. 2, which illustrates the occurrence of three dykes of different type in allotment 81, Parish of Cudgewa. It is not certain whether the granitic dykes belong to the dyke swarm, or are a final product of the earlier igneous activity. They are closely associated with the quartz-porphyry dykes in several localities, but, as shown in Fig. 2, the quartz-porphyry and quartz-diorite dykes fill fissures and fractures which have displaced the granite dykes as much as 100 feet laterally.

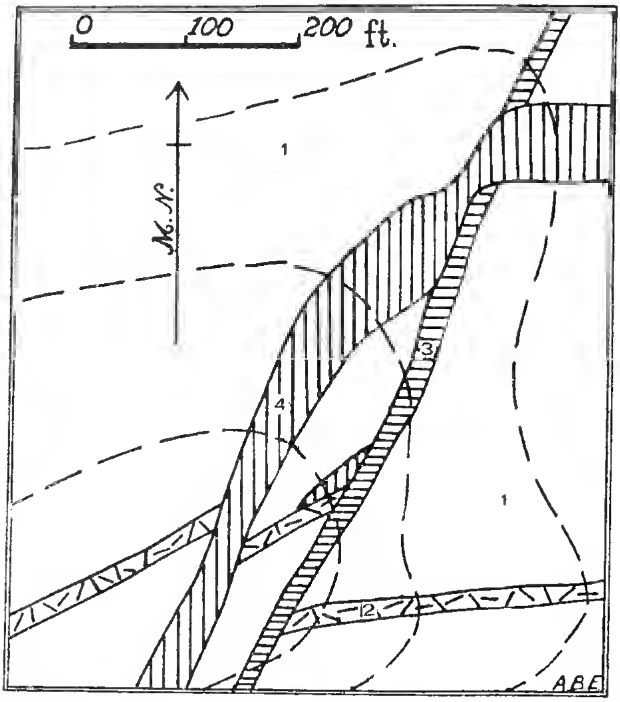


Fig. 2. Dyke Sequence in Allotment 81, Parish of Cudgewa. 1. Grey Corryong Granite. 2. White Granite Dyke. 3. Granophyric Quartz-Porphyry Dyke. 4. Quartz-diorite Dyke.

The diorite dykes intrude the quartz-porphyry dykes, but frequently they have risen up the same channel, since they occur as parallel or composite dykes, often along the contact of the quartz-porphyry dykes and the wall rock. Occasionally they bulge, like the porphyries. Two of the largest outcrops are in allotment 8, section VI., Parish of Wabba, and in the basin of a big gully east of Scammel's homestead, on Thowgla Creek, where a coarsely crystalline diorite occupies an area of about 30 acres.

The strike of the dyke swarm appears to have been controlled by pre-existing structures in the Corryong granite, and in the Ordovician sediments. In the granitic areas, and within the shallower parts of the contact aureoles, the strike of the dykes is generally between N. 30° E. and N. 60° E. corresponding with a strong jointing direction in the granite. Outside the contact aureoles the dykes are parellel to the strike of the invaded Ordovician, and strike more or less N. 30° W.

There are marked concentrations of the dykes, one in Walwa, centred about the later granitic intrusion of Pine Mountain, and the other in Tintaldra and Colac Colac, centred about the similar later granite intrusion of Mt. Mittamatite (Fig. 3). In these

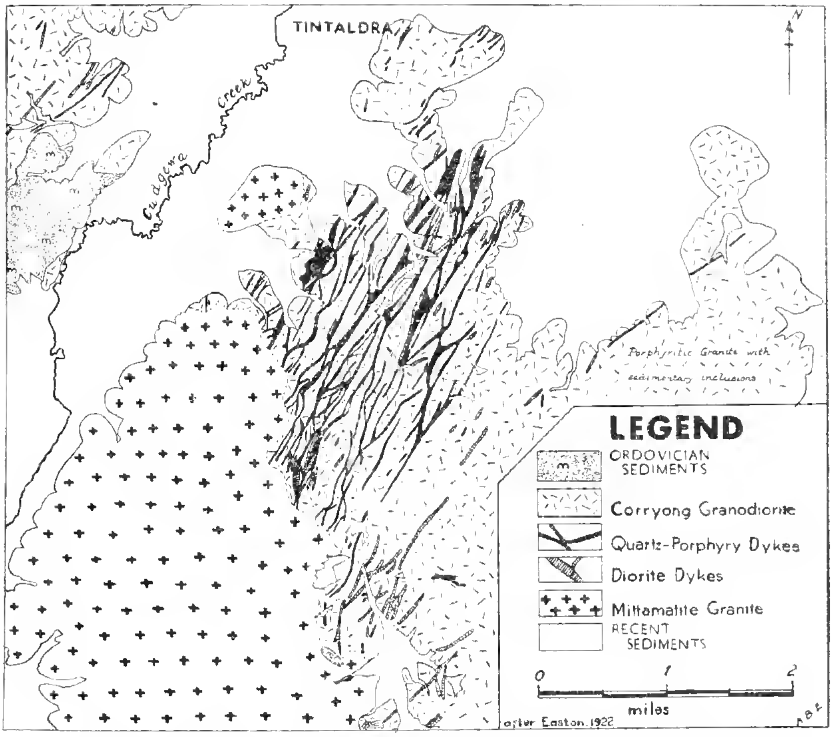


Fig. 3. "Dyke Stockwerk" on the N.E. slopes of Mt. Mittamatite.

two regions the swarm becomes more or less a "dyke stockwerk". The individual dykes branch and rejoin and lie at all angles to the vertical, up to 90°. It is further noticeable that while the quartz-porphyry dykes are found practically throughout the whole area, the diorite dykes are more or less limited to the vicinity of these intrusions. There are numerous exceptions.

This concentration of dykes in association with the later granite, of composition identical with that of the acid dykes, suggests a close magmatic and structural relation.

In the southern part of Towong, the strike of the dykes approaches nearer east-west, while a subsidiary group strike parallel with the strike of the sediments. Still further south, in Thowgla, the quartz-porphyry dykes strike with the sediments, while later dioritic dykes cut them more or less at right angles.

(*b*) *The Jemba Rhyolite.*

Subsequent to, or possibly contemporaneous with, the intrusion of the dykes, a flow or flows or rhyolite (nevadite), totalling over 2,000 feet in thickness, was extruded and covered almost all of what is now the Parish of Jemba. The rhyolites extend northwards some distance into the Parish of Walwa, where there are some very broad quartz-porphyry dykes close to their boundary, and eastwards into the Parishes of Cudgewa and Tintaldra, forming an irregularly elliptical mass of rhyolite of about 25 square miles area, with its longer axis striking west of north.

Along its eastern and north-western boundaries the rhyolite rests on the exposed surface of the Corryong granite, and along its western and southern edge, and in the extreme north, it overlies an erosion surface of contact-metamorphosed Upper Ordovician sediments, and occasionally what appear to be river gravels, as in allotment 39, Parish of Jemba (the S.W. side), and allotment 56, Parish of Cudgewa (the N.E. side). The gravels consist of water worn, and angular, pebbles of hard black slate, quartzite, and a hard flinty rock enclosed in granite. Mount Burrowye, the highest point, is 4,194 feet above sea-level, and several other peaks are over 4,000 feet.

The base of the rhyolite, so far as can be ascertained from the level of its boundaries, is uneven. It averages between 2,000 feet and 2,500 feet above sea-level, but on the north-western side it is as low as 1,500 feet above sea-level. Since the later granite rocks of Pine Mountain and Mount Mittamatite intruded to levels at least 1,300 feet above the base of the rhyolite, and the rocks to the west are still of higher level than the rhyolite base, it is evident that the rhyolite was extruded into a valley or basin-like erosion structure, whose outlet was to the north-west.

This indicates that localized erosion accomplished as great a degree of unroofing of the Corryong granite in such time as elapsed between the (?) Lower Devonian orogeny and the second period of igneous activity, as has all the erosion that has gone on in the area since. This " fossil basin " or Devonian deep lead which has been preserved by the rhyolite extrusion, indicates that enormously greater erosive forces were at work immediately subsequent to the orogeny, than in later times; and the fact that this erosion uncovered part of the Corryong granite is evidence that the intrusion of this batholith did concur with, or develop immediately after the orogeny.

(*c*) *Red Granites of Pine Mountain and Mt. Mittamatite.*

The final stage of the second period of igneous activity was the intrusion of two stocks or cupolas of red granite through the Corryong grey granite, and the dyke swarms, for some hundreds of feet into the sedimentary cover above. These two stocks now stand out as prominent, steep-sided, more or less conical hills, Mt. Mittamatite (3,340 feet) and Pine Mountain (3,310 feet), and support a flora different from that of the adjacent grey granite. Mt. Mittamatite is more or less elliptical in cross-section, the long axis of the ellipse being parallel to the strike of the dyke swarm.

No dykes exist within either of these masses, and all the pre-existing dykes are cut off abruptly at the contact, but a number of red porphyry dykes of the same age as the granites radiate out into the network of other dykes. Some of these are not easily discriminated from the indurated older dykes near the contact. Occasional outcrops of similar red porphyry dykes occur in other parts of the area.

3. *Post-Pliocene Deposits.*

Remnants of old creek beds occur at several localities, as between Lucyvale and Berringama, where they form small cappings on the low granite spurs. Similar deposits are found west of the present area, and have been worked for their tin and gold content.

More recent alluvium forms flats along the lower reaches of most of the streams, and on either side of the Murray River.

Petrology.

1. The Corryong Granite.

The Corryong granite is a medium-grained grey rock, grading locally into a porphyritic phase, in which large phenocrysts of orthoclase, an inch or more in length, are prominent. The minerals constituting it are quartz, orthoclase and oligoclase (Ab_{75}) in about equal proportions, a little microcline and vein-perthite, abundant biotite, muscovite, and coarse prisms of apatite. The plagioclase is sometimes zoned, the core zones consisting of acid andesine. Occasionally it occurs as idiomorphic tabular crystals with rims of orthoclase. Myrmekite intergrowths are abundant. The biotite is almost uniaxial, and is pleochroic from pale yellow or pinkish-yellow to rusty red-brown, so that it is an iron-magnesia- rich variety. In places it is intergrown with green or white muscovite.

Where the granite is porphyritic, it is frequently much contaminated with sedimentary xenoliths, e.g., in the vicinity of Wermatong, Parish of Tintaldra, it contains a prolific number of partially digested xenoliths.

Examination of the chemical analyses of Victorian granitic rocks shows that they fall into three well defined groups, granites proper, granodiorites proper, and an intermediate group, whose character is most nearly indicated by the now discarded name "adamellite" (26). A chemical analysis of the Corryong granite (Table 1, No. 1), shows that it has a composition comparable with this third group of Victorian granites, which verge

TABLE I.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	
SiO_2	67·67	68·92	75·98	74·67	67·72	50·79	49·65	46·90	76·60	74·28	74·80	SiO_2
Al_2O_3	14·50	16·21	12·75	12·18	13·62	16·40	16·73	16·54	12·14	12·90	12·53	Al_2O_3
Fe_2O_3	0·87	0·57	0·58	1·56	0·88	2·11	0·31	4·66	1·01	1·16	1·02	Fe_2O_3
FeO	3·78	2·42	0·65	1·03	2·44	6·26	8·99	9·19	0·26	1·04	0·91	FeO
MgO	2·21	1·04	tr.	tr.	1·39	5·68	5·88	7·29	tr.	tr.	tr.	MgO
CaO	2·18	2·31	0·68	1·04	2·91	8·31	7·87	10·32	0·49	1·12	0·78	CaO
Na_2O	2·38	2·43	3·15	3·28	3·04	3·42	3·10	2·59	3·29	2·96	3·06	Na_2O
K_2O	3·42	4·36	5·47	5·34	3·64	1·37	0·80	1·36	5·26	5·32	5·95	K_2O
H_2O + ..	1·81	0·93	0·40	0·32	1·65	3·59	2·50	0·55	0·71	0·78	0·81	H_2O +
H_2O − ..	0·11	0·08	0·04	0·07	0·26	0·28	0·14	0·15	0·09	0·07	0·14	H_2O −
CO_2	tr.	..	tr.	Nil	1·95	0·30	1·08	tr.	tr.	tr.	tr.	CO_2
TiO_2	0·61	0·52	tr.	tr.	0·45	1·43	2·81	0·52	tr.	0·17	0·21	TiO_2
P_2O_5	tr.	0·30	Nil	tr.	tr.	tr.	0·04	0·02	Nil	tr.	tr.	P_2O_5
MnO	tr.	0·03	tr.	0·03	tr.	tr.	0·14	0·03	tr.	tr.	tr.	MnO
Cl	tr.	..	tr.	..	tr.	tr.	..	..	tr.	tr.	tr.	Cl
FeS_2	Nil	tr.	Nil	..	Nil	0·34	..	..	Nil	Nil	Nil	FeS_2
SO_3	Nil	..	Nil	..	Nil	Nil	..	..	Nil	Nil	Nil	SO_3
Total ..	99·54	100·12	99·70	99·52	99·95	100·28	100·04	100·12	99·85	99·80	100·21	Total

1. Grey biotite granite, E. of Allot. 8, Sect. VII., near contact, Parish of Cudgewa. Analyst—F. F. Field. [G.S., 1907.]
2. Granite. Koetong Mass, Tallangatta-Granya road. Analyst—C. M. Tattam. [Bull. Geol. Surv. Victoria, No. 52, 1929, p. 38.]
3. Rhyolite from Mt. Burrowye, Parish of Jemba. Analyst—F. F. Field. [G.S. 1914.]
4. Quartz porphyry dyke. Allot. 56 of Cudgewa. Analyst—A. B. Edwards. [M.U., 2150.]
5. Quartz-felspar-porphyrite, dyke at Tintaldra bridge, Parish of Tintaldra. Analyst—F. F. Field. [G.S., 2097.]
6. Quartz-augite-diorite. Harris Hill, Allot. 4B, Parish of Colac. Colac. Analyst—F. F. Field. [G.S., 2098.]
7. Propylitized diorite porphyrite, Morning Star Dyke, 10 feet from Cherry's reef, Hope adit level. Analyst—N. R. Junner. [Proc. 39, Aust. Inst. Min. Met., 1920, p. 188.]
8. Labradorite-porphyrite dyke, Allot. 4, Sect. 6, Parish of Tintaldra. Analyst—A. B. Edwards. [M.U., 2157.]
9. Red granite from Pine Mountain Creek. Parish of Cudegwa. Analyst—F. F. Field. [G.S., 2101.]
10. Red granite from Mt. Mittamatite, Allot. 69. Parish of Towong. Analyst—F. F. Field. [G.S., 2099.]
11. Red porphyry dyke, N. boundary of Allot. 8, Sect. VIII., Parish of Walwa. Analyst—F. F. Field. [G.S., 2100.]

on granodiorite. The composition varies somewhat in other parts of the batholith. Thus Tattam (27, pp. 21, 38) has described outcrops of the porphyritic variation at Koetong as normal granite, but as will be seen from Table 1, the analysis of the Koetong granite resembles that of the Corryong granite in its SiO_2, CaO, and Na_2O contents much more closely than it resembles the true granites (Nos. 9, 10). The higher Al_2O_3, SiO_2 and K_2O correspond to the development of large phenocrysts of orthoclase. The Yackandandah granite (27, p. 38) is also of this variety. Mahony, on the other hand, has described the rock from Mt. Cudgewa as a granodiorite (3, p. 96). The Corryong granite, however, is as distinct from the Victorian granodiorites proper as it is from the granites proper.

2. The Jemba Rhyolite (Nevadite).

In hand specimen the rhyolite varies in appearance from a pinkish-red rock, studded with small glassy phenocrysts of quartz, to a brownish-grey rock speckled with pink crystals of microperthite and glassy quartz crystals. Fragmental facies, in which the rhyolite is crowded with small angular fragments of hornfels, are common.

In thin section the phenocrysts are found to consist of quartz, perthitic orthoclase, subordinate acid plagioclase, a little biotite, and occasional tourmalines, set in a microcrystalline groundmass of quartz and felspar, which occasionally shows granophyric or spherulitic textures.

The quartz phenocrysts occur as doubly terminated rhombohedra which are deeply embayed. They may be as large as 2 to 3 mm. in diameter, and contain inclusions of sphene and fine rods of (?) apatite. They are perhaps the most abundant phenocrysts.

The orthoclase occurs as rounded, sometimes embayed, crystals. It is frequently brownish from the presence of iron oxide, which forms vaguely defined bands parallel to the cleavage, and is responsible for the pink colour of the felspar in hand specimen. Much of the orthoclase contains microperthite, both ex-solution perthite in fine parallel lamellae, and vein-perthite. In some crystals a transition from one type of perthite to the other can be observed. These orthoclase crystals are invariably edged with a narrow ragged rim of clear, non-perthitic orthoclase, in optical continuity with the crystal as a whole, and probably developing during the general crystallization subsequent to extrusion. The crystals show simple Carlsbad twinning, and not infrequently enclose areas of acid plagioclase. Such plagioclase inclusions often have a partially sericitized core. Phenocrysts of plagioclase are subordinate to orthoclase. They consist of oligoclase (Ab_{80}), showing a maximum symmetrical extinction angle of about 5°, and rarely zoned.

Biotite is present as occasional longitudinal crystals, which are frequently bent or crushed. It is often partially bleached or chloritized, and has precipitated grains of iron oxide. Many of the crystals are fringed with granules of tourmaline. The tourmaline also occurs as crystals as large as the biotite, or as granular aggregates. Blue, green, and brown varieties occur, the blue being the more usual. Sometimes it occurs as a fringe about sporadic crystals of pyrrhotite. Minute trigonal crystals occur throughout the groundmass, and are often concentrated in small clusters in the embayments of the quartz phenocrysts (cf. 16, p. 189).

Microscopically, and chemically (Table 1, No. 3), the Jemba rhyolite closely resembles the nevadite rhyolites of Taggerty (16), and Narbethong (20). It is slightly more acid than these, but the most distinctive difference is the apparent absence of cordierite from the Jemba rhyolite. It equally resembles the rhyolite (or quartz-porphyry) mass of Mt. Benambra, to the south of the area under discussion. Chemically it is almost identical with the more common type of quartz-porphyry dykes of the dyke swarm, and with the red granites of Pine Mountain and Mt. Mittamatite and their related red porphyry dykes; and it resembles them still further in its content of clouded orthoclase, vein-perthite, and tourmaline.

3. Granitic Dykes.

The earliest members of the dyke swarm are granite dykes, not easily distinguished in hand-specimen from the red granites of Mt. Mittamatite and Pine Mountain, and aplites.

(i) *The Granites.*

The granite dykes consist of quartz, microperthite, orthoclase, subordinate oligoclase, and biotite, sometimes with a small amount of coarse-grained groundmass of quartz and felspar. Orthoclase with vein-perthite is the dominant felspar, and it is strongly clouded with particles of iron oxide dust, which gives it a pinkish colour in the hand-specimen. The plagioclase is sericitized and occurs both as large crystals, and as numerous inclusions in the orthoclase and microperthite. The biotite is pleochroic from yellow to deep green, and is sometimes partially chloritized. In some dykes its place is taken by colourless muscovite. Occasionally patches of tourmaline, and more rarely crystals of orthite and cassiterite, are seen.

(ii) *The Aplites.*

The aplites are microporphyritic, with idiomorphic crystals of quartz, less numerous orthoclase, and large plates of muscovite, set in a coarsely granular groundmass of quartz, orthoclase, and slightly larger crystals of oligoclase. The quartz and orthoclase phenocrysts contain numerous inclusions of the groundmass minerals. Generally these are scattered throughout the crystals, but in some quartz phenocrysts there is a tendency for them to be arranged zonally.

4. Quartz-porphyry Dykes.

These, the most abundant among the dykes, may be sub-divided into two groups:—

(i) *Quartz-felspar-porphyries, and Granophyres.*

These are light coloured, buff or brown, sometimes grey, rocks, consisting of phenocrysts of quartz and pink felspar, with occasional small clots of biotite or sheaves of green hornblende, set in a microcrystalline groundmass of quartz, orthoclase, sometimes biotite, and subordinate tourmaline. The relative proportions of the quartz and felspar phenocrysts are variable. The phenocrysts are invariably embayed, the embayments usually containing small aggregates of minute tourmaline granules.

The felspar is mostly orthoclase, or vein microperthite, cloudy or brownish from the presence of iron oxide dust. Subordinate oligoelase (Ab_{70}) is generally present, and frequently is sericitized.

Ferromagnesians are generally absent; but when present they consist of decussate sheaves of biotite, pleochroic from faint yellow to foxy red, or, more often, clusters of minute sheaves or prisms of green hornblende. The hornblende has an extinction angle of 16°, and is pleochroic with X = green, Y = straw yellow, Z = blue green. It is altering (fig. 4, C) to biotite and iron ore, and the derived biotite flakes show a decussate structure with two sets of sheaves more or less parallel to the original hornblende cleavages. The iron ore thrown out from the hornblende forms into crystals, and the biotite flakes frequently centre about

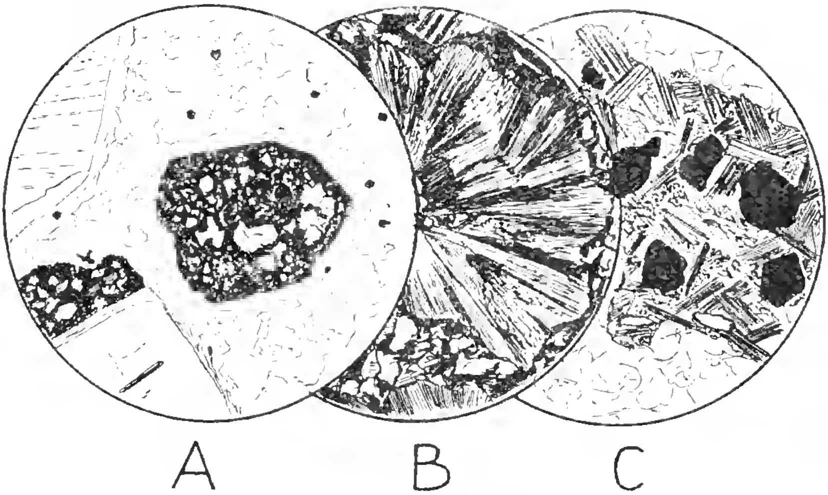


Fig. 4. A. Micro-"quartz-tourmaline nodule" in quartz-porphyry. × 200.
B. Micro-spherulitic growth in groundmass of quartz-porphyry. × 200.
C. Hornblende altering to biotite and iron ore in quartz-porphyry. × 200.

these crystals. Sometimes, however, the biotite appears to develop as a result of a reaction of the iron ore with the groundmass, as described by Richards (24) and Edwards (10).

The groundmass varies from coarse to finely microcrystalline, and in some instances is micro-spherulitic (fig. 4, B). More often it is a more or less granophyric intergrowth of quartz and orthoclase. Tourmaline is present in almost every section, mostly as the blue or brown variety, but sometimes as the green variety. In one section "micro-quartz-tourmaline nodules" are abundant (fig. 4, A). These consist of single crystals of blue tourmaline, poecilitically enclosing numerous quartz grains. Sometimes they possess a prismatic outline, but more frequently the outline is rounded. These structures appear to be equivalent on a micro-scale to the quartz-tourmaline nodules found in granites (12); and they probably represent bubbles of boron which formed in the rock during its intrusion, and reacted with the orthoclase felspar to form the blue potash-rich variety of tourmaline as the groundmass of the rock chilled.

In general appearance these rocks closely resemble the Mt. Burrowye rhyolite, particularly in the matter of the cloudy red microperthite phenocrysts, and the common presence of tourmaline. Chemically (Table 1, No. 4) they are identical with the Mt. Burrowye rhyolite, and with the red granites of Mt. Mittamatite and Pine Mountain, and their subsequent red porphyries.

(ii) *Quartz-felspar-hornblende-porphyrites.*

Dykes of this sub-group are easily recognized in the hand specimen. They are grey-green rocks, plentifully studded with glassy grey quartz phenocrysts, as large as 4 mm. across, whitish-grey felspars, and spots of blackish-green ferromagnesians, set in a dense grey groundmass which is spotted with greenish calcitized patches. Sometimes in addition, as in the dyke at Tintaldra Bridge, they contain megaphenocrysts, often 10–15 mm. in diameter, of pink orthoclase. In the absence of these the rocks closely resemble the quartz-dacite (rhyodacite) of Maroondah Dam, Healesville (10).

In thin section they consist of phenocrysts of quartz, felspar and altered hornblende, set in a micro-crystalline or granophyric groundmass of quartz and orthoclase, and sometimes tourmaline.

In the Tintaldra Bridge dyke, which has been propylitised, the hornblende phenocrysts are completely altered to composite pseudomorphs of chlorite (penninite), calcite, and apatite, which frequently retain the idiomorphic outline of the hornblende. The felspar is all altered to sericite, the biotite is chloritized, and pyrrhotite has been introduced. The normal alteration of the hornblende is to decussate sheaves of biotite and granules of quartz, which also still preserve to some extent the outline of the original hornblende crystals. Small flakes of a later green hornblende are sometimes developed. In other instances the original hornblende has been replaced by aggregates of small hornblende crystals, pleochroic with X = pale yellow, Y = green, Z = blue-green. Both types of replacement may occur in the same slide.

In addition to the clusters of decussate biotite, larger, ragged-ended flakes of biotite can be found, possibly formed by the coalescence of such sheaves. The quartz and the felspar generally form embayed, composite phenocrysts; and both may be present in the same clot. The individual crystals in the clots are generally allotriomorphic and interlocked. When the large pink, clouded orthoclase phenocrysts are not developed, the dominant felspar is oligoclase (Ab_{70}). In one specimen a xenocryst of quartz is present surrounded by a reaction rim of green hornblende.

Mineralogically and chemically the rocks of this group are intermediate between the quartz-felspar-porphyries and the hornblende-diorite-porphyrites. The analysis of the Tintaldra Bridge dyke (Table 1, No. 5) closely resembles that of the grey Corryong granite.

5. Diorite-porphyrite Dykes.

The diorite-porphyrite dykes are readily distinguished in hand specimen from the more acid varieties by their green, or less commonly black, colour, connoting increased content of ferromagnesian minerals. They fall into three closely related, but increasingly basic, sub-groups:—(i) quartz-hornblende-diorite porphyrites, (ii) quartz-hornblende-augite-diorite porphyrites, and (iii) labradorite-porphyrites. Sub-groups (i) and (ii) can only be distinguished from one another under the microscope.

(i) *Quartz-hornblende-diorite porphyrites.*

These are greenish, medium to fine-grained, holocrystalline, equigranular rocks, consisting of brown hornblende and andesine felspar, with subordinate amounts of orthoclase, quartz, iron ores and apatite, and secondary minerals, notably sericite, chlorite, calcite, epidote, albite, and quartz.

The hornblende occurs as abundant idiomorphic prisms, showing strong pleochroism with X = Y = light yellow, Z = reddish-brown or brown, and an extinction angle of $Z\Lambda c = 22°$ (approx). Zoned crystals are common, and in these the extinction angle $Z\Lambda c$ for the cores is about 17°-18°, for the intermediate zones about 19°-20°, and for the outer zone 22°. This may indicate, according to Kennedy and Read (22, p. 127) a progressive enrichment of the hornblende in Mg and Fe during its crystallization, an early common hornblende [H_2 Na Ca_2 (Mg, Fe) $_4Al_3Si_6O_{24}$] giving place to a pargasite [H_2 Na Ca_2(Mg, Fe)$_5$Al Si_7O_{24}]. The hornblende is generally more or less altered to an apple-green chlorite which retains the outlines, and often the cleavages of the hornblende crystals.

A number of the hornblende crystals enclose a core of colourless augite with 2V about 50°, or are moulded upon such augites (calcic pigeonites ?). This feature has been described by Junner (21, p. 158) as charcteristic of the hornblende in the hornblende-diorite-porphyrites of the Wood's Point-Walhalla dyke swarm. There, however, two varieties of pyroxene are found enclosed by the hornblende crystals, (i) a colourless augite, and (ii) a titaniferous enstatite-augite, or pigeonite with a very low optic axial angle.

Andesine (Ab_{65}) is the dominant felspar of these porphyrites, and is generally of later crystallization than the hornblende. Together with subordinate orthoclase and quartz, it forms allotriomorphic, or sometimes tabular, crystals which enclose the hornblende. It is frequently much altered to sericite if the hornblende is replaced by chlorite.

The quartz frequently occurs as ovoids of allotriomorphic grains in intimate association with crystals of bright yellow epidote, and lesser amounts of calcite, chlorite, and occasionally (?) albite. Such quartz is of secondary origin, and from the general association of quartz throughout the rock with secondary minerals it is a question whether most of the quartz is not of secondary origin, derived from the alteration of the felspars and hornblende by invading mineralizers. Hornblende phenocrysts are found crowded about the edges of the ovoids, with their longer axes tangential to the edges, so that the growth of the quartz-epidote areas must have preceded complete consolidation of the rock, i.e., the alteration of the rocks must have been deuteric.

(ii) *Quartz-hornblende-augite-diorite Porphyrites.*

The rocks of this sub-group contain less hornblende than those of the former, but their chief distinction is that they possess a second generation of pyroxene, which has crystallized later than the hornblende, and belongs to the groundmass. It is colourless, relatively calcic (?) pigeonite, with 2V about 40° (compared against muscovite with 2V = 40°), and occurs either as idiomorphic or irregular crystals in the coarser-grained dykes, or in ophitic or intergranular intergrowth with plagioclase laths in the more doleritic types. Where ophitic it is often a pale violet, though not pleochroic; and the iron ores in the rock contain ilmenite, frequently altering to leucoxene. In some instances the pigeonite appears to have been entirely replaced by chlorite and epidote, since these minerals form pseudo-"ophitic" intergrowths with the andesine laths. Small, irregular, and intersertal areas of secondary quartz are associated with such intergrowths.

The earlier generation of pyroxene is also preserved in these rocks, as inclusions in the hornblende crystals, or within altered phenocrysts of plagioclase. Generally it is a colourless augite, but occasionally the included pyroxene is enstatite, showing a slight pleochroism from pale green to colourless.

In one section granophyric intergrowths of quartz and orthoclase may be observed in the groundmass, together with occasional myrmekite intergrowths. A similar feature was observed by Junner (**21**, p. 158) in some of the diorite-porphyrites of the Woods Point-Walhalla series.

An analysis (Table 1, No. 6) has been made by Mr. Field of a typical specimen of this group, from Harris Hill, Parish of Colac Colac. The hornblende is almost completely altered to chlorite, but, as may be seen by comparing the analysis with analysis No. 7 of the table, it is closely comparable with the propylitized diorite-porphyrites of the Woods Point-Walhalla swarm.

(iii) *Labradorite-porphyrites.*

These are dense black rocks, studded with glassy felspar phenocrysts, which may be 2 to 3 mm. long. They are easily recognized in the hand specimen, and are less numerous than the diorite-porphyrites. They compare most closely in appearance with the chilled border phases of the felspar-hornblende-porphyrite dykes of Warburton (**11**), but are more basic.

In thin section they are seen to consist of strongly zoned idiomorphic columnar crystals of labradorite (Ab_{45}) with a maximum extinction angle in the symmetrical zone of 30°, set in a pilotaxitic groundmass of stumpy andesine laths, chloritized brown hornblende prisms and fibres, and granular iron ore. The outermost zone of the phenocrysts is andesine (Ab_{60}), of composition similar to that of the groundmass felspars. In some specimens the felspar is quite fresh; in others it is strongly sericitized, and a little secondary quartz is developed. The chloritization of the hornblende and the sericitization of the felspar appear to be of comparable degree. No augite has been observed in this subgroup.

A chemical analysis was made of a typical specimen from Tintaldra (Table 1, No. 8). It is more basic than the quartz-hornblende-diorite dykes, but equally rich in alumina, and with abundant lime and magnesia. In many respects it resembles a basalt. The nearest approach to it among rocks of related suites is the meta-basalt of Marysville (**17**).

6. Red Granites of Pine Mountain and Mt. Mittamatite.

The granites of these two stocks are identical in appearance. They are fine-grained equigranular, pink to reddish, potash granites, distinctly poor in ferromagnesians by contrast with the grey Corryong granite.

In thin section they are seen to consist of quartz, vein-perthite, and orthoclase, subordinate oligoclase, a small amount of green biotite, chlorite, and epidote possibly pseudomorphous after hornblende, and a little iron ore. The pink colour of the rock is due to the presence of innumerable specks of (?) hematite in the orthoclase. The dust is absent from the perthite veins. The oligoclase is somewhat sericitized, and is often found as a "sieve structure," invaded by the orthoclase. In the final stages of disintegration these "sieves" give rise to numerous small, optically parallel, inclusions in the orthoclase. The oligoclase is mostly about Ab_{75} with cores of Ab_{70}.

The biotite of these granites is similar to that in the granitic dykes, and is distinct from the brown biotite of the Corryong granite. It is pleochroic from yellow to green, even when not obviously chloritized. It contains occasional vaguely outlined inclusions which are pleochroic from pale yellow to brown, and are suggestive of brown hornblende. Small areas of chlorite and epidote, similar to those observed replacing hornblende in the quartz-felspar-hornblende porphyrites, occur scattered through the rock, and some have shapes suggestive of hornblende.

Chemically the Pine Mountain and Mt. Mittamatite granites are almost identical, and fall within the group of granites proper referred to earlier (p. 81). Their analyses (Table 1, Nos. 9, 10) are also closely comparable with that of the Jemba rhyolite, and with the analyses of the quartz-porphyry and red-porphyry dykes.

7. The Red Quartz-porphyry Dykes.

These are porphyritic dyke rocks with phenocrysts of glassy quartz and red felspar in a dense reddish groundmass. The felspar consists of orthoclase and vein-perthite, which form clots of allotriomorphic crystals, and a minor amount of acid plagioclase. The orthoclase is very cloudy, being filled with minute specks of (?) hematite. Occasional microphenocrysts of green biotite, and colourless corroded garnet are present. The groundmass is coarsely micro-crystalline, and consists of quartz and felspar. The felspar is so strongly clouded with hematite dust as to be indeterminate, but is almost certainly orthoclase. Purple fluorite occurs in the groundmass, in association with chloritized biotite.

These dykes are somewhat coarser-grained than the earlier quartz-porphyry dykes, which they otherwise resemble. Like the two red granites a high proportion of their iron content is present as Fe_2O_3 (Table 1, No. 11) owing to the presence of so much hematite dust in the orthoclase, but otherwise the ana'ysis is almost identical with that of the Jemba rhyolite, and quartz-porphyry.

Thickness of the Cover.

Minimum estimates can be made of the thickness of cover under which the Corryong granite batholith and the Red Granite stocks solidified. The shape of the Jemba rhyolite residual suggests that the rhyolite did not greatly overflow the Jemba basin. Since there is still over 2,000 feet thickness of rhyolite, the sediments enclosing the basin must have stood at least 2,000 feet above its floor, and were presumably higher, i.e., more than 4,000 feet above present sea-level. The general level of the top of the Corryong batholith in the northern part of the area is between 2,000 and 2,500 feet above sea-level. It must therefore have consolidated under a cover not less than 2,500 feet thick, and probably a good deal thicker.

The two Red Granite stocks rise through the Corryong granite to 3,340 feet and 3,310 feet above sea-level respectively. The level of their contacts with the Corryong batholith varies from 1,500 feet to 2,000 feet above sea-level, and rises to 2,500 feet on the N.E. side of Mt. Mittamatite. The Red Granites, therefore, penetrated between 800 feet and 1,350 feet into the Ordovician above the Corryong granite. If it is assumed that the Jemba rhyolite is contemporaneous with these later granites, then the Jemba basin had been formed by this time, so that the thickness of the original cover above the Corryong batholith was much reduced, although it must still have been more than 2,000 feet thick where the red granites were intruded. Since they rose about 1,000 feet into this cover, the minimum thickness of the cover indicated is about 1,500 feet.

The dyke swarms developed at considerably greater depths, since their outcrops are found mostly at 1,000 feet or more, below the summits of the Red Granites. Their extension in depth cannot be gauged. Clearly, the differentiation of the Red Granite cupolas continued during a rise of several thousand feet subsequent to the intrusion of the dykes.

These minimum values, whilst more or less comparable with other estimates of the thickness of batholith roofs (Daly, 1, p. 126), indicate a relatively thin roof for the red granite stocks.

Age Relations of the Intrusions.

It can only be demonstrated that both series of igneous intrusion were later than the Devonian orogeny by which the Upper Ordovician rocks were folded. If this orogeny was delayed until the Middle Devonian period (18, p. 116), then the intrusion of the Corryong granite batholith (which includes the Koetong granite, and hence (27) the Tallangatta gneisses) can be tentatively placed as late Middle, or Upper Devonian.

The time interval between the intrusion of the Corryong granite, and the later Red Granite series, can be gauged only in terms of erosion. The exposure of the Corryong granite in the floor of the "fossil basin" or deep lead, preserved beneath the Jemba rhyolite, indicates that some thousands of feet of sediments had been removed in this area subsequent to the orogeny, and previous to the second period of intrusion. If the orogeny can be regarded as Lower Devonian in age, then the Corryong granite may be post-Lower Devonian, while the Red Granite series may coincide with a Middle or Upper Devonian minor orogeny. If the

Corryong granite, on the other hand is post-Middle Devonian, the Red Granite series cannot be older than Lower Carboniferous, and may be much younger.

This development of at least two periods of igneous intrusion within a single area is not unique to this part of Victoria. In the Wedderburn District (28) an earlier, coarse-grained granite with porphyritic orthoclase is intruded by a later finer-grained, pink granite which carries tourmaline; while, intrusive into both granites, are a series of quartz-porphyry dykes, with subordinate quartz-diorite porphyrite dykes.

The Red Granite Complex.

If it be assumed that the dyke swarm, the Jemba rhyolite, and the granites of Pine Mountain and Mt. Mittamatite, with their subsequent red porphyry dykes, were consanguineous, then a comprehensive picture of the second period of intrusion can be drawn.

The differentiated character of the dykes and the fact that the diorites do not grade into quartz-porphyry along their strike, but are distinctly later intrusions which have come up the same channels, makes it clear that the dykes as a whole are derived from different levels in a differentiated magma. The upper layers of granite were drawn off first, and solidified in the cooler parts of the crust. They were followed by quartz-porphyry dykes from rather lower and hotter levels; and subsequently, by diorite magma from still lower, hotter levels. In each instance, however, the previously intruded magma had chilled before the later magma approached its level, so that the later, hotter magma in each case cut through the previous injection. The series of intrusions may have been continuous at depth, or possibly pulsatory.

We may picture a series of cupolas of dioritic magma, differentiating to granite partially by crystallization differentiation and partly by assimilation (13), rising through the Corryong granite into the overlying sedimentary cover. In advance of some of the cupolas, but in continuity with them, a series of dykes extend into fissures, faults, or planes of weakness in the roof. In the Corryong granite these coincide mostly with the direction of the joint planes, while in the sediments, if sufficiently thick to overcome the influence of this underlying Corryong granite, they coincide with the strike of the beds. These dykes draw their supply of magma from the upper portions of the cupolas: and if they are sufficiently numerous, drain off all the upper differentiated layers, and then some of the diorite. The dykes congeal: and into them stopes the slowly rising magma, differentiating more and more to granite in its upper regions.

Two such cupolas (Pine Mountain and Mt. Mittamatite) rose right through the Corryong granite and 1,000 feet or more into the overlying sediments. Where channels were available, these two granites sent out red porphyry dykes before they consolidated.

Above some of the other (supposititious) cupolas, dykes did not form in great numbers, but plugs of magma were injected under pressure into the cool upper crust, where they contorted the sediments, and congealed as quartz-porphyry owing to their small bulk. Mt. Morgan and Mt. Unicorn are examples of such plugs; and there are others in Walwa.

In Jemba, however, where the several thousand feet of sediments elsewhere covering the Corryong granite had been removed, the magma burst through the surface when it still possessed sufficient energy to stope up for another 1,000 feet. The absence of dykes round the edge of the rhyolite mass may indicate that the magma here rose as a plug, as at Mt. Morgan and Mt. Unicorn: or that the first few dykes reaching to the surface served as the necessary channels, and tapped the upper layers of the cupola. The bulk and uniformity of the rhyolite, and the apparent absence of diorite, suggest that the first alternative is the more probable. Magma was extruded until a thickness of lava of sufficient strength and pressure to seal the cupola was attained.

Mechanics of Intrusion.

The mechanism by which such a cupola-dyke complex might form requires some consideration. The predominant factors in such an intrusion will be temperature and pressure.

The mode of operation of temperature in connexion with cupola intrusion has been adequately explained by Holmes (19, pp. 243-250), from the principles of convective circulation taken in conjunction with the large differences that exist between the thermal gradients maintained by convective currents and the much steeper gradients of the rise of fusion temperature with pressure (i.e. depth). As a result of this difference, the convection currents would maintain the magma at the top of the cupola well above its fusion point, and so long as the supply of heat from the main reservoir continued, this superheat would be available for fusing the material of the roof and sides nearby. The augmented magma and liberated crystals or blocks would be carried down by the return peripheral circulation, along or parallel to the enclosing walls. In this way the roof of the cupola would be gradually extended upwards so long as the supply of heat was maintained.

The pressures in such a system (ignoring the possibility of tectonic forces) will be due to three major factors: the weight of the overlying rocks, which will be proportional to their thickness: the pressure inherent in the magma from the presence in it of volatile substances above their critical temperatures; and the strength of the overlying (or containing) rocks.

The inherent pressure of the magma will act in the direction of expansion, while the strength of the rocks, which is limited, acts purely in a retaining fashion. The pressure of the overlying strata will tend to cancel out, since action and reaction are equal and opposite, so that only factors (2) and (3) are active.

When a cupola rises sufficiently close to the surface, the inherent "volatile" pressure of the magma, being in excess of the resistant strength of the invaded rocks, will tend to raise the roof of the cupola. Anderson (30, pp. 11, 12, Fig. 1) and Thomas (31, pp. 56, 57, Fig. 5) have shown that if the invaded rocks are homogeneous, a system of more or less concentric conical tensions will develop in them above the cupola: and if these are filled with magma, will give rise to cone sheets.

In the area under consideration, however, the invaded rocks are not homogeneous, but consist of folded sediments and granite, possessing well defined directions of weakness, namely the bedding planes of the sediments, and the joint planes of the granite. The effort of the cupola to lift its roof found relief therefore in the opening up of these pre-existing planes of weakness, rather than by the development of a system of conical tensions. As a result, instead of cone-sheets, a dyke swarm developed, concentrated above each cupola, and parallel in direction to either the strike of the sediments, or the joint planes of the granite, according as to which was locally predominant.

With the re-sealing of the openings by the dykes, the strength of the invaded rocks would be more or less restored, and at the same time the excess internal pressure due to the volatiles would be reduced or dissipated. The addition of further hot material from the depths to fill the part of the cupola drained off into the dykes would cause a repetition of this process, or would permit the process of rise by convection assimilation to continue, when the cupola would rise into and replace the dykes.

Corryong Batholith.

Inadequate exposures prohibit speculation as to the behaviour of the Corryong granite in depth, but it has the apparent form and characteristics of a batholith (1, p. 113 et seq.).

The batholith is rather more completely deroofed in the northern part of the area than in the south. Knowing the shape of the contact aureole, and assuming its absolute width as uniformly 500 feet, it is possible to indicate the contours of the still covered portions. In the north the original irregularities of the granite surface have been eroded away, and only disconnected remnants of the deeper re-entrants of sedimentary cover remain as roof pendants, with their major axes and their strike parallel to the average strike of the Ordovician strata around and above the batholith, as in the N.W. (Parishes of Burrowye and Koetong). Further south, however, the roof is diversified by two well defined salients and re-entrants, in the manner of Daly's diagram (p. 122, Fig. 42).

The outcrops of the granite salients are more or less linear and parallel to the strike of the invaded Ordovician. The discordant relation of the outcrops and the surface contours and the contours of the hidden granite surface indicate that these granitic ridges are steep sided. Their surfaces are diversified by minor peaks and saddles. Excellent examples on a large scale occur to the S.W. outside of the area, where the Tallangatta Creek has cut a course parallel to the Ordovician strike in an acutely-angled, downwardly-directed, wedge-shaped roof pendant of sediments. On either side of the stream are elongated ellipses of granite, bordered by uniform contact aureoles, the long axes of the ellipses also being parallel to the Ordovician strike.

Certain beds of sediment are probably much more prone to replacement than others, and since they will present themselves to the magma as lenticles elongated parallel to the strike, their direction will be impressed on the roof of the magma chamber, and so control the ultimate shape of the main body of magma. The strike of the invaded sediments presents, moreover, a direction of more easy access to the molten magma. In this way the surface of the magma chamber will always be diversified by a number of lenticular steep ridges, with intervening downwardly-directed wedges, all with their long axes parallel to the strike of the invaded sediments.

As the magma chamber increases and engulfs the intervening wedges of sediments, the strike direction of the sediments will be constantly impressed upon it.

In view of the apparent relation in origin of batholiths with orogenic movements, it is probable that the shape of the granite magma in its origin conforms more or less to the shape of the newly formed mountain region, or to the geosyncline from which the mountains sprang. The shape of the batholith at great depths, therefore, will be concentric with the shape of the mountains with which it originated, but in its upper regions it will conform with the strike of the sediments, quite apart from the relation of the strike to the shape of the original mountains, or of the still earlier geosyncline.

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[Proc. Roy. Soc. Victoria, 50 (N.S.), Pt. I., 1937.]

Art. VI.—*Quartz-Diorite Magma in Eastern Victoria.*

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[Read 13th May, 1937; issued separately, 29th December, 1937.]

Contents.

Introduction.

Localized developments of quartz-diorite are of frequent occurrence throughout Eastern Victoria (9, 12, 13, 14, 15, 17, 18), generally in association with more acid rocks; and despite their small total bulk, they reveal something of the processes of the progressive differentiation by which they, and presumably their granitic associates, were evolved.

A "Two-Pyroxene" Magma.

The magma which gave rise to the quartz-diorites was saturated with respect to silica, and was a "two-pyroxene" magma, i.e., as intratelluric cooling progressed, two immiscible series of pyroxenes crystallized out from it, namely diopsidic augites ($2V = 50°–60°$) and hypersthenes (in some instances enstatite, or even monoclinic enstatite-augite). At a later stage a single hornblende began to crystallize in place of the two immiscible pyroxenes, and by a discontinuous reaction the already crystallized pyroxenes were converted to hornblende.

This state of affairs is amply illustrated by the quartz-diorite of Granite Flat (on the Mitta Mitta River), in which large crystals of green-brown hornblende are found enclosing crystals of colourless augite ($2V = 60°$) and less numerous crystals of hypersthene. The contact of the hornblende and the enclosed pyroxenes is of a transitional nature. In the quartz-diorite-porphyrites of the Walhalla-Wood's Point dyke swarm (17), the brown hornblende phenocrysts enclose augite, and in one dyke an almost uniaxial pyroxene (i.e. monoclinic enstatite-augite).

The diorite dykes of North-east Benambra (9) show the same phenomena, the enclosed pyroxene being mostly augite ($2V = 50°$), but occasionally enstatite. Similarly, in the quartz-diorite of Reedy Creek, near Broadford, the hornblende phenocrysts enclose cores, partially altered, of augite and enstatite. Howitt (12) has described diorites from Swift's Creek, near Omeo, in which the hornblende encloses cores of augite, and examination of rock slides in the Howitt Collection at the University of Melbourne reveals this feature in a number of diorites from the Omeo region. In quartz-diorites from Swift's Creek, Riley's Creek, and Tongio Gap, the inclusions are of colourless augite and of enstatite; in those from Parsloe's and King's Spur, of augite and hypersthene; and at Jambarra River, in a more basic diorite, phenocrysts of augite and enstatite occur, with a lesser amount of later hornblende.

Other instances of this "two-pyroxene" magma in Victoria are provided by the hypersthene-dacites of the Dandenong Ranges, the Mt. Juliet-Donna Buang Ranges near Warburton, and probably that of the Macedon Ranges. In these, hypersthene is the dominant pyroxene, but occasional crystals of colourless augite ($2V = 50°$-$60°$) have been observed in the former two.

With continued intratelluric cooling of the magma the hornblende is replaced by a ferro-magnesian biotite, and this by muscovite; but where the cooling has been more rapid the hornblende has given place in some instances, as in the more basic hornblende-diorite dykes of North-east Benambra (9) to a groundmass phase of pigeonite ($2V = 40°$); while in others, as in the felspar-hornblende-porphyrites of Warburton (6), and the labradorite-porphyrites of Benambra (9), the hornblende itself occurs in the groundmass phase of the rock.

Petrological Theory.

These features of the quartz-diorite magma are fully in accordance with recent petrological theory. Thus, Sosman (27) and Asklund (1) have shown, by plotting the chemical analyses of igneous pyroxenes on a triangular basis (with MgO, FeO and CaO as poles), that there is apparently an immiscibility gap between the diopsidic pyroxenes (augites) and the enstatite-hypersthene series. This was confirmed by Tsuboi (28), who showed from a study of the "two-pyroxene" andesites of Japan, that two immiscible series of pyroxenes, diopsidic augites, and hypersthenes, crystallize during the intratelluric stage of cooling, their proportions depending upon the composition of the magma; but that during extrusion they give place, with certain exceptions, to a pigeonite which is a mixed crystal of the two. More recently, Bowen and Schairer (3), from their study of the ternary system MgO-FeO-SiO_2, have suggested an explanation of the phenomenon. They have demonstrated that the monoclinic Mg-Fe rich pyroxenes (pigeonites) are high temperature forms, while the augites and hypersthenes are relatively low temperature forms, stable at the temperatures existing in magmas. Under the conditions prevailing during intratelluric cooling these two low temperature pyroxenes crystallize side by side, but with rapid cooling, such as is caused by extrusion, a metastable phase of the high temperature form, pigeonite, crystallizes. In exceptional instances, where the cooling is not so sudden, the stable phases might persist into the groundmass, as Tsuboi indicated. Kuno (24) has shown that under equally exceptional conditions the high temperature pigeonites can persist as metastable phenocrysts.

Kennedy (20), on plotting the compositions of igneous hornblendes on a similar triangular basis to that used by Sosman and Asklund for the pyroxenes, found that they all fall within the immiscibility gap which separates the diopsidic augites from the hypersthenes; and are, apparently, equivalent to low-temperature mixed-crystals of these two pyroxenes. He suggests that when a rock in which hornblende is crystallizing is extruded these two pyroxenes should be formed in their equivalent proportions. In fact, however, the metastable pyroxene, pigeonite, appears (9), or the hornblende itself crystallizes in the groundmass phase. Presumably the hornblende is of approximately the same composition as the pigeonite.

Formation of Hornblende.

The stage of crystallization at which hornblende crystallizes is subject to variation. Thus, occasionally, as in the quartz-diorite of Granite Flat, it is not as far advanced as in the more basic diorites. What factors control this variation?

Since the mineralizers enter into the composition of the hornblende, their presence is essential—but not sufficient, as Kennedy and Read (21) have shown. The other controlling factors will be the composition of the magma, the temperature, the rate of cooling, and the pressure. A slow (intratelluric) rate of cooling is a favorable factor. Rapid cooling from a moderately high initial temperature may give rise to pigeonite; with a low initial temperature a groundmass phase of hornblende may form.

Grout states (10, p. 440) that brown hornblende, such as characterizes the common type of Victorian diorite, forms at above 850° C., while green hornblende, such as occurs in the more acid diorites, and in the granitic rocks, forms at below 800° C. Kozu, Yoshiki and Kani (22, 23) have shown, however, that common brown and green hornblendes, equally, are oxidized to basaltic hornblende at about 750° C., so that common hornblende probably forms at or below this lower temperature. Kennedy and Read (21, p. 127) cite an instance in which the hornblende became enriched in MgO and FeO as crystallization progressed; and the zoned hornblendes of some of the Benambra diorites (9) suggest a similar progressive change of composition. It seems probable, therefore, that CaO-rich types crystallize at higher temperatures than the iron-magnesia-rich varieties.

Whether pressure is important of itself, or merely because it is an essential accompaniment to retention of volatiles cannot be ascertained.

Hypersthene-Dacite.

Rosenbusch (26, p. 402) has directed attention to the fact that in andesites, phenocrysts of biotite or hornblende are generally accompanied by phenocrysts of acid plagioclase, while phenocrysts of hypersthene and augite are generally accompanied by basic plagioclase. The hypersthene-dacites of Central Eastern Victoria are a case in point.

The chilled border phases of these lavas give an approximate picture of the magma immediately prior to their extrusion. Its ferromagnesian content had almost completely crystallized out as hypersthene (and occasional augite) crystals, which were still in equilibrium with it. Practically all of the lime had also precipitated as basic plagioclase-zoned crystals, with cores of basic labradorite, and rims of andesine. The plagioclase, however, was not in equilibrium with the magma, and was in process of reacting with it to form more sodic plagioclase. Free silica had scarcely commenced to crystallize, so that the temperature was probably too high for hornblende to form.

The state of differentiation of the magma prior to the extrusion of the dacite may be pictured as a series of gradational layers, thus:—

Layer.	Crystalline Portion, i.e., Phenocrysts.		CaO per cent.	Al_2O_3 per cent.	SiO_2 per cent.
Hypersthene-Dacite	Hypersthene (augite)	Andesine	4	16	60–62
Augite Hypersthene-Diorite	Augite Hypersthene	Andesine (Basic)	8	16–20	52–55
?	?	?			

It is evident that in the upper layer all the lime and alumina has gone to form plagioclase, leaving the MgO and the FeO to form hypersthene. How could such a magma originate from a dioritic magma in which augite was the dominant pyroxene, with subordinate hypersthene?

The explanation probably lies in the fact that a large part of the lime in the hypersthene-dacite magma (probably as much as half the total) was locked up in "armoured" cores of labradorite in the plagioclase phenocrysts, leaving insufficient lime in the residual magma to produce both plagioclase felspars and lime-bearing pyroxenes. Such lime as was available was taken by the plagioclase, and the magnesia and iron left to form hypersthene as the increasingly dominant pyroxene. In other words, absence of equilibrium relations between the felspar and the magma led to marked fractional differentiation.

Three factors may have acted to produce this fractional crystallization of the felspars:—

(1) Relatively rapid intratelluric cooling, resulting from the approach of the magma close to the surface while it was still at a high temperature. This would prevent the basic plagioclase felspar from establishing equilibrium with the magma, and lead to zoning of the felspars.

(2) The reduction of pressure within the magma chamber, incident upon such thinning of the roof, might lower the crystallization temperature of the plagioclase felspars to some degree (11), and thus enable basic plagioclase to crystallize for a longer period than would be normal without such a reduction of pressure. This also would extract lime from the magma.

(3) Assimilation of argillaceous sediments might have this effect. Both Bowen (2) and Read (25) consider that the addition of alumina-rich material to basaltic magma "would result in the increase of the amount of magnesia in the pyroxene, and of anorthite in the plagioclase." Moreover, the potash content of such assimilated rocks would, as Daly (4, p. 450) has suggested, provide the essential potash of the andesitic rocks, potash not easily derived by differentiation of a basaltic magma.

That the roof of the magma chamber was thin at the time immediately preceding extrusion must apply equally to all dacites and andesites. The important factor for rapid cooling, therefore, is that the magma should be at a relatively high temperature during its approach to the surface, or that it should rise rapidly through the crust. Since quartz had barely commenced to crystallize from the hypersthene-dacites, the temperature of the magma was probably not greatly below 870° C.; and since the hypersthene was still stable, the temperature was probably well above 700° C. (5, p. 74).

Hornblende-andesites, in comparable situation within the crust, must have considerably lower temperatures than hypersthene-dacites, if common hornblende does not form above 750° C.; and the rate of cooling in these rocks must have been correspondingly slower, over a longer period, permitting a better establishment of equilibrium relations between early formed plagioclase and the magma. At the lower temperatures, moreover, a considerably more sodic plagioclase (about 10-20 per cent. richer in soda) should be able to crystallize from the hornblende-andesite than would be possible for the hypersthene-dacites.

Assimilation of argillaceous sediments by the magma must have occurred to some extent, but the degree cannot be gauged. The difficulty in determining what fraction of the assimilated material is incorporated in the hypersthene-dacites is illustrated by the following analyses of a xenolith of argillaceous sandstone, and of the typical hypersthene-dacite in which it occurs:—

—	1.	2.	3.	4.	
SiO_2	61·38	62·73	64·00	63·74	
Al_2O_3	20·28	17·41	19·81	19·91	
Fe_2O_3	6·91	0·45	3·50	4·07	
FeO	0·78	5·17	..	0·45	
MgO	0·99	2·94	2·14	2·10	
CaO	tr.	4·25	0·24	Nil	
Na_2O	1·07	2·03	1·10	0·55	
K_2O	3·46	3·30	4·41	3·89	
H_2O	3·38	0·66	2·23	4·49	
H_2O	0·57	0·16	0·85	0·47	
CO_2	Nil	Nil	..	..	
TiO_2	1·12	0·93	..	0·79	
P_2O_5	tr.	0·23	0·01	tr.	
MnO_2	tr.	tr.	..	..	
FeS_2	Nil	0·30	..	Nil	
Carbon	..	..	3·32	..	
				0·11	Cl
	99·94	100·56	100·94	100·54	

1. Indurated argillaceous sandstone, sedimentary inclusion in dacite, Mount Dandenong. Analyst—F. F. Field.
2. Hypersthene-dacite, road cutting, allotment 925A, Parish of Mooroolbark, 15 chains N.E. of Kalorama, Mount Dandenong. Analyst—F. F. Field.
3. Mica-schist, Omeo District. Analyst—A. W. Howitt.
4. Slate, Baker Mine, Wedderburn.

One might be tempted to ask—how much of the xenolith is derived from the dacite? The analyses of the mica schist from Omeo and the slate from Wedderburn are quoted to show that the composition of the xenolith is quite normal.

The other possibility arises—is the dacite a fused argillaceous sediment? If so, from where does it derive its lime and soda, and possibly, phosphorus?

The probability is that the silica of the assimilated sediments floated or rose to form the more acid, rhyolitic upper layer in the magma chamber, while the alumina crystallized as plagioclase, which would either sink or retain its level. Similarly the increased magnesian pyroxene would either sink or retain its position. In this way the lime of the magma would be increasingly diminished in the upper layers.

Origin of the Quartz Diorite Magma.

The origin of the quartz diorite magma in Eastern Victoria is not obvious; and bound up with it is the origin of the granites, granodiorites, rhyolites, toscanites, rhyo-dacites, and porphyries, which are apparently consanguineous with it. There are, however, certain outstanding features which any hypothesis must explain:—

1. The rocks in question are all saturated varieties, e.g., the diorites are always quartz-diorites. Quartz-free diorites have not been met with.

2. The basic rocks associated with the dioritic magma show a diversity of types. They include basalts, hornblende-mica-lamprophyres, gabbro-porphyrite, in one instance grading into porphyritic pyroxene-basalt, and in another into hornblende-peridotite, hornblende-hypersthene-gabbro, hornblende-peridotites, hornblende-pyroxenites, and hornblendites (18).

3. From the nature of their occurrences these ultra-basic types are not crystal accumulations, but represent magmas.

4. As emphasized in a previous paper (7), the dioritic magma in Victoria is intimately associated with an immediately previous orogeny. Tertiary magma intruding the same sediments, and probably additional granite, gave rise to a typical olivine-basalt-trachyte association. Therefore, either the original magma of the diorite suite was of different composition from that of the Tertiary period, or the differentiation was in some way effected by the orogenic period preceding it.

5. Whereas basic types are predominant, and monotonously uniform among the Tertiary rocks, they are distinctly a minor but diverse feature among the rocks associates of the diorite magma.

6. The gradational relationship which can be observed between the dioritic rocks and their more acid associates suggest that they were derived from a single magma stock by crystal differentiation.

7. A vast amount of assimilation, abyssal or otherwise, must have taken place to make room for the granitic intrusions; or else a volume of sediments equal to the total bulk of the intrusions must have been fused.

Daly (4, p. 450) directs attention to the association of andesites with (i) plateau basalts, and (ii) continental regions; and from this he infers that dioritic magma is probably derived from a primary basaltic magma, the process being aided by assimilation of Sialic xenoliths. Kennedy (19), for similar reasons, is led to believe that there are two distinct types of primary basaltic magma, which he designates as olivine-basalt magma type, and tholeiitic magma type. The olivine-basalt magma type differentiates towards trachytic magma, the tholeiite to andesitic or dioritic magma, the control being exerted by the different types of pyroxene which separate out from each magma type.

The five available analyses of the basalts associated with the Victorian diorite magma are not typically tholeiitic in character, being either too rich in MgO or else in Al_2O_3. A more fundamental objection lies in the presence of peridotite magma, which could not easily be derived from a tholeiite type of basalt. As Holmes writes (16, p. 555), "peridotite magmas cannot be accounted for otherwise than by refusion."

The Refusion Theory.

The Refusion Theory, as outlined by Holmes (16), supplies an explanation of the association of the diorite magma with orogenic periods. Basing his ideas on the layered character of the crust in continental regions, as suggested by seismic evidence, he pictures the possible development, more or less in association, of three main types of parental magma: ultra-basic, basic, and acid. When, from some cause such as leads to an orogenesis, heat accumulates within the crust, fusion occurs in the peridotite layer. The fused magma commences to rise upwards, producing a "wave of magma," whose composition will depend upon which layer is undergoing fusion. Each layer, when fused, will give rise to a parent magma—a peridotite magma, a basaltic magma, and possibly an intermediate magma, or a granitic magma. All three may intermingle as the wave rises, or assimilate, giving rise to intermediate types, or, provided they can obtain access to the crust, may appear side by side as intrusions.

Three such magmas existed, side by side, during the Upper Palaeozoic period, in Victoria—whether of this or other origin.

Acidification of Basic Magma.

Two points are clear. Despite the association of the diorite magma with basalt, basalts do not, when they differentiate normally, give rise to vast amounts of acid magma. On the contrary, as the olivine-basalt-trachyte province indicates, they give rise to only minor amounts of acid magma.

Secondly, a vast bulk of sediments has disappeared to make room for the granitic intrusions accompanying the dioritic magma. These sediments may have been (i) fused *in situ*, and recrystallized, or (ii) assimilated. In either case they must have formed part of the magma which gave rise to the granitic intrusions. That they simply fused *in situ* and recrystallized to form granite is improbable, in view of the analyses quoted, which are comparable in composition with the average of all the available Victorian analyses of Silurian and Ordovician sediments. The magma resulting from such a fusion would have a composition corresponding with no known igneous rock. It is clear therefore that the second alternative is the more probable, i.e., that material was combined with the sediments to form granitic magma.

Addition of material could only be achieved by the sediments being assimilated, or being fused and mixed with other magma. This other magma, moreover, would require to contain abundant lime, little potash, and low alumina. A "plagioclase magma" of the type defined by Reynolds (*27*) in connexion with hybridization in the Newry Igneous Complex, would contain the desired proportions of lime, soda, and potash, but would be much too rich in alumina (22 per cent.). Plateau basalt (Kennedy's tholeiite magma type) more nearly fulfils the specifications. It contains 10 per cent. of CaO, about 1 per cent. of K_2O, and only 13-14 per cent. of Al_2O_3. Moreover, it is the type of basalt commonly found associated with dioritic magma throughout the world.

Imagine then such an admixture taking place, accompanied by crystallization differentiation. The addition of alumina to the tholeiite magma would cause lime to form basic plagioclase, thereby removing much alumina from the residual magma, and creating an intermediate magma richer in alumina than either the parent basalt or the residual magma.

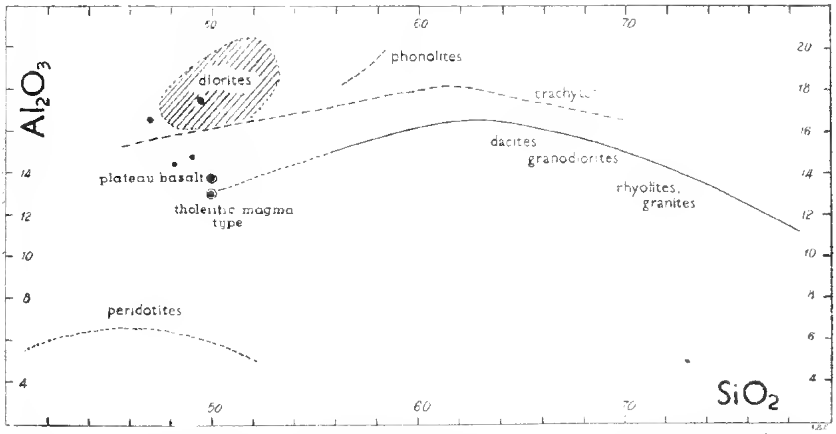

FIG. 1.—Quartz Diorite Magma in Eastern Victoria.—Variation of Al_2O_3 with SiO_2 for (1) Tertiary basalt-trachyte suite, shown by broken line; (2) Palaeozoic andesite-rhyolite suite, which is genetically related to the quartz-diorites, shown by full line. (3) Peridotites contemporaneous with the quartz-diorites, shown by the dotted line. (4) The quartz-diorites, by the shaded area. (5) Palaeozoic basalt associated with the quartz-diorite, andesite-rhyolite, and peridotite suites, by black dots.

In Fig. 1 the variation of Al_2O_3 with SiO_2 has been plotted for (i) the Tertiary olivine-basalt-trachyte suite in Victoria, represented by the broken line, (ii) for the Palaeozoic andesite-rhyolite suite (quartz-diorite magma), represented by the full line, and (iii) the peridotite-magma, by the dotted line.

It has been assumed that the tholeiite magma type is the parent magma for the andesite-rhyolite suite, and the full line has been extrapolated as a broken line to suggest the variation in Al_2O_3 with SiO_2 percentage which would have to occur if the more acid types were derived from simple crystallization differentiation

The oval shaded area embraces the Al_2O_3 contents of all the analysed Victorian quartz-diorites. It is clear that if the plateau-basalt is the parent of the andesite-rhyolite series, then the quartz-diorites are all exceptionally rich in Al_2O_3. Even if olivine-basalt magma were the parent magma, they still remain unusually rich in Al_2O_3.

The black dots represent the Al_2O_3 contents of the four reliable analyses of associated basalts. One falls within the diorite area and one close to its edge; the other two lie half-way between the tholeiite magma and the olivine-basalt-magma. All have been enriched in Al_2O_3 with regard to tholeiite magma type.

The removal of the lime as basic plagioclase would cause the magnesia and iron to crystallize as hypersthene in the presence of excess SiO_2. Some of the potash introduced might conceivably form biotite if the temperature permitted.

The greater part of the assimilated material would be rejected by the basaltic magma in the normal way, by crystallization differentiation, but would carry with it some additional lime and soda from the basalt. Until the alumina content was sufficiently reduced, lime plagioclase and hypersthene would continue to form, thus giving rise to hypersthene-dacites, which would grade into rhyolites. The characteristic pyrogenetic garnets in the more acid dacites (8) is adequate evidence that those rocks were saturated with respect to alumina. All the rock types produced subsequent to the assimilation would necessarily be saturated with respect to silica, so that quartz-basalts, quartz-diorites, quartz-andesites, and rhyolites would be expected.

The fact that the Tertiary olivine-basalt magma was scarcely affected by assimilation (7) makes it clear that the effect of the orogenic period must be to pre-heat, or even fuse the sediments at the roots of the newly-formed mountainous tract, or in some other way dispose them to ready assimilation or intermingling with the wave of basaltic magma rising from the deeper layers.

It is suggested that the diorite magma of Victoria, and its basic and ultrabasic associates, furnish evidence of refusion and intermingling of magmas, in the manner suggested by Holmes.

Summary and Conclusions.

Quartz diorites, though of limited development, are of such frequent occurrence throughout Eastern Victoria in genetic association with granitic intrusives and lavas, that any hypothesis as to the origin of the one must include the other.

Any such hypothesis must also account for the disappearance of a vast bulk of alumina-rich sediments which the granitic intrusives have replaced. Their disappearance cannot be accounted for by simple fusion and recrystallization, since they contain too little lime or soda and too much Al_2O_3 to give rise to granites; nor can it be explained by the soaking up into such sediments of a "plagioclase magma", since this would have raised the alumina content still higher.

The intrusion of the diorite-granite suite followed a major orogenesis, and was associated with the intrusion of minor quantities of basalt and peridotite. This is in marked contrast with the Tertiary intrusions of the same areas, which took place during a period free from orogeny, when the extrusions were dominantly basaltic, with only minor amounts of acid types (trachytes).

Since basaltic magma was undoubtedly associated with the intrusion of the diorites and granites, it is suggested that the development of heat accompanying the orogenesis (1) pre-heated the roots of the folded sediments in such a way as to predispose them to assimilation, and (2) caused the fusion of the periodotite layer of the crust, leading to the slow ascent of a wave of magma through the crust. The basaltic layer of the crust fused to form plateau basalt magma (Kennedy's tholeiite magma type), and this rose into and assimilated, either *in situ* or in depth, the preheated and possibly fused, granitic and alumina-rich sedimentary layers above it.

Crystallization differentiation, in combination with this process, would then have been adequate to produce the rock types now exposed. The addition of abundant alumina to the rising magma would cause the precipitation of lime plagioclase. The resultant withdrawal of lime from the sphere of the ferro-magnesians would lead to the formation of a two-pyroxene magma: such of the pyroxene as could obtain lime would form diopsidic augite: such as could not would form hypersthene or enstatite, the two series being immiscible under intratelluric conditions. With continued removal of the lime, subsequent to continued addition of alumina, the hypersthene would become the dominant ferro-magnesian. Throughout this period the silica and potash added to the magma by assimilation, and the soda already in it, would become increasingly concentrated in the residual magma. As the temperature decreased the soda would enter increasingly into the constitution of the plagioclase. Finally the silica would commence to crystallize as phenocrysts. At this stage, also, if the excess of Al_2O_3 continued, almandine garnets might form, since the continued removal of magnesia as hypersthene would have relatively increased the Fe/Mg ratio of the residue. Potash would also begin to crystallize out in combination with the excess Al_2O_3 and Fe as biotite, and with Al_2O_3 and SiO_2 as orthoclase.

Extrusion of the magma at these various stages would readily give the rhyolite, biotite-rhyodacite, hypersthene-dacite, and the quartz-porphyry, quartz-biotite-porphyrite, quartz-diorite associations so characteristic of Victoria, while abyssal consolidation would give rise to the widespread granitic rocks.

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[Proc. Roy. Soc. Victoria 50 (N.S.), Pt. I., 1937.]

Art VII.—*The Geology of the Korkuperrimul Creek Area, Bacchus Marsh.*

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(Howitt and Kernot Research Scholars in Geology.)

[Read 13th May, 1937; issued separately, 29th December, 1937.]

Table of Contents.

Introduction.

The area described in this paper lies approximately 1 mile west of the Township of Bacchus Marsh, which is 33 miles west-north-west of Melbourne.

There are two main occurrences of Permo-Carboniferous rocks along the Korkuperrimul Creek—

(*a*) The Bald Hill area ($\frac{3}{4}$ square mile), which lies 1 mile west of Bacchus Marsh. Here Permian beds with *Gangamopteris* leaves are overlain without angular unconformity by the only definitely recorded Triassic rocks in Victoria.

(*b*) The North Korkuperrimul area ($1\frac{1}{4}$ square miles), which is 2 miles north-north-west of the Bald Hill area. It has been comparatively neglected by geologists, the only references to it being those of

David (1896), and Sweet and Brittlebank (1893); yet it is unique in the Bacchus Marsh district in that it provides an almost complete section along the dip through some 2,000 feet of sediments.

Between the above two areas, the Korkuperrimul Creek flows in a steep-sided valley cut through the Older Volcanics. To the west, the Pentland Hills extend for several miles and, except for a few small outliers of Tertiary sands, consist entirely of basalt. To the east is Bald Hill, which is also composed of Older Volcanics. The total area of basalts dealt with is about 5 square miles, and is bounded in the north and north-east by the Greendale fault and in the east by the Rowsley fault, while to the south the Older Volcanics dip under Tertiary sands and to the west they are overlain by the Newer Basalt flow from Mt. Blackwood.

Previous Work.

Summers (1935) has given a summary of our present knowledge of the Permo-Carboniferous rocks and an extensive bibliography will be found in an earlier paper (Summers, 1923).

The first record of Older Volcanics in this district consists of a few brief notes in the Progress Reports of the Geological Survey for 1863 (reprinted in 1897). Fenner (1918) mentioned the Older Volcanics and the Permian rocks in connexion with the physiography and faulting of this area, but he did no detailed work on them.

The map is taken, with few alterations, from portions of quarter-sheets 11 S.E. (unpublished) and 12 N.E. (published 1868), the boundary between these two running east-west across Anderson's Quarry. Both were mapped on the scale of 2 inches to 1 mile. Later maps issued by the Geological Survey are the geological sketch maps of the Werribee Gorge and adjacent country (1914) and of the Bacchus Marsh district (1925), both of which are on a scale of 1 inch to 1 mile. The contours are taken from the Military Survey map of Ballan.

Faulting.

The whole area is complexly faulted, minor faults being common. The more important faults are described below.

The Rowsley fault was shown by Fenner (1918) to mark the eastern boundary of the Bald Hill area of Permian and Triassic rocks. The somewhat irregular boundary here between Triassic and Tertiary beds indicates that the fault passes into a monocline in this part of its course.

The Greendale fault forms the northern and eastern boundaries of the North Korkuperrimul area of Permian rocks. East of

Long Gully, it cannot be observed in section, but the nature of the mapped junction between Permian and Ordovician suggests that the fault does extend down Long Gully (see map).

The Bald Hill faults (F.1 and F.6, see map) were noted by Fenner (1918). F.1 marks the junction between Permian to the south and Older Volcanics to the north, but is not visible in section. From a study of the lava sequence, it has been proved that this fault continues across the creek into the Older Volcanics of the Pentland Hills. F.6 marks the western boundary of the Bald Hill area and may be seen in several sections along the Korkuperrimul Creek (Plate VII., fig. 2). Each of these faults must have a throw of several hundred feet.

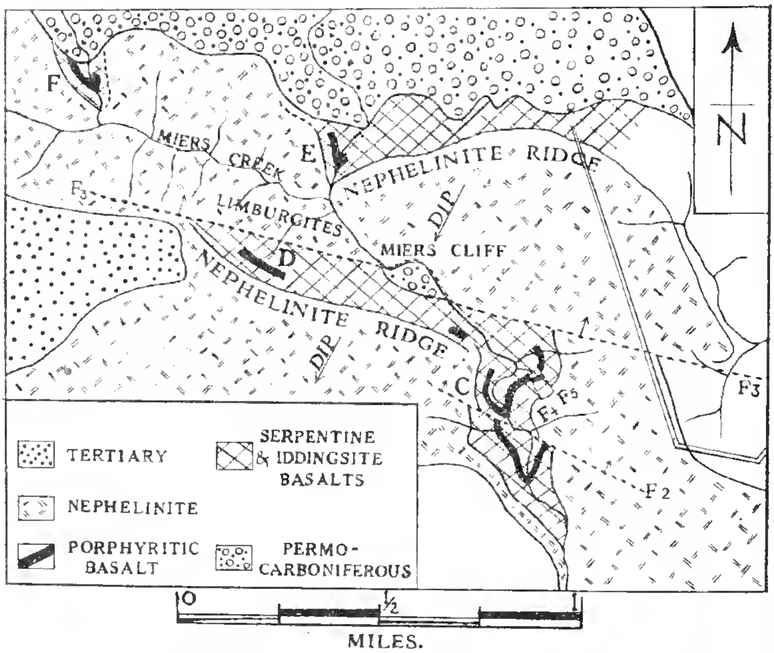

Fig. 1.—A geological sketch map illustrating the relationships of the Pentland Hills fault (F_3 on the figure).

The Pentland Hills fault (Fig. 1), with a downthrow of 500 to 1,000 feet to the north, passes immediately to the north of Mier's Cliff. Its presence is indicated by two lines of evidence—

(*a*) The sequence of Permian beds in Mier's Cliff is the same as that seen at Anderson's Quarry, which is over half a mile upstream, though at much the same height above sea level. No important change in the amount or direction of dip can be observed between these two localities. Such a feature can best be explained by postulating an east-west fault, with the downthrow to the north, lying somewhere between the southern boundary of the North Korkuperrimul area and Mier's Cliff. Assuming the dip of the Permian to be 25 deg. to 30 deg. to the south-south-west, the throw of this fault cannot be much less than 1,000 feet.

(*b*) The proposed sequence of the Older Volcanics (q.v.) affords evidence which allows us to fix the position of this fault more closely. Immediately to the north of the cliff, olivine nephelinite rests against Permian at creek level, while to the south the same olivine nephelinite occurs several hundred feet above creek level, dipping gently to the south. Such a displacement must be due to a fault running east-west immediately north of Mier's Cliff. The section (Fig. 7) indicates that the throw of this fault probably exceeds 500 feet. The fault has been traced for well over a mile. The irregularity in the fault-line at Mier's Cliff may be due to a number of subsidiary faults, intersecting the main fault obliquely.

Of the other faults which have been recognized, F.2 (Fig. 1) has a downthrow of 80 to 100 feet to the north-east. It may be seen in section on the west bank of the creek, where it is almost vertical and is characterized by a fault zone 3 to 4 feet wide, impregnated with carbonates. F.3 and F.4 are two smaller faults seen on the east bank of the creek, about 200 yards east of Section C (see Fig. 6).

Generally the basalts have a much lower dip than the Permian beds though they dip in the same general direction. Moreover, the calculated displacement of the Older Volcanics along the Pentland Hills fault is much less than that of the Permian beds along the same fault-line. These facts indicate that the Permian suffered a certain amount of tilting and displacement before the basalts were extruded and that later tilting of both Permian and basalts occurred in post-Older Volcanic times.

The Permian Rocks.

By T. R. SCOTT, M.Sc.

(A) General Geology.

Dip of the Permian Beds.

In the North Korkuperrimul area the average dip of the beds is at least 35 deg. and varies from 64 deg. to 27 deg. The direction of dip varies between S. 14°W. and S. 30°W., the average being S. 24°W. (mag.). The variation in the amount of dip may be due either to local faulting and warping or to variation in the thickness of individual beds. The very high dips (50 deg. to 64 deg.) seen in the Korkuperrimul Creek at the southern boundary of the Permian are probably due to faulting along the line of the Pentland Hills fault in pre-Older Volcanic times. Very low dips occur only in the north-west corner of the area.

At Mier's Cliff, the average dip is 36 deg. to the south-south-west, though local open folds occur at right angles to the regional tilt.

In the Bald Hill area, the direction of dip is easterly, varying from E. 12°S. to almost due north, while the amount of dip varies between 40 deg. and 23 deg., with an average of 30 deg. The Triassic beds show no angular unconformity with the Permian beds below them. Along the Bald Hill ridge, from the Council Trench northwards, the direction of dip is consistently a few degrees south of east, but in the deep gulch in the north-east corner of the area, it is E. 38°N. From this point to the Main Quarry, the strike continues to change, until at the Main Quarry itself the direction of dip is E. 66°N. In the western part of this area, the dip is low. At Bald Hill, there appears to be a close relation between the dip of the Permian and Triassic beds and the bounding faults. If the Rowsley displacement, which forms the eastern boundary here, is monoclinal in this part of its course, as Fenner (1918) suggested, the beds should dip towards its downthrow side; this actually does occur. Along the northern boundary of the Bald Hill area, the beds strike almost parallel with the east-west fault (F.1) and dip towards its downthrow side. This result is probably due to the downward drag which is frequently seen in the beds on the upthrow side of a fault. In the north-east corner of the Bald Hill area, where the two fault lines should intersect, the attitude of the beds is a compromise, the dip being to the north-east.

Apart from the Bald Hill area, however, the Permian of the whole Korkuperrimul Creek area shows a well-marked regional dip to the south-south-west, which is also seen (Sweet and Brittlebank, 1893) in the glacial beds of the Werribee Gorge and Lerderderg Gorge areas.

Sequence and Thickness of the Permian in the North Korkuperrimul Area.

It is only in the North Korkuperrimul area that a good sequence of the Permian can be obtained, as was realized by David (1896). The present author's interpretation of this sequence is given in the accompanying table (Table 1).

This interpretation of the sequence differs from that of David (1896, 1920) in the following points:—

1. David based his estimate of the thickness on an average dip of 30 deg., whereas it is now believed that the average is not less than 35 deg.

TABLE NO. 1.

Sequence of the Permian from Anderson's Quarry to Cockatoo Gully, in the North Korkuperrimul Area.

Stage No.	Description.	Thickness in Feet.	
		Formations.	Stages.
1	Glacial conglomerate ("winnowed tillite")	..	25
2	Sandstones containing fossil wood, with intercalated clay bands near the base	..	200
3	Glacial mudstones, brown above, blue-grey below, jointed and poorly bedded, with occasional bands of grit or sandstone	..	347
4	Tillites, sandstones and mudstones. Starting from the top beds, the formations are :—		
	(*a*) Sandstones	69	
	(*b*) Conglomerate	1	
	(*c*) Tillite, perhaps in part glacial mudstone ..	83	
	(*d*) Sandstones	35	
	(*e*) Tillite	18	
	(*f*) Mudstones and sandstones	7	
	(*g*) Glacial mudstones	9	
	(*h*) Well-bedded sandstones and pebbly mudstones, multi-coloured	17	
	(*i*) Jointed glacial mudstones	18	
	(*j*) Sandstones and brown jointed shales ..	23	
	(*k*) Jointed glacial mudstones	12	
			292
5	Well stratified sandstones	..	71
6	Tillite, sandstones and conglomerates. Formations are as follows :—		
	(*a*) Tillite with thin bands of sandstone and pebbles	11	
	(*b*) Sandstones	13	
	(*c*) Jointed tillite	7	
	(*d*) Shales and sandstone with conglomerate at the base	29	
			60
7	Tillite, passing down into glacial mudstones ..	..	153
8	Conglomerate and sandstones	..	150
9	Tillite, with bands of sandstone and conglomerate; passes down into glacial mudstones	..	220
10	Tillite Creek Stage. Formations are :—		
	(*a*) Sandstones	45	
	(*b*) Tillite	35	
	(*c*) Laminated shales (impersistent)	4	
	(*d*) Sandstones and conglomerate ..	56	
	(*e*) Tillite with intercalated sandstones	30	
	(*f*) Laminated shales (impersistent)	6	
	(*g*) Sandstones and conglomerate	20	
	(*h*) Tillite (at mouth of Tillite Creek)	45	
	(*i*) Sandstones and conglomerates . ..	24	
	(*j*) Tillite	4	
	(*k*) Sandstones and conglomerate	29	
	(*l*) Tillite with intercalated sandstones and gravel	67	
	(*m*) Hard laminated sandstones . ..	4	
	(*n*) Sandstones with basal conglomerate ..	14	
	(*o*) Tillite	42	
			425
11	Sandstones and conglomerates at mouth of Cockatoo Gully	..	60
12	Glacial mudstones (englacial deposits ?) with thin bands of calcareous sandstone	..	100
	Total thickness	..	2,103

2. David gave a thickness of only 30 feet to the beds of Stage 2, though in the North Korkuperrimul area they are quite 200 feet thick.

3. In Stage 10, David stated that repetition of strata was caused by a large fault of 120 feet throw. The author has been unable to find any sign of such a fault.

4. The author agrees with David (1920) that the boulder beds of Stages 7 and 9 (upper parts) and 10 are true tillites. But the beds of Stage 12, which David called tillites, apparently believing them to be equivalent to the basal tillites of Werribee Gorge and Coimadai Creek, are distinctly stratified and therefore cannot be true tillites. It is also believed that several tillites occur in Stage 4, though none are mentioned here by David.

The Base of the Series.

David implied that the glacial mudstones of Stage 12 were the basal beds of the Permo-Carboniferous, resting unconformably on the Ordovician, but actually these beds are faulted against the Ordovician in Cockatoo Gully (along the line of the Greendale fault). Thus there are probably beds below Stage 12 which are not exposed. The basal beds of the Permo-Carboniferous differ so greatly from place to place (e.g. Coimadai Creek, Werribee Gorge, Myrniong Creek) that the exact stratigraphical position of Stage 12 with respect to the base of the glacial series cannot be determined. All that can be done is to allot to Stage 12 a minimum thickness of 100 feet, in which case our estimate of the thickness of the whole series is the minimum value, viz., 2,103 feet.

The Top of the Series.

In the North Korkuperrimul area, the beds of Stages 1 to 3 are seen along the creek from the junction with Long Gully down to the southern boundary of the area, and also in Anderson's Quarry. At the latter locality, Stage 1 is overlain by well stratified red, yellow, brown and purple sandstones and mudstones, generally very hard, and quite different from any of the sandstones lower down in the series, being often micaceous and considerably indurated. At Mier's Cliff, this same sequence, from the hard sandstones above Stage 1 down to the glacial mudstones of Stage 3, is seen again, the lithological resemblance to the Anderson's Quarry section being so close as to warrant immediate correlation of the beds at the two localities.

Moreover, this same sequence is again found at Morton's Quarry in the Bald Hill area, where the mudstones of Stage 3 are only seen in a miniature canyon several hundred yards north of the quarry. These glacial mudstones are overlain by the *Gangamopteris* sandstones of Morton's Quarry, above which is a thin conglomerate, which in its turn is overlain by hard multi-coloured sandstones and mudstones. It is probable that the *Gangamopteris* sandstones of the Main Quarry belong to the same horizon as the similar beds at Morton's Quarry.

It is therefore held that the sandstones of Morton's Quarry, Mier's Cliff and Anderson's Quarry all belong to the same horizon.

The conglomerate which overlies these sandstones at all the above localities has characteristic features. It contains numerous pebbles and boulders which are rarely striated and often sub-angular and even rounded. Many of the pebbles are foreign to the district, decomposed granites being very common. The matrix of the rock varies in grain size from coarse to very fine. It is often rudely stratified and sometimes contains fossil wood. At Bald Hill, this conglomerate makes a sharp junction with the underlying sandstones, which at Morton's Quarry show strong contortion and other features, probably due to the movement above them of an ice sheet or glacier (q.v.). The striking feature about this conglomerate is that, although very hard, it seems to have been deeply weathered at some time. As the above evidence shows, it is not a true tillite. David called it a "winnowed" (redistributed) tillite and such a description agrees with its properties very well, for it does not resemble any of the glacial mudstones in the area.

This winnowed tillite therefore marks an erosion interval and in fact was considered by David to mark the interval between the so-called Permo-Carboniferous beds and the Triassic beds at Bald Hill.

The Age of the Series.

The hard mudstones and sandstones above the winnowed tillite at Morton's Quarry were believed by David to be Triassic in age, and the similar beds at Mier's Cliff and Anderson's Quarry must be of the same age. Since at each of these three localities the lowest Triassic beds rest on the same horizon of the Permo-Carboniferous, viz., the winnowed tillite, the erosion interval between the Triassic and the Permo-Carboniferous must have been extremely short. Otherwise, differential erosion would have caused the lowermost Triassic beds to rest on different Permo-Carboniferous horizons at different localities.

Now there are 400 feet of sediments between Morton's Quarry and the Council Trench, where a Triassic flora is found (Chapman, 1927). If the top of the winnowed tillite marks the Permian-Trias interval, then this 400 feet of sediments must have been accumulating through a great part of Triassic time. The lithological nature of these beds indicates that this is quite likely. But since the Permian-Trias interval was so short, the *Gangamopteris* sandstones must represent the uppermost Permian; yet David (1920) correlated tentatively the whole of the Bacchus Marsh beds with the Upper Carboniferous Lochinvar glacial beds of New South Wales. However, the resemblance between the Lochinvar beds and those at Bacchus Marsh is only superficial. While the beds at Lochinvar contain marine fossils, there is no evidence to indicate that the Bacchus Marsh beds were formed under marine conditions. Further, while glacial pavements and true tillites are developed at Bacchus Marsh, neither has been observed at Lochinvar. (The only formation which physically resembles the Bacchus Marsh deposits to any degree of closeness is the glacial stage of the Kuttung (Upper Culm) series of New South Wales, which shows a considerable development of tillites and fluvio-glacial deposits, and is largely the product of a land-ice glaciation.)

The lithological nature (q.v.) of the beds of the Korkuperrimul Creek area indicates that they must have accumulated fairly rapidly. This suggests that the 2,000 feet of sediments at Bacchus Marsh accumulated during only a portion of Permo-Carboniferous time, particularly as several thousand feet of similar sediments accumulated during the Kuttung (Upper Culm) period in New South Wales.

Therefore, since the *Gangamopteris* sandstones and the winnowed tillite are uppermost Permian in age (*vide supra*), it is believed that the whole of the Bacchus Marsh beds, with the possible exception of the basal tillites resting on the Ordovician, are Upper Permian in age. They will be referred to as such in the sequel.

B. Petrology.

Erratics.

The term "erratic" is used here to denote the boulders and pebbles found in sediments of glacial origin. A large number of erratics from the Bald Hill and North Korkuperrimul areas have been studied by the author in the hope that some might be traceable to their source rocks. Most of the erratics are sedimentary types closely resembling the Ordovician rocks of the Bacchus Marsh area, and a search for unusual types resulted as follows:—

Igneous Rocks.

	Number of Specimens.
Granites—dominantly alkaline, with little biotite but common muscovite, occasionally garnetiferous	34
Pegmatites, aplites, &c.	8
Greisen, with much tourmaline and rare topaz ..	3
Quartz and felspar porphyries	8
Rhyolites, including resilicified aegirine rhyolite ..	2
Reef quartz	2

Metamorphic Rocks.

	Number of Specimens.
Granitoid rock with abundant andalusite, garnet and tourmaline	1
Gneiss and schist (biotite and muscovite types) ..	14
Cordierite hornfels	3
Slate and phyllite	10
Jasper	1
Cream-coloured rock with numerous brown spots (hornfels?)	3
	89

Sedimentary Rocks.

Sandstones and quartzites are very common, with occasional grits and mudstones. Limestones are absent.

Unfortunately, distinctive as many of these specimens are, they cannot be satisfactorily traced to their source rocks, since they either occur *in situ* at a number of widely-separated localities or cannot be matched with any known Victorian rocks. Assuming that the ice sheets came from the south-west (Summers, 1935), the above difficulty arises from the fact that all the pre-Permian rocks of the country south-west of Bacchus Marsh are entirely covered by Jurassic sediments or Tertiary basalts. All that can be done at present is to place on record the great variety of erratics in the Bacchus Marsh Permian beds.

Heavy Mineral Assemblages.

The heavy mineral assemblage of the Permian sediments at Bacchus Marsh is quite characteristic, though the proportions of the various minerals vary widely. The heavy mineral index varies between .05 per cent. and .3 per cent. The mineral species present are zircon, apatite, tourmaline, and garnet, which constitute 90 per cent. of the assemblages, together with smaller amounts of rutile, leucoxene, muscovite, biotite, iron oxides and ilmenite. Rarer minerals are staurolite, kyanite, sillimanite, brookite, dumortierite, corundum, various metallic sulphides, and possibly gold and anatase. The heavy mineral assemblage of the Triassic is very similar to that of the Permian, though kyanite is more common in the Triassic.

The heavy mineral assemblage of the Permian sediments is characterized by the abundance of highly stable minerals, such as garnet, zircon, tourmaline and rutile. The heavy minerals of the sedimentary erratics, and of the Ordovician *in situ* in the Bacchus Marsh area, show a distinct resemblance to the Permian heavy minerals, containing abundant apatite, tourmaline, zircon and rutile. It appears, therefore, that the Permian rocks were largely derived from the Ordovician sediments surrounding

Bacchus Marsh. Support is given to this belief by the fact that the brown apatite and pleochroic blue tourmaline which occur in small amounts in the Permian are also found in the Ordovician. One difficulty appears, however, for in the Ordovician heavy minerals, which have been studied, pink garnet is absent and only 1 per cent. of colourless garnet can be found, though both are common in the Permian. The source of this garnet has not been discovered as yet, though certain granitic erratics in the Permian tillites do contain pink garnets in small amount.

The Occurrence of Apatite.

Boswell (1933) claims that " the presence or absence of apatite is determined to a very great extent by the local conditions as regards the permeability of the containing rocks to (carbonated) water." If these views are applicable to the Bacchus Marsh beds, the sandstones (porous) and the tillites (relatively impermeable) should differ appreciably in the proportion of apatite which they contain. This does not occur, however, nor does the degree of corrosion (due to solution) of the apatite vary with the permeability of the containing rocks. Moreover, the bands of calcareous sandstone in Stage 12 of the North Korkuperrimul area contain abundant apatite, yet these sandstones have obviously been traversed by carbonated waters.

In the Bacchus Marsh Permian beds, therefore, the apatite appears to have survived at least one cycle of erosion (two cycles, where it has been derived from the Ordovician sediments), and has only succumbed to a small extent, if at all, to the attack of carbonated waters. These facts suggest that apatite may sometimes be much more stable to erosion and solution than is generally believed.

Nature and Origin of the Sediments.

The sandstones are coarse and medium-grained, generally well stratified and with argillacious, limonitic or calcitic cement. The latter type is fairly common, sometimes containing up to 50 per cent. of calcite, as in Stage 12.

The conglomerates are hard and rudely stratified, the pebbles being generally sub-angular. They may grade vertically and laterally into gravel and thence into sandstone.

Where sandstone and conglomerates are intimately associated, as frequently happens in the Bacchus Marsh Permian beds (see Plate VII., fig. 4), they are believed to be fluviatile (fluvioglacial) in origin. That this is true for the conglomerates is shown by their rude bedding and impersistent nature, together with the roundness or sub-angularity and the incomplete sorting of the contained pebbles. A similar origin for the sandstones is indicated by the strong current bedding of the sandstones (except for the laminated types), their lenticular nature in many cases and the considerable amount of lateral variation in lithology, and the linguoid ripple-marks in the sandstones of Stage 8, which, according to Bucher (1919), generally indicate a fluviatile environment. The well stratified and laminated sandstones, such as the *Gangamopteris* sandstones, were probably formed in shallow lakes.

Shales (grain size 0.03 mm.) are fairly common, especially in Stage 10, where they are always found immediately below a tillite horizon. They are usually laminated, but no seasonal banding has been observed. Erratics are rare in these rocks and do not indent the strata appreciably. Probably the shales are partly lacustrine and partly fluviatile in origin, since they may either grade up into lacustrine glacial mudstones (q.v.) or pass down into fluviatile sandstones.

In the Bacchus Marsh area, there are two types of boulder beds, generally intimately associated. These are glacial mudstones (lacustrine) and tillites (which were the ground moraines of glaciers or ice-sheets). At times, the change from tillite to glacial mudstone is gradual and no sharp line of division can be drawn between the two types. The lowest section of Permo-Carboniferous in Coimadai Creek is undoubtedly tillite, the contact with the Ordovician clearly showing the plucking and gouging action of the ice-sheet. Along the Korkuperrimul Creek, however, apparently unstratified boulder beds often pass without a break into well bedded mudstones. Such boulder beds, though physically resembling the tillites, could not have been the ground moraines of ice-sheets.

Microscopically, there is little difference in grain size and shape between the glacial mudstones and tillites. The tillites are frequently sandy in texture, due to the incorporation of previously formed sands (q.v.) and they also contain at times irregular bands and lenses of sandstone, as well as pockets and strings of conglomerate and gravel. The glacial mudstones, however, are consistently fine-grained and only rarely contain bands of grit or ferruginous sandstone, which are quite different from those seen in the tillites.

The erratics in the glacial mudstones are perhaps smaller, less numerous and less frequently striated, than those occurring in the tillites. The essential constituent mineral is quartz. Felspars are rare and always weathered. The tillites are invariably hard, but the glacial mudstones are sometimes much softer.

The tillites are generally brown in colour, but the glacial mudstones show considerable variety, most frequently being light brown or grey-blue.

Though the tillites are invariably unstratified, the glacial mudstones occasionally show bedding. The presence of pockets and lenses of sandstone and gravel in tillite does not necessarily mean that the tillites are stratified. The extensive jointing of the boulder beds sometimes gives the impression of stratification, especially when certain of the joint planes dip in the same direction as the stratified beds of the area (see Plate VII., fig. 3). At times, these joints may curve round, or stop at the junction with, large erratics. This has led to the erroneous belief that the bedding planes of the rocks have been indented by the larger erratics. Actually, such a phenomenon can only occur in the rare cases where large erratics are found in bedded rocks and it is not general even under these circumstances.

Tillites (Plate VII., fig. 3).

That the tillites were once the ground moraines of glaciers or ice-sheets is clearly shown by their peculiar lithological nature, the absence of stratification and the striated pebbles which they generally contain. The presence of bands and pockets of sandstone, gravel and conglomerate in the Bacchus Marsh tillites (Plate VII., fig. 1) may have been one of the factors which led the early investigators to doubt their ground-morainic nature. However, J. Geikie (1894) points out that "nests and irregular patches and lenticular layers and thick beds of water-arranged material are not infrequently enclosed in till": while Salisbury (1896) states that an advancing glacier may often incorporate the previously-formed deposits of its extra-glacial streams and lakes, and shows how sub-glacial streams may sometimes be responsible for the formation of quite large amounts of sand and gravel, &c., in the actual body of the ground moraine.

If the tillites of the North Korkuperrimul area were ground moraines of ice-sheets, the sediments above which the ice moved should show some evidence of such movement above them. Such evidence is present, but only to a limited extent, mainly because the Permian beds were probably more or less horizontal until at least Triassic times and thus offered little resistance to the passage of ice-sheets over them. The sandy nature of certain tillites and the presence in them of erratics of Permian sandstones (sometimes very large, as in Stage 9) indicate the influence of glacial action on the Permian sediments. The shales beneath the two top tillites in Stage 10 in the North Korkuperrimul area show extensive minor faulting and occasionally well-developed shear planes. Both of these features are probably due to the movement of an ice-sheet above the shales.

It is only in the *Gangamopteris* sandstones of Stage 2 that contortions of the sediments are developed to an important extent. On the south and east faces of Morton's Quarry in the Bald Hill area, considerable overfoldings and contortions occur, the bedding planes at one part being vertical, though the general dip is to the east at 30 deg. (Figs. 2 and 3). It is possible that some of this contortion was caused by floating ice, but, in the author's opinion, the large scale overfolding seen in the east face of the quarry and much of the contortion can only be explained by the immense pressure exerted by an ice-sheet in overriding the sandstones. Such features are often recorded from the Pleistocene glacial deposits of the Northern Hemisphere.

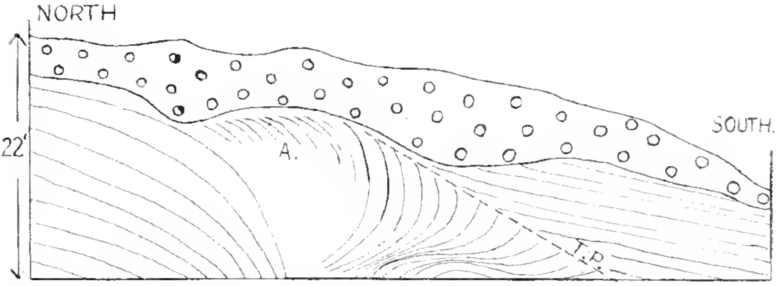

Fig. 2.—Vertical section of main face, Morton's Quarry, Bald Hill area, showing the winnowed tillite overlying *Gangamopteris* sandstones. T.P.=thrust plane (?). Beds are vertical at A.

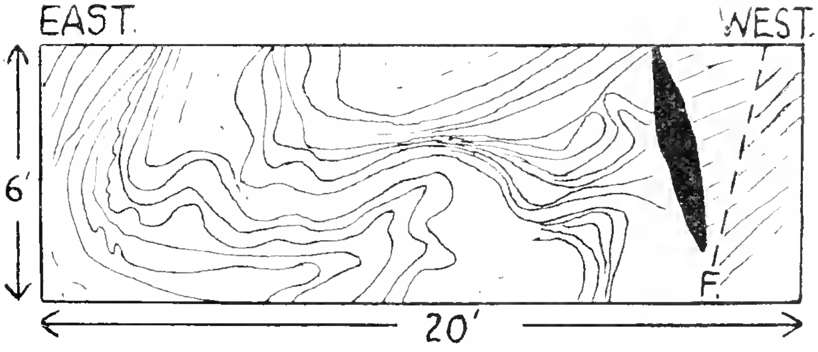

Fig. 3.—Vertical section, south side of Morton's Quarry, Bald Hill area. F.=fault. Black represents injected material (see also Fig. 4).

In the north-west corner of Morton's Quarry, there occurs a striking feature, a vertical section of which is given in Fig. 4. The black part represents a tumultuous mass of large boulders imbedded in a fine-grained matrix, which consists partly of broken fragments of Permian sandstone similar to that found *in situ* elsewhere in the quarry and partly of a material identical in appearance with the matrix of some of the tillites of the North Korkuperrimul area. The boulders themselves are mostly foreign

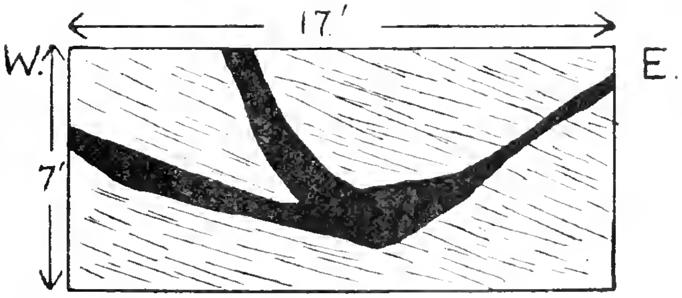

Fig. 4.—Vertical section, north side of Morton's Quarry, Bald Hill area, showing tillitic material (black) injected into sandstones (shaded).

types, including mica-schist, felspar porphyry and many granites, some of which occur as very large blocks. This mass of boulder clay is partly interbedded with the sandstones around it and partly cross-cutting. It can best be explained by postulating that the sandstones were cracked and fissured by the movement above them of an ice-sheet or glacier, which subsequently forced material from the ground moraine into the cracks and fissures so formed.

Glacial Mudstones.

These rocks always pass gradually into well-bedded sediments and occasionally show rude bedding themselves. These facts, coupled with the great thickness and fine grain of the mudstones, seem to indicate a lacustrine origin for them. They were probably formed partly from the material dropped to the bottom of lakes by icebergs detached from glaciers, and partly by the discharge of sub-glacial streams into glacier-dammed lakes (as described by Officer and Hogg, 1894).

In Stages 7 and 9 in the North Korkuperrimul area, where glacial mudstones below grade into tillite above, it seems necessary to postulate that glacial lakes were formed in advance of the approaching ice-sheets or glaciers, and that glacial mudstones were formed in these lakes as suggested above. In some cases, the ice-sheet terminated in the lakes and then tillite and glacial mudstones were formed together, one grading into the other, much as Officer and Hogg (1894) suggested. At other times, the lakes in which the mudstones had formed were either drained or greatly shallowed, with the result that the ice-sheet advanced over the mudstones and deposited tillites above them. In such cases, contortion of the underlying mudstones would have probably occurred. However, the close physical similarity between glacial mudstones and tillite might prevent the line of junction between them from being seen, and the frequent absence of stratification in the glacial mudstones would prevent evidence of contortion from being preserved, i.e., the mudstones may have been complexly mixed up with the ground moraine of the glacier or ice-sheet, but unless they were clearly stratified, no evidence of this phenomenon would be retained.

Englacial Deposits.

According to Chamberlin (1895) and Slater (1926), englacial material occurs as thin interstratified bands and laminae in the ice of a glacier. Boulders are numerous and the laminae of englacial material often curve both below and above them. When the ice melts, the englacial material forms, among other things, deposits of boulder clay, which often preserve the tectonic structures imposed upon the englacial material when it was in the ice of the glacier. The beds of Stage 12 in the North Korkuperrimul area are believed to be englacial deposits, for, though they show distinct stratification in parts, they differ from the mudstones of glacial origin seen elsewhere in the area. For instance, they contain thin sandstone bands (now calcareous) which are sometimes contorted and frequently faulted, and are usually sharply demarcated from the mudstone above and below them. Between these bands, the rock consists of boulder mudstone, generally unstratified, and soft greasy blue-black shale, perfectly laminated and occurring in bands from 1 inch to 1 foot in thickness. Boulders are present in this soft shale, the laminae of the shale curving both above and below them.

Typical Sequence of Deposits, (fig. 5).

Even though glacial mudstones are absent, Stage 10 is the most representative (and complex) in the North Korkuperrimul area. In particular, the cycle of events due to alternate advances and retreats of the glaciers is very well shown. In each cycle, the lowest bed is a tillite, representing an advance of the ice over the area. Almost invariably, the tillite is overlain by conglomerate, which varies greatly in thickness and always shows an exceedingly sharp junction with the tillite below. This is only what would be expected, for immediately the ice-sheet withdrew from the area, streams originating from it would work over the ground moraine which had become exposed. The fine material would be carried away, but the coarser material, including pebbles and boulders, would be soon deposited on the surface of the till. Usually, the junction between conglomerate and till is very straight and sharp; but sometimes it is highly uneven, a feature which is probably explained by the great erosive power of the fast-flowing extra-glacial streams.

The great development of fluviatile deposits following the retreat of the ice-sheets is a typical feature in the Pleistocene glaciation of parts of the United States of America. Salisbury

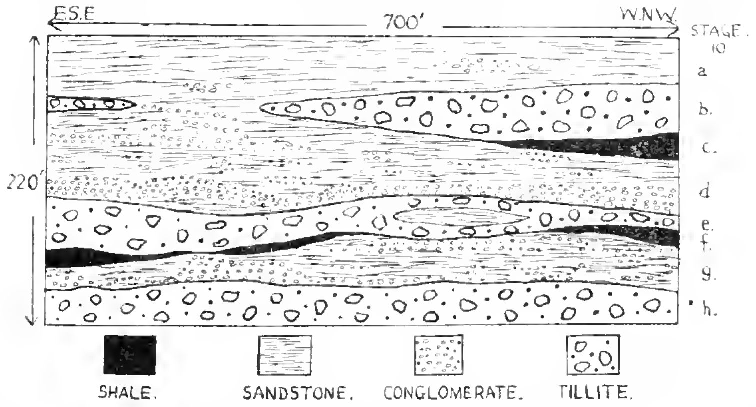

Fig. 5.—Reconstructed vertical section along the strike of the beds of Stage 10, North Korkuperrimul area, showing the extent of lateral and vertical variation.

(1896) has described how a typically braided type of drainage is developed, the streams rapidly alternating between aggradation and degradation, so that a channel is no sooner scoured out of the till than it is filled up with conglomerate and sand and a new channel is formed. It is believed that such extensive "outwash plains" were the usual development in the North Korkuperrimul area following the retreat of the ice.

The conglomerates resting on the tillites grade up into sandstones with gravel bands and occasional lenticles of conglomerate, and the sandstones grade upwards into well laminated shales or finer-grained sandstone. This can best be explained by assuming that the ice-sheet was gradually receding, despite Salisbury's statement (1896) that the deposits of such outwash plains are best developed when the ice-sheet is practically stationary.

As this recession went on, the velocity of an extra-glacial stream at any fixed point on the outwash plain would become smaller and smaller and the material it deposited would be finer and finer, until ultimately at any such point, the ideal sequence of the deposits would be conglomerate at the base, passing up into gravel, then sandstone and finally siltstones or shales.

This sequence, which occurs throughout Stage 10, could also be explained by postulating the incidence of lacustrine conditions soon after the first sandstones were deposited, with gradual deepening of the lake to allow the deposition of the finer sediments. However, while lacustrine conditions were not absent, fluviatile conditions were probably predominant for most of the time between successive advances of the ice.

This cycle of events, as described above, occurs six times in Stage 10 and there is no evidence that repetition of beds by faulting has occurred. Of course, variations do occur, particularly with the tillites, whose variation in thickness (see Fig. 5) may be explained by—

(*a*) irregularities in the sub-tillitic surface and/or

(*b*) differential erosion of the till after the retreat of the ice.

Interglacial Periods.

Since land-ice glaciation probably persisted in the Bacchus Marsh area until the close of the Permian (see Effect on associated sediments, page 122), the sandstones of Stage 2 (*Gangamopteris* sandstones) may represent an interglacial period, for the presence of *Gangamopteris* leaves and the large amount of carbonaceous material and fossil wood in these sandstones shows that land vegetation was well established by this time. Nowhere else in the Permian of this area have plant remains been found, except for the carbonaceous material in the sandstones of Stage 11, which may mark an earlier interglacial period.

The Older Volcanics.

By R. JACOBSON, M.Sc.

The Older Volcanic lavas extend for several square miles over the Pentland Hills and Bald Hill. The series comprises both basalts and ultra-basic lavas, and therefore the term "Older Volcanic," as used by the Geological Survey of Victoria under A. R. C. Selwyn, is considered preferable to "Older Basalts." Between the two main areas of Permo-Carboniferous rocks the Korkuperrimul Creek flows almost entirely in Older Volcanics, and the steep-sided valley provides excellent sections for the study of the lavas and their sequence (see Fig. 7).

Basaltic Lavas.

Olivine Basalts with Magnesia-Rich Glass.

This group of lavas is characterized by phenocrysts of partially serpentinized olivine, and a base which consists of magnesia-rich glass and serpentine. For convenience these lavas are henceforth referred to as the "serpentine basalts." Their distribution is shown in Figure 1. There are usually about three flows of serpentine basalt resting on the Permo-Carboniferous at the base of the Older Volcanic series. One of these flows at Section E contains a certain amount of analcite.

In hand-specimens the serpentine basalts are generally greenish-black in colour, with numerous brownish-green phenocrysts of olivine. Microscopically [5077], Sect. C, No. 2, (numbers in brackets refer to slides in the University collection, and descriptions of the character—Sect. C, No. 2—refer to localities shown in Figure 6) is a medium grained serpentine basalt characterized by phenocrysts of olivine only, with a mero-crystalline groundmass composed mostly of plagioclase, together with pyroxene, iron-ore, and a residual serpentine-glass base. In this rock the texture is intersertal-intergranular (Pl. VIII., fig. 3), but in coarser grained types, such as [5084], Sect. D, No. 1, there is a distinct tendency for the transition from the intergranular to the ophitic type of texture. The olivine phenocrysts, up to 2.5 mm. in diameter, are generally resorbed, and invariably partly serpentinized. Only a few small granules of olivine occur, and these probably do not represent a true groundmass generation of olivine. Iddingsite is absent.

Narrow crowded laths of labradorite (Ab. 40), forming about 60 per cent. of the groundmass, average about 0.3 mm. in length, and usually show a slight flow structure around the olivine phenocrysts. The pyroxene is intergranular, and occurs as pale brown to almost colourless prisms which average 0.05 mm. in length. A violet tinge indicates that it is slightly titaniferous. The iron-ore is coarse grained, and as determined on a polished section, consists mostly of skeletal-octahedral plates of magnetite,

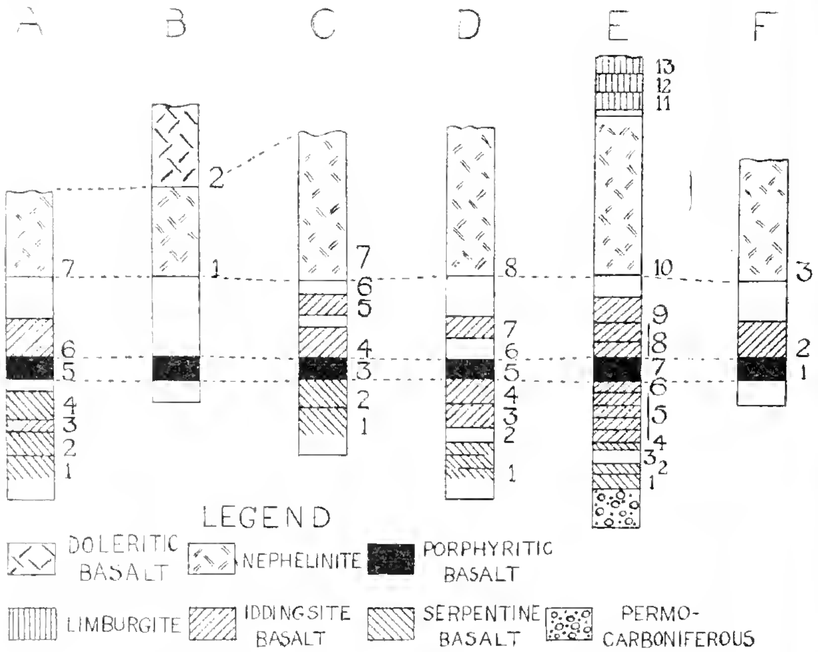

Fig 6.—Shows the detailed lava sequence at six localities, Sections A to F, shown on the map. Approximate vertical scale, 0.66 inches equals 100 feet.

with a few laths of ilmenite. The magnetite is sometimes moulded on pyroxene or felspar. Apatite is not abundant, while occasional small flakes of biotite are associated with the iron-ore. A little secondary calcite is also present. The magnesia-rich mesostasis occurs in intersertal wedges which consist of a mixture of pale green glass, and a pale green micro-crystalline serpentine with a fibrous and micro-radiate structure. This serpentine is faintly pleochroic from green to yellow, has a fairly high double refraction (first order reds and greens), and a refractive index greater than that of labradorite. The serpentinization of these basalts has probably been due to a late-magmatic tendency towards the concentration of magnesia and water in the residual liquid.

A Serpentine-Analcite-Basalt.—This basalt [5092], Sect. E. No. 1. contains abundant phenocrysts of altered olivine, the cores of which consist of an unusual type of iddingsite, and the rims of pleochroic serpentine. The iddingsite is pleochroic from green to yellow, and has a higher double refraction than usual. A moderate amount of limpid analcite occurs in irregular patches in the serpentine-glass mesostasis. It has a good cleavage, and is mostly isotropic, but in part shows low double refraction. The analcitization was probably brought about by a local late-magmatic process.

The Porphyritic Basalt.

Overlying the serpentine basalts is a thin persistent flow of porphyritic basalt. The coarse grain, and porphyritic texture of this rock, permit ready identification in the field, so that it can be used as a "marker flow." There are two varieties, one crowded with phenocrysts of both pyroxene and plagioclase, the other with numerous phenocrysts of plagioclase, but few large pyroxenes. The rock when fresh is dense and dark coloured, but weathering etches out the phenocrysts of pyroxene and plagioclase.

The specimen selected for analysis, [5079], Sect. C, No. 3, contains numerous phenocrysts of pyroxene and plagioclase, and a few smaller olivines. The mero-crystalline groundmass, which is subordinate to the phenocrysts, consists of plagioclase, augite, iron ore, apatite and a little intersertal glass. The phenocrysts of plagioclase, averaging 5 mm. in diameter, are tabular parallel to (010). As shown by the albite twinning, the plagioclase laths have a divergent interleaved structure (Pl. VIII., fig. 2), with small inclusions of glass and wedge-shaped crystals of pyroxene. Narrow films of green glass, crowded with apatite and feathery iron ore, sometimes occur between the twin lamellae and along the cleavage planes. Sometimes the inclusions have been injected along secondary fractures produced by flow movements of the partially crystallized lava. The plagioclase is strongly zoned in sections parallel to (010), the composition ranging from bytownite (Ab. 25) at the core, to andesine (Ab. 60) at the rim.

The composite, prismatic phenocrysts of titaniferous augite are idiomorphic, but sometimes partially enclose small plagioclase laths around the margins. The rims of the pyroxene phenocrysts are deep violet-brown in colour, and faintly pleochroic, with X, Z; yellow-brown, and Y; violet-brown. Polysynthetic twinning on (100), shown by narrow diagonal bands across the crystal, sometimes occurs. The resorbed, glomeroporphyritic, partially serpentinized olivine phenocrysts are subordinate to pyroxene and plagioclase.

The coarse grained groundmass consists of violet-brown titan-augite, plagioclase, apatite and abundant iron-ore. The iron-ore is coarse grained, and as determined on a polished section, consists of skeletal-octahedral plates of magnetite, and simple laths of ilmenite. The magnetite is often moulded on pyroxene or felspar. Stout needles of apatite are very numerous, but biotite is uncommon. The intersertal mesostasis, crowded with apatite and iron-ore, consists partly of green or orange coloured glass, and partly of serpentine. Occasional amygdales, filled with zeolites, calcite or serpentine, also occur.

Another specimen [5078] of the porphyritic basalt from Sect. C differs from the one described above in having the olivine phenocrysts completely iddingsitized. [5088], Sect. D, No. 5, is a rock crowded with plagioclase phenocrysts, while olivine and pyroxene, which are often glomeroporphyritic, are less common and smaller in size. The groundmass is coarse grained and almost holocrystalline. Large apatite crystals, up to 1 mm. in length, are common in this rock.

The Iddingsite Basalts.

Numerous flows of iddingsite basalt occur in this Older Volcanic series. They occur mostly above, but also below the porphyritic basalt, and as a group are characterized by phenocrysts of iddingsitized olivine. Minor variations in grain size, in the proportion of pyroxene to felspar, and also in the amount of glass present, occur among the lavas of this group.

In the hand-specimen the iddingsite basalts may be recognized by glassy red phenocrysts of olivine, which become brown when the rock is weathered. The rock [5081] from Sect. C, No. 5, is a coarse grained iddingsite basalt characterized by large olivine phenocrysts rimmed with iddingsite, set in a coarse grained micro-crystalline groundmass composed of plagioclase, intergranular pyroxene, iron-ore, apatite, a little biotite and a residual intersertal glass. The texture is intersertal-intergranular. The sporadic, slightly resorbed olivine phenocrysts, up to 2.5 mm. in length, are surrounded by conspicuous rims of red iddingsite. They are often glomeroporphyritic, with the individual crystals united by the iddingsite rims. In addition to the iddingsitized olivine phenocrysts, a few small crystals of non-iddingsitized olivine occur in the groundmass, indicating that the groundmass generation of olivine crystallized after iddingsitization had ceased. Only occasional micro-phenocrysts of pyroxene occur in this rock, but in [5108], Sect. F, No. 2, pyroxene phenocrysts are more abundant, occurring glomeroporphyritically with olivine in groups up to 5 mm. in diameter.

The groundmass pyroxene, a pale violet-brown, slightly titaniferous augite, is only approximately intergranular. The labradorite laths (Ab. 45), which are tabular and strongly zoned in sections parallel to (010), are fairly even in size, and average 0.5 mm. in length. Sometimes, as in [5108], the cores of the laths are altered to a fawn coloured cryptocrystalline saussurite. Apatite is common, while a little biotite is associated with the hypidiomorphic iron-ores, which consist of laths of ilmenite and plates of magnetite. An intersertal, yellow, green or orange coloured mesostasis, consisting of glass and a little serpentine, is fairly abundant. In [5074], Sect. A, No. 6, the mesostasis consists of glass, zeolites and serpentine.

[5080], Sect. C, No. 4, is a medium grained iddingsite basalt, which differs from the coarse grained type described above, in that the groundmass is finer in grain, and the large sporadic phenocrysts of olivine are replaced by numerous micro-phenocrysts.

[5090], Sect. D, No. 7, is a fine grained iddingsite basalt with a few large phenocrysts of olivine and pyroxene, and occasional micro-phenocrysts of plagioclase, set in a fine grained groundmass composed mostly of pyroxene and plagioclase, together with magnetite, apatite and a little interstitial glass. The plagioclase laths show flow structure, especially around the olivine phenocrysts.

[5087], Sect. D, No. 4, is a rock with abundant olivine phenocrysts rimmed with iddingsite, and occasional micro-phenocrysts of pyroxene and plagioclase, set in a glassy groundmass which is comparatively poor in felspar. Brown glass and stellate clots of titaniferous augite fill the interspaces in the open felspar mesh. The glass, which is crowded with apatite and brownish skeletal crystals, forms about 30 per cent. of the groundmass. There are also a number of rounded patches of zeolites, often bordered with tangentially arranged pyroxene prisms.

The Doleritic Basalt.

The term "doleritic basalt" has been reserved for a type of basalt with an ophitic texture and richly titaniferous pyroxene. At Section B (on the west bank of the Korkuperrimul Creek) a thick flow of doleritic basalt overlies the nephelinite, but further to the south it is faulted against the nephelinite which caps the hill above Section A. This doleritic basalt can be traced for half a mile to the west of the Korkuperrimul Creek.

In the hand specimen the doleritic basalt is medium grained and grey-black in colour, with olivine phenocrysts and glassy felspar visible under a lens. Under the microscope, the rock [5076], Sect. B, No. 2, is a medium grained olivine basalt characterized by its ophitic texture (Pl. VIII., fig. 1). It is holocrystalline and lacks a distinct groundmass. The resorbed olivine phenocrysts, up to 1.5 mm. in length, together with smaller granules, are only slightly iddingsitized. Titan-augite occurs as large allotriomorphic plates up to 1.5 mm. in length, intergrown ophitically with the plagioclase. Sections normal to (010) are strongly pleochroic, with X, Z; yellow-brown, and Y; reddish-violet. Labradorite (Ab. 45) occurs as tabular laths up to 1 mm. in length, but averaging half this size.

The iron-ores, as determined on polished sections, consist of large skeletal-octahedral plates of magnetite, laths of ilmenite and a small amount of pyrite. The magnetite is often moulded on pyroxene or felspar. Apatite occurs as stout needles up to 0.5 mm. in length, while a small amount of biotite is associated with the iron-ore. The intersertal base, consisting mostly of zeolites, is not very abundant. The rock [5124] from the fault junction just north of Section A is similar to the one described above, except that the olivine phenocrysts are rimmed with deep red iddingsite, and the base is more glassy.

Tachylyte Flows.

Small flows of tachylyte are found at Dyke Cliff, and also along Morton's Creek, but in a gully on the western slopes of Bald Hill, a tachylyte flow, which is interbedded with a series of decomposed lavas, has a thickness of about 15 inches, and can be traced for a distance of about 100 yards. As these tachylytes are interbedded with the nephelinites they may be alkaline-ultra-basic and not basaltic in composition, but whether basaltic or ultra-basic glasses, flows of such dimensions are unusual. The flows are well jointed, and weather out as a line of rounded nodules. In the hand-specimen the glass is dense, brittle and dark brown in colour, with a vitreous to resinous lustre. Tiny crystals of olivine are the only phenocrysts visible.

Under the microscope, the tachylyte [5140] is seen to contain small idiomorphic phenocrysts of olivine, up to 1 mm. in length, which often have complex outlines and inclusions of glass. Some of the smaller crystals are skeletal in outline. A small xenocryst of olivine, surrounded by a reaction rim of granular olivine, also occurs. The glass is orange-red to yellow in colour according to the thickness of the section, and contains numerous perlitic fractures. It has a refractive index greater than 1.530, and is mostly isotropic, but occasionally cryptocrystalline. Flow lines, marked by brownish dust-like inclusions, are especially noticeable around the phenocrysts. A small lenticle of colourless glass, containing a few fragments of xenocrystic quartz, also occurs.

Ultra-Basic Lavas.

These include the following groups:—

- The olivine nephelinites—
  - (*a*) Felspar-free.
  - (*b*) With accessory felspar.
  - (*c*) The nepheline limburgites.
- The limburgites.
- The limburgite-basalts.

The limburgites and limburgite-basalts represent separate flows overlying the nephelinites, but the sub-varieties of the olivine nephelinites, namely the felspar-free nephelinite, the nephelinite with accessory acid plagioclase, and the nepheline limburgites, are not usually represented by separate flows, but are merely lateral variations in massive nephelinite flows. Three limburgite flows occur at Section E, and the limburgite-basalts occur at three points on the Pentland Hills (see map), but as the extent of these flows is unknown, no distinction between these lavas and the nephelinites is made on the map. The total area mapped as olivine nephelinite is about 3½ square miles, and comprises the higher parts of the Pentland Hills, and also Bald Hill. The olivine nephelinite commonly occurs as massive columnar flows of considerable thickness. At Bald Hill the individual flows are comparatively thin, but eleswhere the nephelinite capping probably consists only of one or two flows. The columnar jointing is somewhat irregular, with individual columns up to 6 feet in diameter. As the massive nephelinites offer greater resistance to erosion than the basaltic lavas, the edges of the tilted nephelinite flows stand out as rocky ridges, and small waterfalls occur where the nephelinites cross the Korkuperrimul Creek. In the hand-specimen the nephelinites and limburgites are extremely fine grained brownish or grey-black coloured rocks with numerous phenocrysts of glassy olivine. Olivine-enstatite xenoliths are locally abundant.

The Olivine Nephelinites.

The olivine nephelinite flows show a certain amount of lateral variation with regard to the amount of nepheline and glass present, the presence or absence of accessory acid plagioclase, the abundance of pyroxene phenocrysts and the degree of iddingsitization of the olivine.

(*a*) *The Felspar-free Nephelinites.*

The specimen selected for analysis [5110] was collected from a columnar flow, about 50 yards from the head of a small gully on the western slopes of Bald Hill. It is a porphyritic rock with abundant phenocrysts of olivine and occasional micro-phenocrysts of pyroxene, set in a fine grained groundmass composed of pyroxene, nepheline, iron-ore, apatite, a little biotite and a small amount of residual glass. Felspar is absent. The olivine phenocrysts, which rarely exceed 2 mm. in diameter, are usually considerably resorbed, and only slightly iddingsitized. Micro-phenocrysts of pale violet-brown, weakly titaniferous augite are rare, but tiny prisms of a similar pyroxene, averaging 0.05 mm. in length, form about 60 per cent. of the groundmass. A violet tinge and faint pleochroism in sections normal to (010), with X, Z: yellow-brown, and Y: violet, indicate the weakly titaniferous nature of this pyroxene.

Allotriomorphic plates of interstitial nepheline, which average 0.08 mm. in diameter, and which often contain small inclusions of pyroxene and apatite, form about 10 per cent. of the rock. Although the nepheline is rarely idiomorphic, it shows a distinct prismatic cleavage to which the extinction is parallel, and is often moulded on small crystals of olivine, in such a way that they both extinguish in approximately the same position. These plates (Pl. 2, Fig. 4) are sometimes nearly 1 mm. in diameter. Granular iron-ore, mostly magnetite with a little ilmenite, is fairly abundant, while micro-segregations of granular olivine, iddingsite and iron-ore are not uncommon. Flakes of deep red-brown biotite are scattered through the groundmass, sometimes associated with the iron-ore, but also with small patches of sodic zeolites. In the latter case both red and green biotite occur, and the inner ends of projecting pyroxene crystals are rimmed with aegirine. Idiomorphic needles and prisms of apatite, strewn through the nepheline and glass, are abundant. A little interstitial glass, and occasional patches of zeolites (natrolite?), usually with a rim of yellow glass, complete the base of the rock.

A specimen [5111], from the top flow of a cliff just north of Dyke Cliff, is a type in which the olivine phenocrysts are surrounded by wide rims of red-brown iddingsite, and which contains, in addition to magnetite, a little red-brown or greenish picotite with a reaction rim of magnetite. A thin flow of olivine nephelinite [5112], which underlies the main nephelinite flow in Morton's Creek, is a fine-grained type which contains iddingsitized olivine phenocrysts, and small stout ragged laths of micro-phenocrystic nepheline. In [5075], Sect. A, No. 7, a few of the idiomorphic pyroxene phenocrysts are moulded on a core of resorbed olivine.

(*b*) *The Nephelinite with Accessory Felspar.*

A specimen selected as typical of this variation [5083] was collected from the base of flow No. 7, Sect. C. Three hundred yards to the south the base of this same flow is a felspar-free olivine nephelinite. The rock contains phenocrysts of partially iddingsitized olivine, and a few small phenocrysts of zoned pyroxene with titaniferous rims and spongy greenish cores. The fine-grained groundmass consists of pyroxene, nepheline, magnetite, ilmenite and chromite, together with colourless veinlets consisting of a mixture of felspar, nepheline, and small patches of glass and zeolites. The felspar shows broad twin lamellae, and sometimes a fine cross hatching suggestive of anorthoclase, but as its refractive index is less than that of nepheline, it is probably an acid plagioclase, possibly oligoclase.

(*c*) *The Nepheline Limburgites.*

A specimen selected as typical of this variation was collected from a columnar outcrop a quarter of a mile to the south of the east end of Mier's Cliff. The rock [5119] and [5120] is really a basic olivine nephelinite as it is relatively poor in nepheline and rich in pyroxene, and as such is closely related to the limburgites. Laterally, with the increase in nepheline, the rock grades into the normal olivine nephelinite. It contains conspicuous phenocrysts of orange-red iddingsite, which are faintly pleochroic and slightly zoned, and occasional micro-phenocrysts of titaniferous augite, set in a fine-grained groundmass composed largely of augite (80 to 90 per cent.), together with subordinate nepheline, iron-ore, apatite, a little glass and veinlets of zeolitic and felspathic materials.

The Limburgites.

Three limburgite flows, each about 20 feet in thickness, overlie the nephelinites at Section E. They dip downstream at a small angle on the west bank of the Korkuperrimul Creek. The lowest flow [5104], Sect. E, No. 11, is a typical limburgite, with phenocrysts of olivine and micro-phenocrysts of pyroxene embedded in a fine-grained groundmass composed mostly of pyroxene, glass and iron-ore. Felspar is absent. Resorbed olivine phenocrysts, rimmed with yellow-brown iddingsite, are fairly abundant. One large phenocryst consists of a core of iddingsite surrounded by a border of olivine, which in turn is rimmed with iddingsite (Pl. VIII., fig. 6), indicating two distinct periods of iddingsitization. The micro-phenocrysts of weakly titaniferous augite are not abundant, and in several cases consist of rims surrounding olivine xenocrysts.

The groundmass is composed almost entirely of pyroxene and glass in approximately equal proportions. The hypidiomorphic, pale violet-brown prisms of titaniferous augite average 0.02 mm. in length, and show faint pleochroism in sections normal to (010). Granular magnetite is abundant, apatite is rare, while a little picotite with a reaction rim of magnetite also occurs. A dark-brown interstitial glass, crowded with skeletal crystals, forms a considerable proportion of the base, while patches of colourless glass and zeolites are locally abundant.

The upper limburgite flow [5106], Sect. E, No. 13, contains more iddingsitized olivine, while the groundmass is composed mostly of pyroxene and interstitial glass, with accessory nepheline and acid plagioclase. The centre flow [5105], Sect. E, No. 12, is coarser in grain, and the groundmass contains a moderate amount of plagioclase. The plagioclase, which occurs in veinlets, is probably andesine.

The Limburgite-Basalts.

The limburgite-basalts overlie the nephelinites at three different points on the Pentland Hills, but the extent of these flows is unknown. The most westerly limburgite-basalt is possibly intrusive into the nephelinite. The first [5122] is situated near the summit of the Pentland Hills, half a mile to the west of the Korkuperrimul Creek (see map). It is a typical limburgite-basalt with micro-phenocrysts of olivine and pyroxene set in a fine-grained groundmass composed of pyroxene and glass, with subordinate plagioclase, iron-ore and apatite. The olivine and pyroxene micro-phenocrysts, which are occasionally glomero-porphyritic, rarely exceed 0.5 mm. in diameter, and are invariably idiomorphic. Sometimes the pyroxene micro-phenocrysts are zoned, and consist of greenish cores of (?) aegirine-augite and rims of titan-augite. The groundmass is composed chiefly of dark-brown glass and crowded prisms of brown augite, averaging less than 0.02 mm. in length, together with subordinate microlites of plagioclase, granular iron-ore and apatite. Occasional patches of zeolites also occur.

The most westerly outcrop [5121] contains abundant phenocrysts of both olivine and augite, set in a fine-grained groundmass consisting largely of augite, glass and iron-ore, together with subordinate plagioclase and nepheline. The plagioclase and hypidiomorphic nepheline are unevenly distributed. In the third limburgite-basalt [5123], which occurs half a mile south of Cockatoo Gully, the olivine and pyroxene phenocrysts are larger and more abundant, the olivine is iddingsitized, and the groundmass is even finer in grain. The bulk of the groundmass consists of tiny prisms of augite and interstitial glass. Iron-ore is unusually abundant, while picotite and apatite are rare. The plagioclase occurs mostly as scattered microlites, but is occasionally microphenocrystic.

Segregation and Xenoliths.

Small rounded micro-segregations of granular olivine [5075], and less frequently pyroxene [5124], are characteristic of all the nephelinite lavas. These segregations are seldom numerous, but one or two occur in almost every slide examined. Sometimes a corroded xenocryst of olivine occupies the core of the xenolith [5142]. Another type of micro-segregation, [5111], consists of granular iddingsite and magnetite.

Olivine-enstatite xenoliths are distributed irregularly through the nephelinite lavas. They are sometimes abundant, with individual nodules up to 6 inches in diameter. As they are rounded in shape and consist of high temperature minerals, olivine, enstatite and picotite, they are probably xenocrystic in origin. Similar xenoliths, containing olivine, diopside and spinel, have been described from the Carboniferous analcite-basalts of Scotland (Memoir No. 33, Geol. Surv. Scot., 1910). Microscopically, the xenoliths [5141] consist mostly of olivine, with moderate amounts of enstatite and picotite. Many of the allotriomorphic grains of olivine, which average 2 mm. in diameter, show a lamellar pseudo-twinning. The lamellae, which are broad and parallel, extinguish in slightly different positions, and have probably been set up by mechanical stress during the grinding-down process. The enstatite is allotriomorphic, and has a good rectangular cleavage. The brown picotite, which occurs in irregular veins between the grains of olivine and enstatite, sometimes shows an octahedral cleavage, and a slight reaction rim of magnetite.

A small xenolith of olivine-free gabbro [5143] was found in the nephelinite dyke at Dyke Cliff. It consists of allotriomorphic grains of bytownite (Ab. 22), averaging 2 mm. in diameter, and allotriomorphic grains of augite averaging half this size, together with a few large grains of apatite and magnetite. The plagioclase is twinned, but only slightly zoned. Most of the augite is brown, but certain irregular zones are strongly pleochroic from red-brown to green. At the junction with the dyke rock, a reaction zone composed of plagioclase and zeolites occurs, while occasional zeolitic veins, derived from the dyke rock, penetrate the xenolith.

Small rounded xenocrysts of quartz are often found in the basalts [5086], nephelinites [5110] and dyke rocks. They rarely exceed 1 mm. in diameter, and are invariably surrounded by a reaction rim. This consist of an inner rim of glass adjacent to the quartz, and an outer zone of pyroxene. The pyroxene, which is diopsidic, is arranged normal to the quartz. Occasionally the ends of the pyroxene prisms nearer the quartz are rimmed with aegirine. A small xenolith of tillite, composed of angular fragments of quartz set in a fine matrix, was found in one basalt [5137]. These inclusions of quartz and tillite represent pieces of country rock picked up during extrusion.

The Lava Sequence.

The lava sequence was worked out along the Korkuperrimul Creek. Figure 7, a diagrammatic section showing the sequence of the Older Volcanics along the Korkuperrimul Creek, is based on a correlation of the detailed sequences at Sections A, B, C, D, E and F (see Fig. 6, p. 128). It is impossible to correlate directly the individual flows of the above Sections, because the flows thin out laterally and give place to others, which are usually, but not always, of a similar type. However certain generalisations can be made. (1) The serpentine basalts occur at the base of the series resting on the Permo-Carboniferous. They are all similar in type. (2) A single persistent flow of porphyritic basalt overlies the serpentine basalts. (3) The iddingsite basalts occur mostly above, but also below the porphyritic basalt, but never at the very base of the series. These basalts present numerous minor variations in type. (4) The olivine nephelinites, limburgites and limburgite-basalts always overlie the serpentine, iddingsite and porphyritic basalts. The limburgites and limburgite-basalts overlie the nephelinites, but their relationship to each other, and to the doleritic basalt, are uncertain, as the boundaries of these flows cannot be traced. (5) The doleritic basalt at Section B overlies the nephelinite. It is also highly probable that the doleritic basalts overlie the limburgites and limburgite-basalts. (6) The only evidence as to the relative ages of the dykes and lavas is a case where a monchiquite is intrusive into the basalts below the nephelinite, but not into the nephelinite itself. Thus the general sequence of the Older Volcanics along the Korkuperrimul Creek (see Fig. 7) is as follows:—

7. Doleritic basalts.
6. Limburgites and limburgite-basalts.
5. Olivine nephelinites.
4. Monchiquite dykes.
3. Iddingsite basalts (also below 2).
2. Porphyritic basalt.
1. Serpentine basalts.
   Permo-Carboniferous.

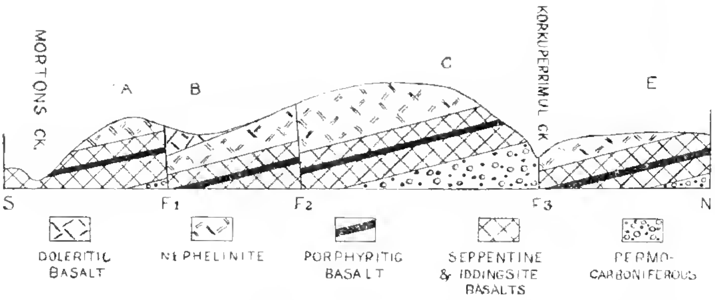

Fig. 7.—A diagrammatic north-south section showing the Older Basalt lava sequence along the Korkuperrimul Creek. The faults F_1, F_2 and F_3 are described on pages 112–113. The length of the section is approximately 1¾ miles.

The lava sequences to the east and west of the Korkuperrimul Creek do not always conform to that described above. Thus south of Morton's Creek, doleritic and iddingsite basalts, which probably overlie the lavas of the Korkuperrimul Creek sequence, occur.

Dip and Thickness of the Lavas.

The Older Volcanic series have a small regional tilt to the south-south-west, but in certain localities, especially in the neighbourhood of large faults, both the amount and direction of tilting varies. Along the Korkuperrimul Creek, between Sections A and C, the lavas are tilted to the south-south-west at about 12 deg., but further north, on the upthrow side of the Pentland Hills fault, the nephelinite dips to the south-west at 20-25 deg., while the overlying limburgites are almost horizontal. Along the Greendale fault, where the Older Volcanics are faulted against the Ordovician, the general dip is south-easterly.

The calculation of the thickness of the Older Volcanic series is complicated by the variations of dip, faulting and lateral thinning of flows. Along the Korkuperrimul Creek (see Fig. 7) the estimated thicknesses are as follows:—

3. Doleritic basalts	150 feet.
2. Nephelinite group	225 feet.
1. Serpentine, iddingsite and porphyritic basalts ..	150–200 feet.
Total .. .	525–575 feet.

Thus the thickness of the Older Volcanic lavas along the Korkuperrimul Creek is at least 525 feet. A series of doleritic and iddingsite basalts, which occur in the south-west corner of the area, and which probably overlie the lavas of the Korkuperrimul Creek sequence, may add considerably to the total thickness of the Older Volcanic series.

Decomposition of the Lavas, and the Origin of the Red Clay Beds.

A striking feature of the Older Volcanic series along the Korkuperrimul Creek is the alternation of decomposed flows with others which show little sign of alteration. The alternation is probably controlled by structural features, such as jointing and tilting. The closely-spaced tabular jointing and the vesicularity of the margins of the flows, and the circulation of the underground waters along the junction planes between the flows results in the decomposition of the flows from the top downwards. As weathering proceeds, the columnar structure is destroyed, and the rock consists of a mass of crumbly semi-decomposed basalt, studded and veined with secondary carbonates, in which occasional nodules of fresh basalt are embedded.

Carbonates are a common product of decomposition of the lavas. They are especially well developed in a small gully on the western slopes of Bald Hill. Earthy magnesite occurs as irregular veins through the decomposed basalt, and also as sheets along joint and fault planes. Secondary calcite occurs in nodules, vesicles and irregular veins through the decomposed rock.

The occurrence of a bright red clay as an irregular layer along the upper margin of a decomposed flow, or as a continuous layer, up to 30 feet or so in thickness, between two solid lava flows, is a common feature of the Older Volcanics along the Korkuperrimul Creek, and also at Myrniong, Flinders and Phillip Island. The material is a closely-jointed, soft, brittle, waxy clay-like substance. The colour of the material is bright red or reddish-brown. The prismoidal jointing is very well developed (especially along the seashore at Flinders). The closely-spaced, more or less vertical joint sets intersect at an acute angle, while a third horizontal set is less prominent. Numerous irregular closed fractures also occur.

A partial analysis shows that, if the material was originally basaltic, considerable chemical alteration has taken place (see Table No. 2).

TABLE NO. 2.

—	1.	2.	3.
SiO_2	26·01	34·45	43·82
Al_2O_3	28·27	17·37	28·76
Fe_2O_3	22·38	} 23·08	2·66
FeO	0·57		0·20
MgO	1·55	3·30	0·03
CaO	0·71	..	0·58
Na_2O	..	..	0·90
K_2O	..	..	1·66
$H_2O + 110°$	12·06	8·27	7·76
CO_2	Tr.	..	0·04
TiO_2	3·03	..	4·75
P_2O_5	Nil	..	0·05
MnO	Tr.	..	..

No. 1 Red clay bed, between flows Nos. 4 and 5, Section C. (R. Jacobson.)
No. 2. Specimen of decomposed basalt from the Bellarine Peninsula. Geol. Surv Rept. 1863.
No. 3. Residual clay decomposed Older Basalt from Royal Park (D McCance.) *Proc Roy. Soc.* Vic., xliv (2), n.s, 1932.

Practically all the CaO, MgO, P_2O_5 and Na_2O have been leached out, while the iron, with most of the FeO converted to Fe_2O_3, has been concentrated along with Al_2O_3 and TiO_2. The water content has been greatly increased, and some silica has been lost. The composition differs from the residual clay derived from the Older Basalt in the Royal Park cutting (see Table No. 2), in the abnormal concentration of iron and in the loss of a greater proportion of the silica. A similar concentration of iron occurs in the red clays associated with the decomposed Older Basalts of the Bellarine Peninsula (see Table No. 2). Microscopically the material is extremely fine grained and mostly isotropic, but occasionally cryptocrystalline. It is a clay mineral, probably with a composition such as hydrated silicate of Al_2O_3 and Fe_2O_3.

The origin of these beds of red clay is uncertain. Selwyn (1854), in addition to describing true volcanic breccias, notes the occurrence of beds of red clay intercalated with the Older Basalt lavas of Flinders, and describes them as beds of volcanic mud. Fenner (1918), when describing the Older Basalts of the Bacchus Marsh area, writes, "Beds of tuff, sometimes bright red, occur in the series, and are to be well seen where the Myrniong-Greendale road crosses the Korobeit Creek." Professor Skeats first drew the attention of the author to the doubt as to the origin of these beds, and later with Dr. Summers assisted the author in the examination of these beds in the field. There are at least three alternative modes of origin of these red clays. They may be decomposed lava flows, pyroclastic rocks or sediments formed in the intervals between the extrusion of the lava flows. Of these three possibilities, the third is very unlikely. In many cases the red clays have a mottled appearance, very suggestive of a pyroclastic rock, such as a volcanic mud, tuff, scoria bed, or volcanic agglomerate. By studying a limited section of these beds one is readily persuaded that these clays are probably pyroelastic in origin, but in many cases they can be traced laterally into decomposed basalts, and occasionally into solid basalt. Red clays with a pyroclastic appearance occur at numerous points along the Korkuperrimul Creek, but the best examples are found at Dyke Cliff, in a gully on the western slopes of Bald Hill, opposite Section C, and along Morton's Creek. The author believes that in the Korkuperrimul Creek area, the evidence points to these red clays being decomposed basalts. The oceurrences at Flinders and Myrniong are such that, while the author is by no means satisfied as to their pyroclastic origin, no definite conclusion is drawn.

Petrology of the Dyke Rocks.

About a dozen small dykes were found intruding the Permo-Carboniferous and Older Volcanics. They are generally small, and can be traced for only short distances. These dykes include the following types:—

MONCHIQUITES—
- (*a*) Felspar-free monchiquites.
- (*b*) Felspathic monchiquites.
- (*c*) Fine-grained monchiquites.

OLIVINE NEPHELINITES.

OLIVINE BASALTS.

Monchiquites.

(*a*) Felspar-free Monchiquites.—A small irregular monchiquite dyke, intrusive into the basaltic lavas below the nephelinite, but not into the nephelinite itself, occurs on the south bank of the Korkuperrimul Creek, $\frac{3}{4}$ mile to the west of Cockatoo Gully. This rock [5126] contains abundant phenocrysts of olivine and micro-phenocrysts of pyroxene, set in a fine-grained glassy groundmass composed of augite, iron-ore and a little picotite and biotite. The olivine phenocrysts are generally idiomorphic, but sometimes resorbed. The pyroxene micro-phenocrysts, which are mostly idiomorphic, are strongly zoned with diopsidic cores, and rims of titan-augite. The groundmass pyroxene is a titaniferous augite corresponding in colour and pleochroism with the rims of the phenocrysts. In addition to magnetite and a few grains of reddish picotite, a small segregation of green spinel (pleonaste) also occurs. Occasional scales of biotite are present, but hornblende is absent. A glassy mesostasis, crowded with minute brownish inclusions, forms about half the base of the rock.

Another small monchiquite dyke is intruded through the Permo-Carboniferous on the east bank of the Korkuperrimul Creek, 50 yards north of Anderson's Quarry. The rock [5127] is considerably decomposed. It contains phenocrysts of completely serpentinized olivine, set in a fairly coarse-grained groundmass composed of pyroxene and a greenish glass crowded with laths of strongly pleochroic biotite, apatite and iron-ore. The pale violet-brown augite occurs in laths which average 0.2 mm. in length. Occasional amygdales, filled with calcite and glass, also occur.

(*b*) Felspathic Monchiquites.—Two small monchiquite dykes are intruded through the Permo-Carboniferous on the west bank of the Korkuperrimul Creek, about a quarter of a mile south of Cockatoo Gully. They are typical monchiquites except for the presence of a certain amount of plagioclase. The more northerly of these dykes [5128] contains abundant idiomorphic phenocrysts of both olivine and pyroxene, embedded in a groundmass composed of augite, iron-ore, subordinate plagioclase, brown hornblende, apatite and a glassy mesostasis. The olivine phenocrysts are generally idiomorphic, and sometimes serpentinized. The idiomorphic pyroxene phenocrysts are zoned, with brownish diopsidic cores and rims of titan-augite. The smaller pyroxenes are often grouped stellately. Plagioclase (about Ab. 50) occurs in ragged laths containing numerous inclusions of pyroxene and apatite. Numerous scales of reddish-brown hornblende, which are pleochroic from green to red-brown, are associated with the iron-ore. The base of the rock consists of a glass crowded with minute brownish inclusions and tiny scraps of biotite. Occasional amygdales, filled with glass, calcite and a little analcite, also occur.

The more southerly [5129] is similar, but the pyroxene phenocrysts are more abundant, and the plagioclase is more acid in composition (approximately Ab. 65). The yellowish glass is crowded with scales of biotite, but hornblende is almost absent.

A similar monchiquite dyke [5130], intrusive into the Older Volcanics, occurs in a cliff on the east bank of the Korkuperrimul Creek, about 250 yards north-east of Section C.

Another small decomposed monchiquite dyke [5131], intrusive into the Permo-Carboniferous, is found in the Korkuperrimul Creek 150 yards east of Cockatoo Gully. The pyroxene and olivine phenocrysts are completely serpentinized, while the felspar and glass have recrystallized as a fine admixture of secondary chlorite, calcite and zeolitic products, criss-crossed with flakes of biotite and needles of apatite.

(*c*) Fine-grained Monchiquites.—At Dyke Cliff there are two small, fine-grained monchiquite dykes which act as feeders to a lava flow at the top of the cliff. A number of xenocrysts of plagioclase, up to 3 inches in length, were found in these dykes. They—[5132] and [5133]—contain small phenocrysts of olivine and occasional micro-phenocrysts of pyroxene set in an exceedingly fine-grained groundmass, the bulk of which consists of pyroxene, iron-ore, and interstitial glass, together with subordinate plagioclase and a little apatite. The olivine phenocrysts are rimmed with iddingsite, and are generally resorbed. The brownish pyroxene phenocrysts are weakly titaniferous. The groundmass pyroxene occurs in tiny prisms less than 0.01 mm. in length. Apatite and granular iron-ore are abundant. The plagioclase occurs in ragged laths, and is probably an acid labradorite. Interstitial glass forms a considerable proportion of the base.

The Olivine Nephelinites.

An irregular dyke of olivine nephelinite about 10 feet wide, which can be traced for only a few yards, occurs at Dyke Cliff. Several xenoliths of porphyritic basalt, small clots of olivine, occasional xenocrysts of quartz, and a single xenolith of gabbro, were found in this dyke. The rock [5134] contains abundant phenocrysts of olivine rimmed with iddingsite, and occasional micro-phenocrysts of pyroxene set in a fine-grained groundmass composed chiefly of pyroxene and nepheline, together with iron-ore, apatite, biotite and a little glass. Occasional veinlets of plagioclase and zeolites occur.

Olivine Basalts.

A coarse-grained basaltic dyke [5135] is intrusive into the Permo-Carboniferous on the east bank of the Korkuperrimul Creek, about ¼ mile north of Anderson's Quarry. In the hand specimen it is a decomposed mottled yellow rock. It contains phenocrysts of completely serpentinized olivine, and augite rimmed with titan-augite, set in a coarse-grained mero-crystalline groundmass composed of plagioclase, intergranular pyroxene, iron-ore, apatite, a little hornblende and abundant intersertal glass.

Another basaltic (?) dyke, about 100 feet in width, is intruded into the Permo-Carboniferous on the east bank of the Korkuperrimul Creek, about half a mile south of Cockatoo Gully. Only one nearly vertical junction, which appears to be an intrusive contact, is clearly exposed. As the intrusion does not appear to extend to the east for any great distance, it probably represents a plug, and not a dyke. Under the microscope, the rock [5136] contains numerous phenocrysts of partially serpentinized olivine, and zoned titaniferous pyroxene set in a fine-grained groundmass composed of microlites of plagioclase, subordinate pyroxene, granular iron-ore, together with a little picotite, apatite and biotite. An interstitial glass forms a considerable proportion of the base.

Petrogenesis.

Iddingsitization.

Ross and Shannon (1925) have shown that iddingsite is a definite mineral species, which may be represented by the formula $MgO.Fe_2O_3.3SiO_2.4H_2O$, with CaO replacing MgO in the ratio of 4:1. and Al_2O_3 partially replacing Fe_2O_3, which is formed by the metasomatic alteration of olivine under oxidising conditions. The conversion of olivine to iddingsite therefore involves an increase in Fe_2O_3 and H_2O. The process is deuteric, and probably takes place just prior to, or during extrusion, because extrusion leads to the escape of the water vapour. The fact that the iddingsite basalts sometimes have a glassy mesostasis crowded with iron-ores of late formation, is additional evidence of the tendency towards the concentration of iron in the residual liquid—as pointed out by Fenner (1929).

The Older Volcanic series of the Korkuperrimul Creek includes a group of iddingsite basalts. The iddingsite usually occurs as a simple rim, varying from a mere film to a wide border, surrounding the olivine crystal. Sometimes the olivine is completely iddingsitized, in which case it is usually slightly zoned and faintly pleochroic. A zoned phenocryst in one of the limburgites (Pl. VIII., fig. 6), which consists of a core of iddingsite rimmed with olivine, and an outer zone of iddingsite, shows clearly that two distinct periods of iddingsitization sometimes occur. In one of the iddingsite basalts [5081] the olivine phenocrysts are iddingsitized, while the groundmass generation of olivine is only slightly affected, indicating that iddingsitization had practically ceased before the crystallization of the groundmass olivine. When serpentine and iddingsite occur together in the same rock, the former is generally secondary in origin, but a strongly pleochroic type of iddingsite, which occurs in the serpentine-analcite-basalt [5092], is probably a normal type of iddingsite which has been modified by subsequent serpentinization.

Serpentinization.

Serpentine is a common alteration product of olivine, and it is now generally accepted that serpentinization, like iddingsitization, may be the result of a primary late-magmatic process. The serpentine basalts of this series, even when perfectly fresh, are characterized by phenocrysts of olivine which are invariably partially serpentinized, and a residual magnesia-rich mesostasis consisting of a mixture of glass and serpentine. The serpentinization of these basalts was almost certainly the result of some primary late-magmatic process. MacGregor, Bailey and Thomas (1930) have described a similar mesostasis, consisting of chlorite, and less commonly of serpentine and chlorophaeite, in the Carboniferous basalts of North Ayrshire. They have also shown that the groundmass felspar has been partially replaced by chlorite at a late stage in the genesis of the rock. Similarly some of the felspar in the serpentine basalts is partially replaced by serpentine.

TABLE No. 3.

—	1.	2.	3.	4.
SiO_2	46·64	39·79	42·39	41·13
Al_2O_3	15·46	12·11	16·17	15·74
Fe_2O_3	4·49	4·67	4·29	4·02
FeO	7·25	7·87	5·79	7·71
MgO	7·24	12·25	7·66	7·98
CaO	10·80	11·29	11·57	10·48
Na_2O	2·43	2·83	4·26	5·56
K_2O	0·92	1·23	1·46	1·12
$H_2O + 110°$	1·83	1·79	1·85	2·11
$H_2O - 110°$	0·89	3·06	0·56	0·58
CO_2	Tr.	Nil	..	..
TiO_2	1·90	1·87	2·13	2·34
P_2O_5	0·32	1·30	1·16	0·54
MnO	0·04	0·02	0·23	0·14
Li_2O	..	..	..	Tr.
Cl	..	..	0·11	Nil
S	..	..	0·13	Nil
BaO	..	..	0·01	Nil
Total	100·21	100·08	100·37	99·45
NORMS.				
Q	..	..	..	..
Or	5·56	7·23	8·62	6·64
Ab	20·44	3·14	11·85	2·26
An	28·63	16·68	21·12	14·61
Ne	..	11·36	12·67	24·32
C	..	..	..	..
di	18·51	24·77	20·57	27·27
hy	3·62	..	..	..
ol	8·75	18·82	8·68	10·23
mg	6·50	6·73	6·22	5·83
il	3·65	3·50	5·06	4·42
hm	..	..	..	..
ap	0·72	3·10	2·76	1·18
cal	..	..	..	..
pyr	..	..	0·24	..

No. 1. Porphyritic basalt, Flow No. 3, Section C. (R. Jacobson.)
No. 2. Olivine nephelinite, a lava flow, 50 yards from the head of a small gully on the western slopes of Bald Hill, Bacchus Marsh. (R. Jacobson.)
No. 3. Olivine nephelinite, plug, 8 chains south of the Greendale Hotel, parish of Blackwood. (A. B. Edwards.) ***Proc. Roy. Soc. Vic.*, xlvii (1), n.s., 1934.**
No. 4. Olivine nephelinite, plug, in allotment 91, parish of Drouin West. (F. F. Field.) ***Proc. Roy. Soc. Vic.*, xliii (2), n.s., 1931.**

Serpentinization requires an enrichment of the residual liquid in MgO and H_2O, and consequently primary serpentization probably occurs just prior to, or during, extrusion. Similarly Thomas and Bailey (1924), have suggested that the chloritic material in the Tertiary mugearites of Mull represents a chloritized glassy residuum. Thus in this Older Volcanic series there are two distinct trends in the later stages of crystallization of the basalts, one consisting of a concentration of Fe_2O_3 and H_2O in the residual liquid (iddingsitization), and the other in a concentration of MgO and H_2O in the residual liquid (serpentinization).

Notes on Analyses.

The analysis of the porphyritic basalt (see Table No. 3) shows it to be a normal basalt type. The silica percentage is a trifle lower than usual, and the lime slightly higher, but neither is abnormal.

Apart from the Pentland Hills nephelinite, the Greendale and Drouin plugs are the only other recorded occurrences of olivine nephelinite from Victoria. Of these the Pentland Hills nephelinite more closely resembles the Greendale rock, especially as the pyroxene is titaniferous. The Pentland Hills nephelinite is more basic than the Greendale rock (see Table No. 3); the SiO_2, Al_2O_3 and total alkalies are distinctly lower, while MgO is much higher. The Pentland Hills nephelinite compares very closely with Daly's average limburgite (Daly, 1934), and is even slightly more basic in character. The higher MgO content of the Pentland Hills nephelinite results from a greater abundance of olivine. It is of interest to note that there is a sympathetic variation of Na_2O and Al_2O_3 when the analyses of the Greendale, Drouin, and Pentland Hills nephelinites are compared.

Differentiation.

Kennedy (1933), has advanced the theory that the olivine basalts and tholeiitic basalts (i.e. plateau basalts) represent two distinct types of primary basaltic magma. The olivine basalt magmas give rise to an alkaline line of descent, while calc-alkaline differentiates are derived from the tholeiitic magmas. Lehmann (1928, 1931), and Kennedy (1933) maintain that it is the type of pyroxene which crystallizes that controls the subsequent trend of differentiation, and according to Kennedy this ultimately depends upon the chemical composition of the magma. Calcic pyroxenes, diopside and titan-augite crystallize from olivine basalt magmas, while lime-poor enstatite-augites form in the tholeiitic magmas. In the case of the olivine basalt magma, the early removal of lime and magnesia as calcic pyroxenes, leaves the alumina free to combine with the alkalies to form alkali-felspar, and later felspathoids, thus giving rise to an alkaline line of descent.

Since no tholeiitic basalts (in Kennedy's sense) are present among the lavas of the Korkuperrimul Creek, and as olivine basalts were extruded both before and after the olivine nephelinites, the parent magma of this suite is believed to have been an olivine basalt type. The pyroxenes of these Older Volcanics, as determined by approximate measurements of the optic axial angles (Schwarzmann scale), are lime-rich, and usually titaniferous. The groundmass pyroxenes match the rims of the phenocrysts in colour and pleochroism, and are therefore similar in type. No lime-poor pyroxenes with small optic axial angles (pigeonites), which according to Barth (1931) and Fermor

(1926) are the common groundmass pyroxenes of basalts, were found in these Older Volcanic lavas. In so far as an olivine basalt magma has given rise to an alkaline line of descent, with the crystallization of calcic pyroxenes, this suite is in agreement with Kennedy's interpretation.

The derivation of an olivine nephelinite from a parent olivine basalt magma, may be considered as consisting of two processes, (*a*) the formation of a limburgitic liquid, and (*b*) the concentration of soda.

(*a*) The olivine nephelinites, limburgite-basalts and limburgites are all extremely fine-grained rocks, in which olivine is the only prominent phenocrystic phase. Thus the only solid phase present when extrusion occurred was olivine, and sometimes perhaps a little pyroxene and picotite. In the case of the limburgite-basalts, the olivine phenocrysts are very small and idiomorphic, and therefore it is necessary to explain the formation of liquids corresponding in composition to these ultrabasic lavas. A limburgitic liquid may be formed in the lower levels of a basaltic magma chamber, only by the re-solution of some of the olivine which accumulates in this layer under gravitational control. No "squeezing mechanism" can account for the formation of a limburgitic liquid from a basaltic magma, so that re-solution of olivine at depth would appear to be the only reasonable alternative. The occurrence of numerous xenoliths of olivine, enstatite and picotite in the nephelinites afford evidence of the part played by gravitational differentiation.

(*b*) The introduction and concentration of soda cannot be brought about by the same process as that leading to the formation of the limburgitic liquid, as the concentration of soda and the concentration of lime are independent of each other. The irregular distribution of soda, as shown by the lateral variation in the nephelinite flows, indicates the localized nature of the process bringing about its introduction. The occurrence of a single flow of olivine-analcite-basalt, probably formed by a late-magmatic process, affords further evidence of the localization of the concentration of soda. Some form of "gas streaming process," such as that suggested by Shand (1933), has probably been responsible for the introduction of the soda into the limburgitic liquid. The limburgite-basalts, limburgites and nepheline limburgites are regarded as types that have been formed from the same ultra-basic liquid as the olivine nephelinite, but which have not been enriched in soda to the same extent. The absence at the surface of a complementary differentiate to the nephelinites, such as an olivine-poor basalt or an oligoclase basalt, does not necessarily imply that these do not occur at depth.

Age-Relations and Correlations.

The age of the Older Volcanics cannot be determined precisely in this area. They are clearly post Permo-Carboniferous, and pre-date the major faulting of the Bacchus Marsh area. They are overlain by Tertiary deposits, which have been mapped as Miocene by the Survey, but the plant remains are such that this cannot be regarded as conclusive evidence of the pre-Miocene age of the Older Volcanic series. The Older Volcanics were formerly referred to the Miocene, but in recent years the tendency has been to place them still lower in the Tertiary, mostly in the Oligocene.

The South Gippsland dyke association, described by Edwards (1934), consisting of trachy-andesites, analcite-olivine dolerites, olivine-analcite-dolerites, olivine-analcite-basalts, monchiquites and olivine nephelinites, presents a fairly close parallel to the Older Volcanic suite of the Korkuperrimul Creek; but while the South Gippsland province is characterized by crinanites, the nephelinites are the outstanding feature of the Korkuperrimul Creek area. Some of the monchiquite-basalts of the South Gippsland province are very similar in chemical composition to the Pentland Hills nephelinites. Edwards has shown that the monchiquite dykes of South Gippsland and Central Victoria are similar, and characteristic of the Older Basalt suite, and therefore the monchiquites of the Korkuperrimul Creek area serve to demonstrate further the genetic relationships of this suite to the Older Basalt period of vulcanicity.

Summary and Conclusions.

The so-called Permo-Carboniferous deposits of the Korkuperrimul Creek area are all Upper Permian in age, and form an extensive series with a minimum thickness of 2,103 feet, having a strong regional tilt to the S.S.W. The beds consist of tillites (at least 11 separate horizons), englacial deposits (not common) and a great variety of aqueo-glacial sediments. The latter consist of a well-developed suite of fluvio-glacial shales, sandstones, gravels and conglomerates (outwash plain type of deposits), together with thick beds of lacustrine mudstones. Some of the sandstones and shales are also lacustrine in origin. A study of the erratics and heavy minerals of the sediments shows that the material forming the Permian beds was essentially derived from the Lower Palaeozoic (mainly Ordovician) sediments, though it was not possible to determine the precise locality from which this material was derived.

A series of gently tilted Older Volcanic lavas, at least 550 feet in thickness, occurs along the Korkuperrimul Creek. The lava suite comprises serpentine basalts, iddingsite basalts, porphyritic basalt, doleritic basalts, olivine nephelinites, limburgite-basalts and limburgites. The nephelinites approximately equal the basaltic lavas in proportion. The lava sequence established along the Korkuperrimul Creek is interrupted by several large faults, the most important of which are the Pentland Hills fault and the Bald Hill faults. The dyke rocks associated with the lavas include monchiquites, olivine basalts and occasional olivine nephelinites. Thick beds of red clay, alternating with flows of solid lava, are a prominent feature of the Older Volcanic series, and, although they have the superficial appearance of pyroclastic rocks, they are considered to be decomposed lavas. Although the age cannot be fixed exactly in this area, there is little doubt that the suite is closely related genetically to the other Victorian Older Basalts, especially to those of the South Gippsland province.

Acknowledgments.

The authors are indebted to Professor Skeats and Associate Professor Summers for suggesting and subsequently directing the work; to Mr. F. A. Singleton, who made available his unpublished thesis for M.Sc. on Bald Hill; to Dr. A. B. Edwards for general criticism and advice on chemical analyses; to Mr. J. S. Mann for taking the photomicrographs; and to the staff of the Geological Department (Melbourne University) for much help and advice.

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Explanation of Plates.

Plate VII.

Fig. 1.—Bands of sandstone intercalated in tillite, Werribee River, 1½ miles downstream from the hanging valley. The cliff is at least 40 feet in height.

Fig. 2.—Fault junction (F.6) between basalt and Permian sandstones, Korkuperrimul Creek, west bank, just below the junction with Morton's Creek, Bald Hill area.

Fig. 3.—Tillite (typical), Stage 4 (*c*), North Korkuperrimul area.

Fig. 4.—Sandstones with interbedded conglomerates and gravels, showing their impersistent nature. Stage 6, North Korkuperrimul area.


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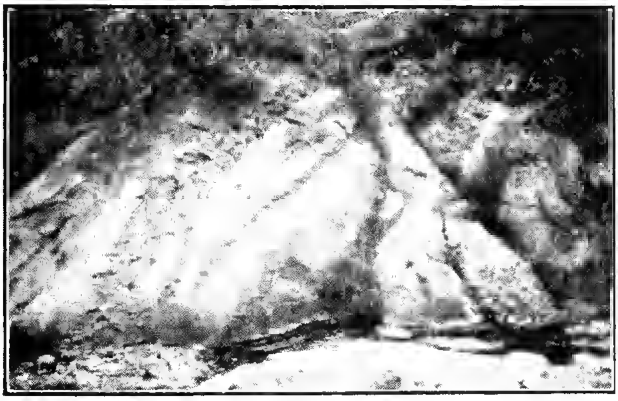
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The Permian Rocks.

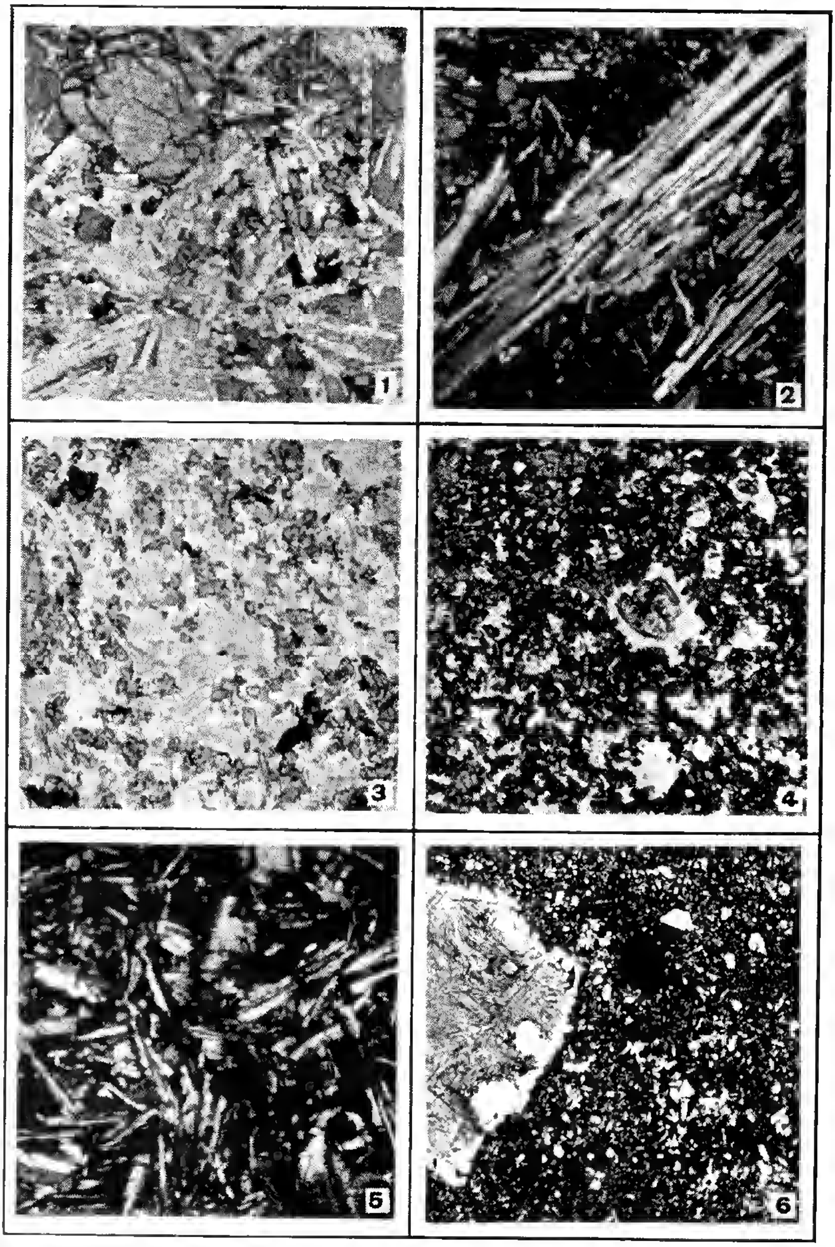
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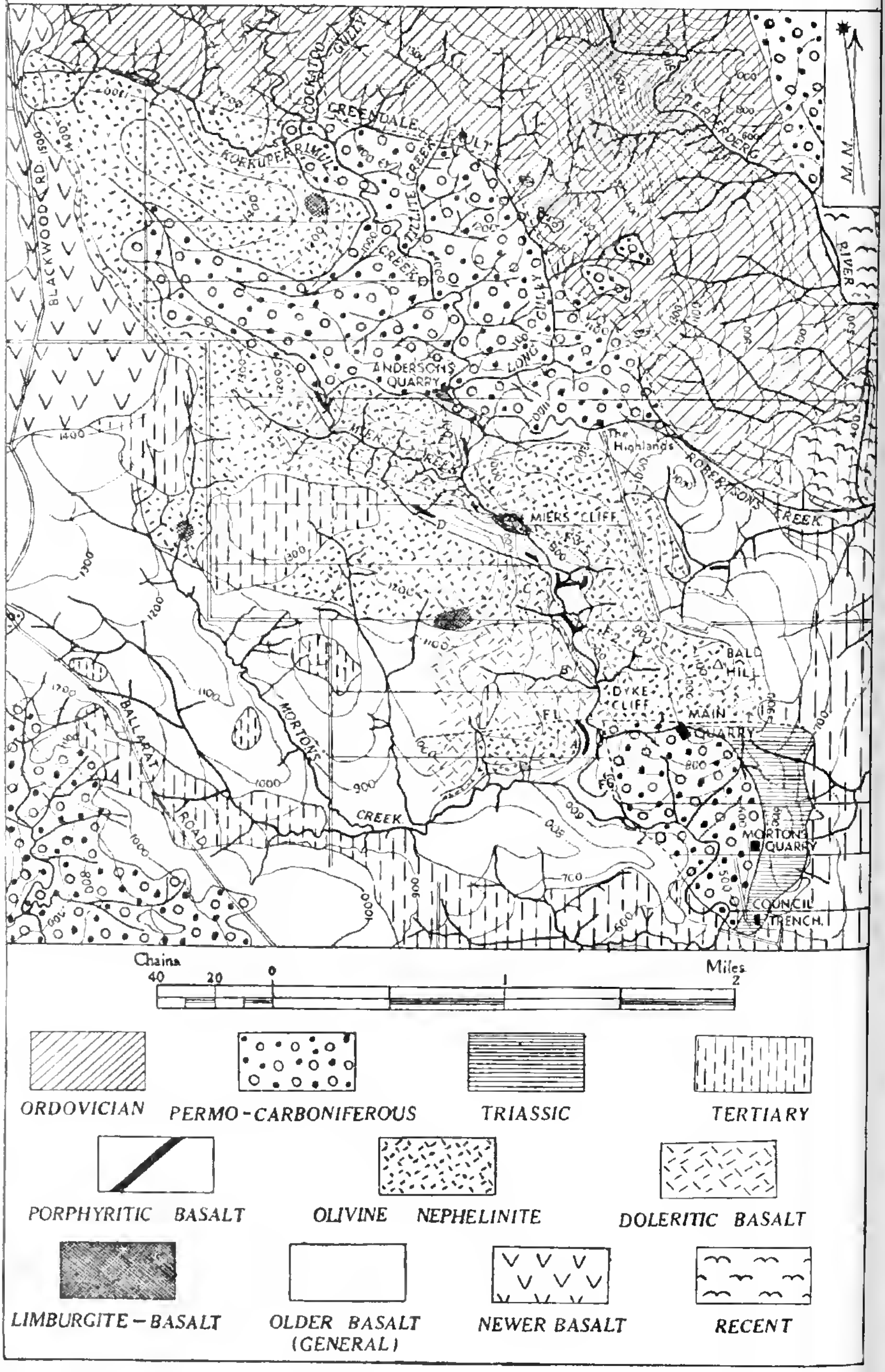
PLATE VIII.—PHOTOMICROGRAPHS.

1. *Doleritic basalt,* Section B, No. 2. Shows small olivine phenocrysts, large irregular plates of ophitic pyroxene, and the lack of a distinct groundmass. Ordinary light, × 18. Slide 5076.
2. *Porphyritic basalt,* Section C, No. 3. Shows large plagioclase phenocrysts with complex inter-leaved structure. Crossed nicols, × 24. Slide 5079.
3. *Serpentine basalt,* Section A, No. 4. The intersertal-intergranular texture is the most important feature. The small, dark, intersertal, sharply defined wedges are the serpentine-glass mesostasis. Ordinary light, × 25. Slide 5077.
4. *Olivine nephelinite,* from a small gully on the western slopes of Bald Hill. Shows large phenocrysts of olivine, abundant small prisms of groundmass pyroxene, and allotriomorphic plates of nepheline surrounding olivine crystals. Ordinary light, × 34. Slide 5110.
5. *Olivine basalt,* collected from the summit of the Pentland Hills, ½ mile west of Dyke Cliff. Shows idiomorphic laths of labradorite embedded in a dark coloured glass forming 40 to 50 per cent. of the rock. Crossed nicols, × 34.
6. *Limburgite,* Section E, No. 11. Shows a large iddingsitized olivine phenocryst. The brown iddingsite core is surrounded by a border of clear olivine, which, in turn, is rimmed with iddingsite. Ordinary light, × 34. Slide 5104.

GEOLOGICAL SKETCH MAP OF THE KORKUPERRIMUL CREEK AREA.

Based on Quarter Sheets 11 SE and 12 NE, by R. Daintree, C. S. Wilkinson and R. A. F. Murray. (Geol. Surv. of Victoria.). Contours from Military Map of Ballan.



[Proc. Roy. Soc. Victoria, **50** (N.S.), Pt. I., 1937.]

Art. VIII.—*A Cultural Study of* Fistulina hepatica *(Huds.) Fries, Isolated from Decayed Jarrah* (Eucalyptus marginata *Sm*).

By M. ROTHBERG, B.Agr.Sc.

[Read 10th June, 1937; issued separately 29th December, 1937.]

Introduction.

Fistulina hepatica (Huds.) Fries has a wide distribution being found in Europe, Asia, North America, and Australia. In addition, Saccardo (1891) recorded a species *F. antarctica*, subsequently considered to be a synonym of *F. hepatica* (Saccardo, 1925), from antarctic regions such as South Patagonia. Cooke (1871) reported that it was common in Britain and occurred on the trunks of old oaks. Saccardo (1888) noted its occurrence on trunks of *Quercus, Fagus* spp., and *Castanea* spp. Rea (1922) listed its occurrence in Britain on the trunks of the following trees:—oak, ash, walnut, willow, beech, sweet chestnut, hornbeam and elm. Cartwright and Findlay (1936) stated that the fungus gained entrance through wounds, and probably acted as a mild parasite.

In Australia, Cooke (1892) recorded *F. hepatica* growing on tree trunks in West Australia, while McAlpine (1895) noted its occurrence in Victoria. The fungus was recorded for Tasmania by McAlpine and Rodway (1896), and Cleland (1935) recorded it in South Australia and New South Wales, on the trunks of living Eucalypts, dead stumps, and on fallen logs (Plate IX., figs. 1, 2).

In this study, the writer will be concerned with the relationship existing between Jarrah (*Eucalyptus marginata* Sm.) and *F. hepatica*.

Outline of Investigation.

During a preliminary investigation of fungal rots in Jarrah, one particular fungus was isolated repeatedly from specimens exhibiting various symptoms of rot. This fungus often produced fertile sporophores in culture which exhibited the characteristics of the sub-family Fistulinaceae in having the "hymenium inferior, lining free and separate tubes" (Rea, 1922), (Plate IX., Figs. 3, 4). Their appearance approximated most closely to that suggested by the description of *Fistulina hepatica* Fries by Saccardo (1888).

F. hepatica has been isolated from the following types of rots:—heart rot or dry rot, pith or doze, straw rot, decayed included sap, yellow-edged pin-holes, and pencilled Jarrah. The rot-nomenclature was that used by timber workers to describe the types of rot, based on their macroscopic appearance. Rot specimens were selected by the Senior Timber Inspector of the Forests Department, West Australia, from the Jarrah forests as examples of the principal types of rot in Jarrah.

Jarrah Rot Specimens.		Fungi Isolated.			
Total No.	No. which Yielded Isolations.	Total No.	*F. hepatica.*	Other B'mycetes.	Other Fungi.
24	16*	19*	10	6	3

* Some specimens yielded more than one fungus.

Method.

Suitable discs, 1 inch thick, were cut from selected specimens of rotted Jarrah. Each disc was transferred to the inside of an inoculation chamber where, by the aid of a pair of chisel forceps, small pieces of wood were removed from designated regions of the disc and sown on to Petri dishes containing $\frac{1}{4}''$ depth of 2.7% malt extract agar. The dishes were incubated at 18–22° C., 60–70% relative humidity, in weak light. Later, those inocula which produced fungal mycelia were transferred to malt-extract agar slopes and incubated. Generally *F. hepatica* appeared within three weeks, and, after vigorous initial growth in the incubator, cultures were maintained in darkness under room conditions.

Beaker cultures were started by inoculating conical beakers containing 1 inch depth of 2.7% malt-extract agar with actively-growing mycelia of *F. hepatica,* and were maintained under conditions similar to those used for Petri dishes. When the surface of the medium was covered (usually 3–4 weeks' growth), a suitable sub-stratum was presented for the artificial attack on sound Jarrah blocks. These were of true wood cut approximately $2'' \times 1'' \times 1''$ from sound Jarrah sticks obtained from a Melbourne timber yard.

Fungus in Culture.

Macroscopic Appearance.

At first (7–8 days) the centre was white to creamy white in colour, downy in texture and surrounded by an annular region consisting of a flat, sodden, colourless, mycelial mat with an irregular margin. Within two weeks of commencement of growth, the central region of the culture was creamy white, loose-woolly in texture, 3–5 mm. thick, surrounded by the sodden annular region with the typical margin. At the end of the third week, the central inoculum, which had protruded above the remainder of the culture, began to assume tints of Cartridge Buff, Ivory Yellow to Light Ochraceous Buff (Ridgway, 1912).

Cultures grown in stronger light exhibited less vigorous aerial growth and generally a thinner and more floccose type of growth than the loose-woolly type described. In addition, in some cases, the sodden annular region of growth occurred centripetally as well as centrifugally to the white floccose region. As the mycelium aged, colour changes occurred and the following ranges of tints were exhibited:—Cartridge Buff to Ochraceous Orange and later Ochraceous Tawny to Russet. The texture also changed and became felty to membranous (in part). Watery exudations, which were often reddish in colour, appeared within five to ten weeks of commencement of growth. These either accompanied, or appeared in advance of, the formation of sporophore initials which often arose as round swellings, Cartridge Buff, Marguerite Yellow, or Pale Pinkish Cinnamon in colour, on the surface of the mycelium or block.

The following types of fructification were obtained in culture:—

A. Sterile (*a*) *Ceriomyces*-type (Plate X., fig. 5).
(*b*) *Solenia*-type.

B. Fertile (*c*) *Cyphella*-type (Plate X., fig. 6).
(*d*) Near-typical (Plate X., fig. 7).
(*e*) Typical (Plate IX., fig. 3).

(*a*) These fructifications arose from either medium or block after the seventh week. They varied in shape from round, cylindrical to phalloidal, and in diameter from $\frac{1}{4}''$ to $2''$. Papillations were generally present over the entire surface. Colours were initially Cartridge Buff to Pinkish Buff, giving way later to Cinnamon Buff to Chestnut tints. At this stage, they often split to reveal a striate appearance. On shrivelling they assumed Drab to Olive-Brown tints. It was observed that these fructifications were often produced in response to injury of the mycelium.

Saccardo (1888), in his description of *F. hepatica*, referred to the gasterosporous stage of the fungus as *Ceriomyces hepaticus* Saccardo, although he recognized that *Ceriomyces* Corda was a spurious genus, being a stage in the life history of certain Polyporaceae (1888, p. 385). Saccardo considered that the genus *Ptychogaster* Corda was synonymous with *Ceriomyces* Corda. Lloyd (1909) stated that the conidial stage of *F. hepatica* was the fungus *Ptychogaster hepaticus* which formed a solid compact ball and contained, instead of pores, filaments bearing abundant conidiospores. Davidson (1935) isolated *F. hepatica* from typical specimens of "Brown" Oak and obtained the *Ptychogaster* stage on ordinary culture media such as potato dextrose or malt-extract agar. Examination of a section of a young sterile fructification cultured from the Jarrah strain of *F. hepatica* showed no conidiospores present but merely a matrix of hyphal elements.

(*b*) *Solenia*-type fructifications obtained in culture were diminutive, narrow cup-shaped and crowded. Initially they appeared as Ivory Yellow papillated patches, on the block or medium after the fifth week and gave rise to a powdery appearance. Some of the papillae remained narrow and cup-shaped while others expanded somewhat at the orifices, which often had fimbriated edges. Hand-sections of the latter fructifications showed the presence of a small number of spores. Final colours varied from Cinnamon Buff to Chestnut.

(*c*) *Cyphella*-type fructifications were observed only on malt-agar slopes and were larger (up to 3 mm. in diameter), more expanded and somewhat less crowded than the *Solenia*-type fructifications. Colours were generally Tilleul Buff to Chestnut. Basidiospores were observed in hand sections, but spore deposits were not evident. Transition stages between *Solenia*- and *Cyphella*-type fructifications were observed.

(*d*) Near-typical fructifications were obtained from both media and blocks. These represented a more advanced stage in the evolution of the typical fructification, in that the open cup-shaped forms (*Cyphella*-type) gave way to tubes 2–5 x 0.2–0.5 mm. These tubes were disposed equilaterally, and sections showed the presence of basidiospores. No spore deposits were obtained. The development of these fructifications was similar to that for typical fructifications.

(*e*) The early development and coloration of typical fructifications were similar to that for the *Ceriomyces*-type already described, but the former soon became more shelf-like and developed comparatively short stipes after the fifteenth week. Immediately prior to hymenium formation, the papillated surface underneath the pileus became Pale Pinkish Cinnamon and the pileus began to flatten, and to expand laterally, while assuming Auburn to Wood Brown tints. This papillated surface developed into free, vertical cylindrical tubes Cartridge Buff in colour, 2–5 x 0.3–0.5 mm., and orifices often with fimbriated edges. The region of the fructification adjacent to the tubes was papillated, and graded into the tubes. The lower parts of the fructification were also papillated.

While tube-differentiation proceeded, the pileus rapidly expanded, flattened, and spore-discharge began. Spore-discharge took place over a period of about ten days, and resulted in the appearance of deposits at first Empire Yellow in colour, but which later darkened to Antimony Yellow. Spore deposits resembling miniature stalagmitic processes were obtained providing the cultures were not moved during spore-discharge. Typical fructifications have, as yet, been obtained in culture only from the surfaces of Jarrah blocks artificially inoculated by *F. hepatica*. The transverse surface seems to supply a more favorable sub-stratum for their production than the longitudinal.

Lloyd (1908) noticed that the normally white flesh of a young sporophore of *F. hepatica* quickly turned red on exposure to air. Buller (1931) observed that excretions of drops of water from the pileus of *F. hepatica* under moist conditions were coloured red. Injury to a sporophore of the Jarrah strain of *F. hepatica*, or its maturation, resulted in the production of a reddish colouration of the matrix, which was usually white. Further, reddish exudations have also been observed in cultures (as previously mentioned). These observations suggest the presence of an oxidase enzyme in the fungus.

Microscopic Appearance.

The submerged hyphae were 2–8μ wide, hyaline but often granular to vacuolate and contained numerous oil globules. Clamp connexions were abundant, simple, present on both narrow and wide hyphae. Branching was free and either acute-angled

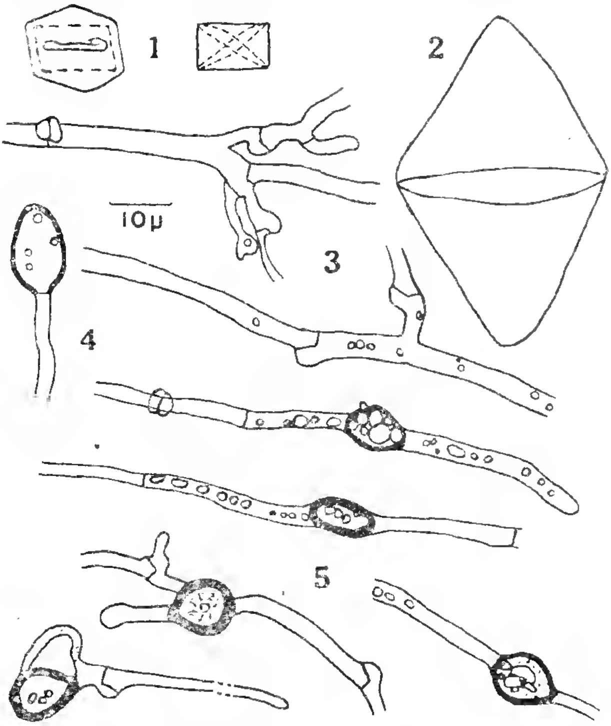


Fig. 1.—1. Crystals from young culture. 2. Crystal from old culture. 3. Clamp connections. 4 Terminal chlamydospore. 5. Intercalary chlamydospores.

or rectangular. Intercalary and terminal chlamydospores contained oil globules, and occurred in the submerged mycelium. They varied in shape from ovoid to sub-cylindrical and measured 2–7 x 10–13μ. Rhomboidal crystals of various sizes occurred in the medium. The aerial mycelium exhibited a similar microscopic appearance to that of the submerged mycelium (crystals being absent). Basidiospores produced on typical sporophores were hyaline, apiculated, varied in shape from ellipsoidal to subspheroidal, and measured 3–5 x 5–8μ. The external layer of hymenial tubes was composed of palisade-like hyphae.

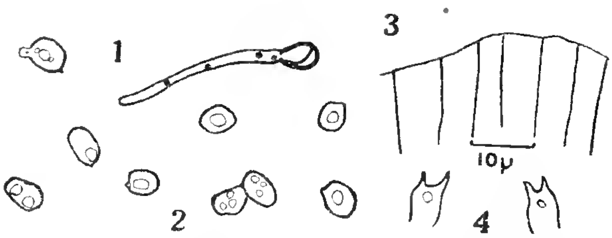


Fig. 2.—1. Germinating basidiospores. 2. Basidiospores. 3. External layer of hymenial tube, composed of palisade-like hyphae. 4. Basidia.

Discussion.

The literature revealed no work done on the relationship between *F. hepatica* and fungal rot in wood other than English Oak (*Quercus Robur* L.). Hartig (1894) stated that it produced a deep red brown decomposition in the wood of the oak. Braid in 1924 suggested that the presence of sporophores of *F. hepatica* might be related to hollow stag-headed Oaks. Latham and Armstrong in 1934 in testing the mechanical strength of " Brown " Oak found that wood containing irregular stains of brown discolouration produced by a fungus, later identified as *F. hepatica* (Cartwright, 1936), had the same density and strength as that of normal Oak, whereas Oak wood showing a uniform intensity of dark brown discolouration (produced by the fungus in the later stage of decay) was softer and more brittle, though the density was the same as that of sound timber. Davidson (1935) stated he had isolated *F. hepatica* without difficulty from typical specimens of " Brown " Oak.

Cartwright and Findlay in 1936 pointed out that in the early stages of infection of Oak by *F. hepatica*, a brown discolouration of heartwood is produced, and the colour of the wood improved so that it commands a higher price than normal Oak. This is the " Brown " Oak of the furniture trade. However, in the later stages of infection, the wood becomes deep reddish-brown, exhibits cubical cracking and gives the general indications of a heart rot. Davidson (1935), on the other hand, stated that in no instance did he find *F. hepatica* associated with any apparent disintegration of the wood which remained hard and heavy. From the foregoing, it appears that the fungus *F. hepatica* has little wood destroying properties in the early stages of infection, but in the later stages it brings about a definite heart rot in Oak.

Cartwright and Findlay, in their publication of 1936 also give some characteristics of the Oak fungus in culture. These are briefly compared with those of *F. hepatica* isolated from specimens of rot in Jarrah.

Oak Strain.	Jarrah Strain.
On 5 per cent. malt agar, forms soft woolly mat, at first creamy-white, and develops series of tints from Pale Pinkish Cinnamon to Straw Yellow, later Light Vinaceous Brown or Russet	On 2·7 per cent. malt agar, forms loose woolly mat, at first white to creamy-white, and develops series of tints from Cartridge Buff to Ochraceous Orange, later Ochraceous Tawny to Russet
Abnormal, phalloid fruit-bodies often formed, apex papillated	Ditto
	Typical fruit-bodies occasionally formed on surfaces of artifically inoculated blocks
Hyphae very variable in diameter	Ditto
Clamp connexions not numerous, particularly in submerged mycelium	Clamp connexions numerous, also in submerged mycelium
Prolific conidial production in some cultures	Conidia not observed
Intercalary and terminal chlamydospores occasionally seen	Intercalary and terminal chlamydospores frequently seen

Cartwright, in a private communication, writes that he has in press a paper to appear in the Transactions of the British Mycological Society on a re-investigation into "Brown" Oak caused by *F. hepatica* and to include a more detailed study of some aspects of its physiology.

It is probable, in view of the repeated isolation of *F. hepatica* from specimens of rot in Jarrah, that the fungus may be considered responsible for a heart rot in Jarrah. At present, experiments are in train in an attempt to ascertain the amount of decay produced in Jarrah blocks artificially inoculated with *F. hepatica.*

Summary.

1. The method used for isolation and culture of *F. hepatica* from specimens of rotted Jarrah as well as the artificial inoculation of sound Jarrah by *F. hepatica* is described.

2. Observations on the macroscopic and microscopic characteristics of *F. hepatica* are recorded. Types of fructifications obtained in culture are figured and described.

3. A comparison of the strain of *F. hepatica* from Oak and of *F. hepatica* from Jarrah is attempted.

4. The view is expressed that *F. hepatica* is responsible for a heart rot of Jarrah.

Acknowledgments.

The writer wishes to thank Associate-Professor E. I. McLennan of the Botanical Department, University of Melbourne, for her help and guidance throughout, and Professor S. M. Wadham of the School of Agriculture, University of Melbourne, for his many helpful suggestions.

Thanks are also due to Mr. I. H. Boas, of the Division of Forest Products of the Council for Scientific and Industrial Research, by whose suggestion this investigation was begun, and to Mr. S. L. Kessell of the West Australian Forests Department for having made available a grant, as well as specimens of rot in Jarrah.

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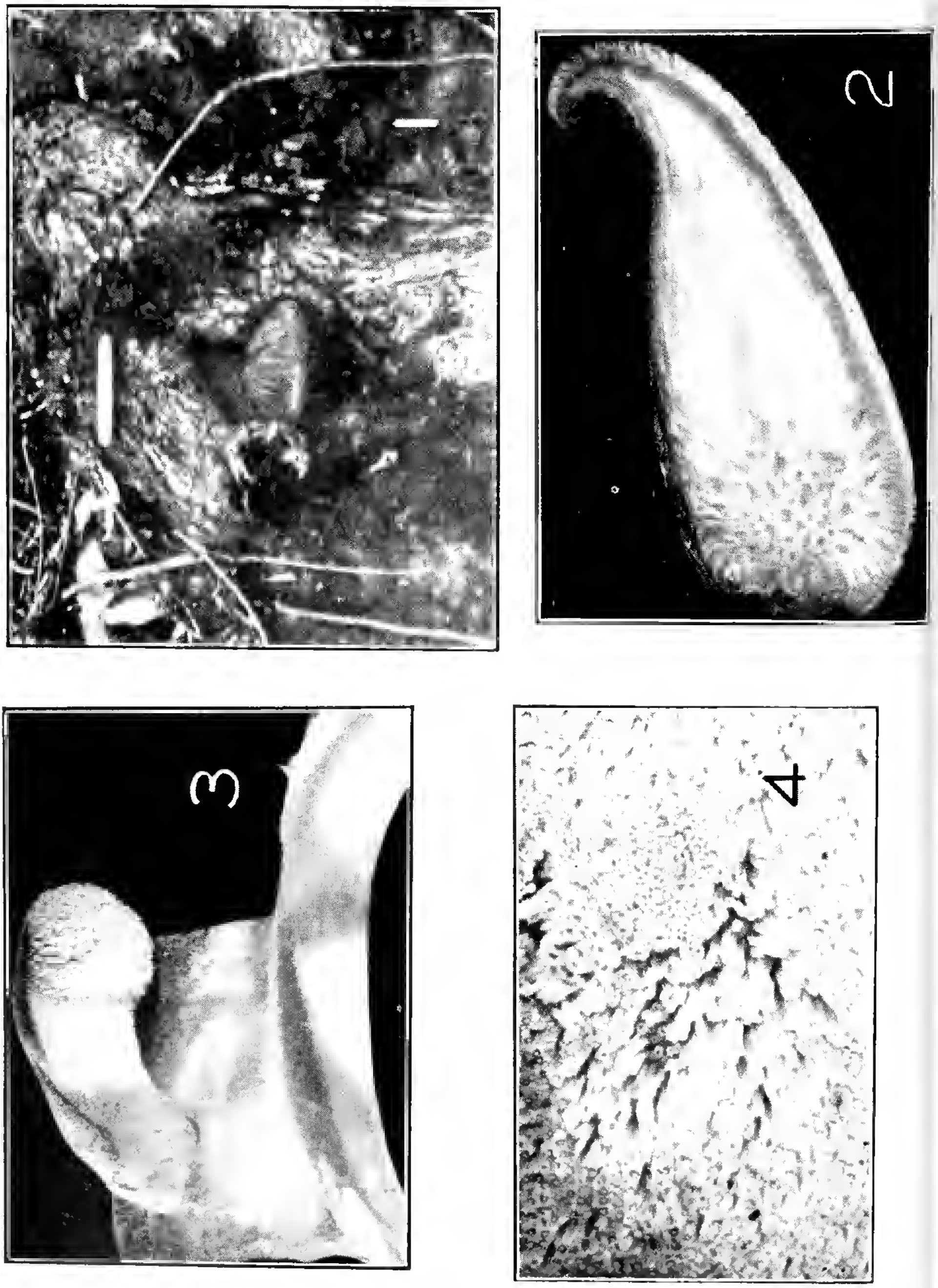
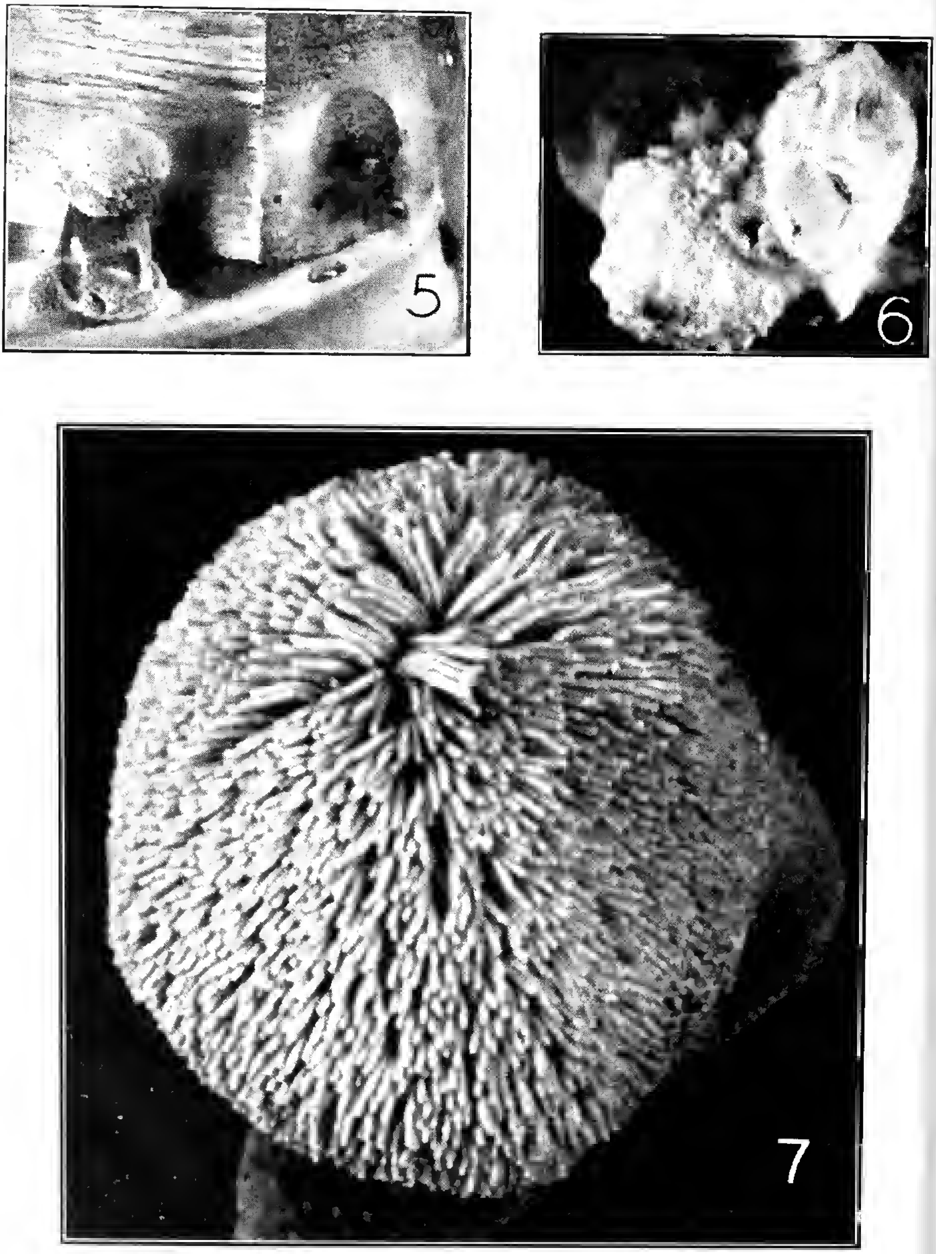


Fistulina hepatica.



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Explanation of Plates.

Plate IX.

Fig. 1.—*F. hepatica* growing on a woody root of a living *Eucalyptus* sp. at Healesville, Victoria. × ⅙.

Fig. 2.—Vertical section of *F. hepatica* (in fig. 1) showing hymenial layer composed of separate tubes. × 7/10.

Fig. 3.—Typical fructification of *F. hepatica* in artificial culture. Spore deposits. Culture 5 months old. × 1 7/10.

Fig. 4.—Hymenial surface of *F. hepatica* (in fig. 1) showing separate tubes. × 3½.

Plate X.

Fig. 5.—*Ceriomyces*-type fructifications of *F. hepatica* in artificial culture. The striate interior and papillations may be observed in one fructification. Exudations present on the mycelium. Culture 3 months old. × 1⅓.

Fig. 6.—*Cyphella*-type fructifications of *F. hepatica* on malt extract agar slope. Culture 7½ months old × 7.

Fig. 7.—Near typical fructification of *F. hepatica* cultured on sound Jarrah on malt extract agar. Free and separate hymenial tubes are present. Culture 4½ months old. × 6½.

[Proc. Roy. Soc. Victoria, 50 (N.S.), Pt. I., 1937.]

Art. IX.—*Notes on Australian Hydrozoa, with Descriptions of Two New Species.*

By Maurice Blackburn, M.Sc.

[Read 10th June, 1937; issued separately, 29th December, 1937.]

Prior to 1926, a considerable amount of work was done in connexion with the systematic review of the Australian Hydrozoa, but since that date very little has been recorded. During the past two years two new species, as well as new records and other interesting data, have been discovered and are dealt with here. Most of the species mentioned were found in Victorian waters. My thanks are due to Dr. O. W. Tiegs and Messrs. Stach and Tubb, of the University of Melbourne, for collected material; and to Mr. R. E. Trebilcock, and to Mr. John Clark, of the National Museum, Melbourne, for much valuable suggestion and assistance.

Types of new species are located in the National Museum, Melbourne.

Order: CALYPTOBLASTEA.

Family: SERTULARIIDAE.

Genus **Sertularia** Linné.

Sertularia unguiculata Busk, 1852.

Sertularia unguiculata Busk, Voy. "Rattlesnake," 1852, p. 394; *idem*, Bale, Cat. Aust. Hyd. Zooph., 1884, p. 76, pl. VI., figs. ix.-xii., pl. XIX., fig. viii.; *idem*, Bale, Proc. Roy. Soc. Vic., n.s., vi., 1893, p. 100; *idem*, Marktanner-Turneretscher, Ann. K. K. naturhist. Hofmus. Wien., v., 1890, p. 231; *idem*, Farquhar, Trans. N.Z. Inst., xxviii., 1896, p. 463; *idem*, Bale, Sci. Res. "Endeavor," ii., 1914, p. 16, *ibid.*, iii., 1915, p. 273.

Sertularia sp. Coughtrey, Ann. Mag. Nat. Hist. (4), xvii., 1876, p. 29, pl. III.

Thuiaria ambigua Thompson, Ann. Mag. Nat. Hist. (5), iii., 1879, p. 111, pl. XIX., figs. ii., ii*a*; *idem*, Kirchenpauer, Abh. Nat. Ver. Hamburg, viii., 1884, p. 25.

Desmoscyphus unguiculata (Busk), Allman, Journ. Linn. Soc., Zool., xix., 1885, p. 144, pl. XVII., figs. v.-vii.

Dynamena australis Kirchenpauer, Verhand. K.L.-C. Akad., xxxi., 1864, p. 11, figs. v. a-c.

Sertularia australis (Kirchenpauer), Thompson, Ann. Mag. Nat. Hist. (5), iii., 1879, p. 105, pl. XVII., figs. iv., iv.*a*; *idem*, Bale, Cat. Aust. Hyd. Zooph., 1884, p. 72, pl. VIII., figs. vii., viii.

Desmoscyphus pectinatus Allman, "Challenger" Report, Zool., xxiii., *Hydroida*, ii., 1888, p. 71, pl. XXXIV., figs. i-i*b*.

Sertularia challengeri Nutting, Amer. Hyd., ii., Sert., 1904, p. 54, pl. II., figs. i., ii.; *idem*, Billard, Ann. Sci. Nat. (9), xi., 1910, p. 19, fig. vi.

?*Thuiaria heteromorpha* Allman, Journ. Linn. Soc., Zool., xix., 1885, p. 147, pl. XX., figs. i.-v.

non *Sertularia australis* (Kirchenpauer), Bale, Trans. and Proc. Roy. Soc. Vic., xxiii, 1887, p. 93.

Amphisbetia unguiculata (Busk), Stechow, Zool. Jahrb., Syst, xlvii., 1923-24, p. 200.

Two points of interest regarding this very variable species are to be noted in two sets of specimens, comprising one from Balnarring and three from Flinders. These are the character of the stem-internodes and the form of the pinna-hydrothecae. The Balnarring specimen is a pinnate shoot 7 mm. long, the stem-internodes of which are all short except the proximal one, which is of the long or double variety; while of the forms from Flinders, which range from 10 to 15 mm. in length, one is similar to that just described and the other two have the proximal half to two-thirds of the stems formed entirely of long internodes, giving place distally to short ones. Regarding the form of the hydrothecae, those of the pinnae of all four specimens show a well-marked and constant tendency to gradual elevation along the length of the pinna. At the proximal end of each pinna the internodes are not very distinctly marked off, and the paired hydrothecae are twisted outwards and downwards; more distally, this twisted upper part of the hydrotheca moves, as it were, upwards, while, at the summit, each internode is distinctly marked off and bears a pair of more or less erect hydrothecae in close contact.

From the nature of the stem-internodes, it seems that the Balnarring form is extremely close to the small variety described by Bale, while the Flinders specimens represent a transition series between it and the large form, with the proportion of long internodes gradually increasing. The transition series of pinna-hydrothecae has not been described previously, although many pecularities of this species have been noted by other workers; it is, however, a regular and striking feature of these Westernport specimens.

Loc.—Balnarring, Flinders (Westernport). Previously recorded from many localities around the south-eastern coast of Australia, New Zealand, and Brazil.

Genus **Sertularella** Gray.

Sertularella robusta Coughtrey, 1875.

(Fig. 1.)

Sertularia simplex Hutton Coughtrey, Trans. N.Z. Inst., vii., 1874, p. 283 (pars), pl. XX., fig. x

Sertularella simplex (Hutton), Coughtrey, Trans. N.Z. Inst., viii., 1875, p. 300 (pars); *idem*, Coughtrey, Ann. Mag. Nat. Hist. (4), xvii., 1876, p. 27 (pars).

Sertularella robusta Coughtrey, Trans. N.Z. Inst., viii., 1875, p. 300; *idem*, Coughtrey, Ann. Mag. Nat. Hist. (4), xvii., 1876, p. 27; *idem*, Farquhar, Trans. N.Z. Inst., xxviii., 1896, p. 464; *idem*, Bale, Trans. N.Z. Inst., lv., 1924, p. 240; *idem*, Trebilcock, Proc. Roy. Soc. Vic., n.s., xli., 1928, p. 16, pl. VI., figs. iii.-v.; *idem*, Blackburn, McCoy Soc. Res., in Proc. Roy. Soc. Vic., n.s., xlix., 1937, p. 367.

? *Sertularella* sp. Thompson, Ann. Mag. Nat. Hist. (5), iii., 1879, p. 101.

? *Sertularella microgona* von Lendenfeld, Proc. Linn. Soc. N.S.W., ix., 1884, p. 416, pl. VII., figs. i.-iii.; *idem*, Bale, Proc. Linn. Soc. N.S.W.; (2), iii., 1888, p. 763, pl. XVI., fig. viii.

Sertularella angulosa Bale, Proc. Roy, Soc. Vic., n.s., vi., 1893, p. 102, pl. IV., fig. vi.

non *Sertularella tenella* Alder, Hartlaub, Zool. Jahrb., xiv., 1901, p. 370.

Two specimens, one from Pt. Leo, Westernport, and the other from Lady Julia Percy Island, present such a close resemblance to Coughtrey's and Trebilcock's descriptions and figures of *S. robusta* that they must be regarded as the first records of this form outside New Zealand waters. Actually since *S. angulosa* Bale has been definitely referred to this species by Trebilcock, and since the locality for this form, although not given by Bale, was presumably Australian, the range of the species must already be considered as probably extending to Australia. *S. angulosa*, however, has a strongly zig-zagged stem whereas these specimens are almost straight-stemmed and in every way comparable with the normal New Zealand form: the hydrothecae range in length from 0.4 to 0.5 mm., and are therefore to be assigned to the category of "small forms" as defined by Trebilcock.

Hartlaub refers not only *S. robusta* and *S. angulosa* but also *S. microgona* von Lendenfeld to the single species *S. tenella* Alder; while this is not accepted by Bale, it seems that the strong similarity between these forms, including *S. microgona*, should permit their being referred to the same species, i.e. *S. robusta*. If *S. microgona* is to be so admitted the known range would include Port Phillip. Failing this, however, and in view of the doubtful locality for *S. angulosa*, these two specimens are the first definite Australian records; in any case they extend considerably the range of the normal variety.

Loc.—Pt. Leo (Westernport), and Lady Julia Percy Island. Previously recorded from New Zealand; and doubtfully from Australia.

Genus **Dynamena** Lamouroux.

Dynamena crisiodes Lamouroux, 1824.

(Fig. 3.)

Dynamena crisiodes Lamouroux, Des. Polyp. Flex. in Quoy et Gaimard, Voy. l'Uranie et la Physicienne, Zool., 1824, p. 613, pl. XC., figs. xi., xii.; *idem*, Billard, Hyd. Siboga-Exped. viii., Synthecidae et Sertularidae, 1925, p. 181, pl. VII., fig. xxi., text-figs. xxxvi.-xxxvii.; *idem*, Briggs and Gardner, Brit. Mus. Great Barrier Reef Exped. Sci. Reports, Hydroida, iv., vi., 1931, p. 190.

Dynamena tubuliformis Marktanner-Turneretscher, Ann. K. K. naturhist. Hofmus. Wien., v. 1890, p. 238, pl. IV., fig. x.; *idem,* Stechow, S.B. Ges. Morph. u. Physiol. München, xxxi., 1919, p. 23; *idem,* Stechow, Journ. Coll. Sci. Imp. Univ. Tokyo, xliv., viii., 1923, p. 12; *idem,* Stechow, Zool. Jahrb., Syst., xlvii., 1923-24, p. 163.

Thuiaria tubuliformis (Marktanner-Turneretscher), Nutting, Amer. Hyd., ii., Sert., 1904, p. 70, pl. XI., figs. i.-viii.; *idem,* Billard, Bull. Mus. Hist. Nat., x., 1904, p. 482, text-fig. ii.; *idem,* Billard, Bull. Mus. Hist. Nat., xiii., 1907, p. 275; *idem,* Clarke, Mem. Mus. Comp. Zool. Harvard, xxxv., 1907, p. 14, pl. IX., figs. i.-v.; *idem,* Warren, Ann. Natal Govt. Mus., i., iii., 1908, p. 314, fig. xii.; *idem,* Thornely, Journ. Linn. Soc., Zool., xxxi., 1908, p. 83; *idem,* Ritchie, Proc. Zool. Soc., 1910, p. 832; *idem,* Jaderholm, Redogörelse f. Norrköpings H. Allm. Läroverk Läsaret, 1916-17, p. 14; *idem,* Briggs, Rec. Aust. Mus., xii., iii., 1918, p. 38.

Sertularia tubuliformis (Marktanner-Turneretscher), Levinsen, Vidd. Medd. f. den natur. Foren. Kbhvn., lxiv., 1913, p. 298; *idem,* Broch, Beitrage zur Kenntnis der Meeresfauna West-Afrikas, hrsgeg. von W. Michaelsen, Hydrozoa, 1914, p. 34.

Sertularia ?tubuliformis (Marktanner-Turneretscher), Broch, Danish Ingolf Exped., v., vii., 1918, p. 132, text-fig. lxxi.; *idem,* Jaderholm, Arkiv. f. Zool., xii., ix., 1919, p. 15.

Sertularia vegae (Thompson), Pictet, Rev. Suisse Zool., i., 1893, p. 44, ii., figs. xxxvii.-xxxviii.

non *Thuiaria vegae* Thompson, Vega Exped. Vetenskap. Arbeten, iv., 1887, p. 397, pl. XX., figs. xviii., xx.-xxii.

The discovery of a single specimen of this species from St. Vincent's Gulf extends the range to the southern as well as the eastern coast of Australia. The colony is about 20 mm. in height, and agrees closely with the accounts and figures furnished by Pictet; opposite instead of alternate branches arise from the proximal stem-internode.

Loc.—St. Vincent's Gulf, South Australia. Previously recorded from various localities on the eastern coast of Australia, Amboyna, Christmas Island, Red Sea, Suez, Natal, St. Thomas, Bahia, Florida, Bahamas, and the Gulf of Panama.

Family: SYNTHECIIDAE.

Genus **Hincksella** Billard.

Hincksella cylindrica (Bale, 1888).

(Fig. 2.)

Sertularella cylindrica Bale, Proc. Linn. Soc. N.S.W. (2), iii., 1888, p. 765, pl. XVI., fig. vii.

Synthecium cylindricum (Bale), Nutting, Amer. Hyd., ii., Sert., 1904, p. 136 (pars), pl. XLI., fig. vii.; *idem,* Stechow, Zool. Jahrb., Syst., xlvii., 1923-24, p. 150 (pars).

Hincksella cylindrica (Bale), Billard, Arch. Zool. exp. gen., lvii., Notes et Revue, 1918, p. 22.

A shoot of this form from Westernport was observed to bear a very curious type of gonosome. As no gonosome has been described previously for this species, the following note is submitted.

Gonosome, a more or less spherical envelope of perisarc, about 0.8 mm. in diameter, containing generative products (nature indeterminable) borne on an undulating peduncle arising from the stem at the base of the proximal hydrotheca; no apparent orifice of any kind.

This last point represents a feature which is certainly very unusual, and indeed possibly unique, but as far as can be seen from the mounted specimen there is no orifice at all in this form; the only other gonosome collected is a rather crumpled unmounted specimen which, although closely studied from all sides, appears to be completely closed.

Nutting regarded this species as synonymous with *Sertularella halecina* Torrey, and referred it to the genus *Synthecium* on the nature of the gonosome as described by that author. In this he was followed by Stechow for apparently the same reason. The discovery of this new gonosome however indicates that the Australian form is in fact a *Hincksella* and in no way related to Torrey's species, which becomes therefore *Synthecium halecinum.*

Loc.—Westernport, growing on the Ascidian *Pyura crinitistellata* Herdman. Previously recorded from Port Jackson.

Family: HALECIIDAE.

Genus **Halecium** Oken.

Halecium buchananae, sp. nov.

(Figs. 4, 5.)

Hydrorhiza creeping, thick, somewhat wrinkled; stems stout, generally about 1 mm. in height, divided into segments, slightly branched, the number of branches never exceeding two; segments often rather irregular in form and succession, but generally more or less cylindrical, with a tendency to become slightly constricted at mid-height; hydrophores deep, tumbler-shaped, borne at summits of stems and/or branches; branches short, terminating in hydrophores, in rare cases tending to bear additional hydrophores along their lengths. Hydranths brown, non-retractile, very large, each possessing a single circlet of from 15 to 20 short filiform tentacles. Gonosome unknown.

This curious form was found in considerable numbers upon a single fragment of seaweed washed up at Balnarring; generally, the form of the hydrophyton is as figured, consisting of a short pedicillate stem with a terminal hydrophore and giving off near the summit a single short branch also with a terminal hydrophore. In one example, however, the stem is forked at the summit, each branch with a terminal hydrophore and one bearing an additional hydrophore along its length; this specimen is nearly twice the usual height, the stem of the upper part apparently having been regenerated, arising from within a hydrophore a little below mid-height.

This species bears some resemblance to *H. robustum* Pieper, from which it differs mainly in the uniformly small size and sparseness of branches.

Loc.—Balnarring (Westernport).

Family: CAMPANULARIIDAE.

Genus **Obelia** Peron et Lesueuer.

Obelia australis von Lendenfeld, 1884.

(Fig. 6.)

Obelia australis von Lendenfeld, Proc. Linn. Soc. N.S.W., ix., 1884, pp. 604, 920, pl. XLIII., figs. xix.-xxii.; *idem*, Bale, Proc. Linn. Soc. N.S.W., (2), iii., 1888, p. 753, pl. XII, figs. i., ii.; *idem*, Farquhar, Trans. N.Z. Inst, xxviii., 1896, p. 460; *idem*, Hartlaub, Zool. Jahrb., Syst., xiv., 1901, p. 367; *idem*, Bale, Trans. N.Z. Inst., lv., 1924, p. 231; *idem*, Trebilcock, Proc. Roy. Soc. Vic, n.s., xli., 1928, p. 2.

Obelia dichotoma (Linné), Hartlaub, Zool. Jahrb., Syst., Suppl.-bd., vi., 1905, p. 580.

This form, represented by a single specimen in the Zoological Museum of the University of Melbourne, appears definitely referable to *O. australis*. The colony, which is thick and bushy and about 5 cm. in height, was found growing upon an isopod attached to the fin of a shark caught in Port Phillip Bay. In spite of its poor condition and the absence of gonangia the identification, based upon comparison with specimens from the type locality, appears quite certain.

This Port Phillip specimen is more robust than most specimens of *O. australis*, and in the manner of its branching and the relatively shorter length of the hydrotheca-pedicels suggests a very close relationship with *O. dichotoma* Linné. It is the author's opinion that closer examination of the two species would indicate, as Hartlaub suggested, that they are synonymous; at present it seems that the only outstanding difference between the two is the character of the diaphragm of the hydrotheca, which is horizontal in *O. dichotoma* but definitely oblique in *O. australis*; pending such examination, however, von Lendenfeld's specific name is retained.

In his original description of this species von Lendenfeld gave as the locality the eastern coast of New Zealand, from which region it has since been recorded by other authors. In another part of his monograph (p. 920) this author however says: "I have described this species from the polyp-colonies and the young larvae which I obtained in Port Jackson." It is therefore somewhat doubtful whether *O. australis* has hitherto been found in Australian waters or not; but the occurrence of this colony definitely extends the range to Victoria.

Loc.—Port Phillip Bay. Previously recorded from New Zealand, St. Paul Island, and doubtfully from Port Jackson.

Genus **Clytia** Lamouroux.

Clytia delicatula (Thornely, 1900).

(Fig. 7.)

Clytia sp. Inaba, Zool. Mag. Tokyo, 1890, figs. xxxiv.-xxxv.

Obelia delicatula Thornely, Willey's Zoo. Results, iv., 1900, p. 453, pl. XLIV., fig. vii.

Campanularia delicatula (Thornely), Jäderholm, Bih. Svensk. Vetensk. Akad. Handl., xxviii., iv., xii., 1902, p. 3.

Clytia delicatula (Thornely), Stechow, Abh. Bayer Akad. Wiss., iii., Suppl.-bd., ii., 1913, p. 65, figs. xx., xxi.; *idem*, Stechow, Zool. Jahrb., Syst., xlvii., 1923, p. 109; *idem*, Briggs and Gardner, Brit. Mus. Great Barrier Reef Expedition Sci. Reports, iv., vi., Hydroida, 1931, p. 187, text-fig. 1.

Briggs and Gardner recorded this form with some hesitation at Low Island. Recently specimens were collected at Mallacoota Inlet, thereby confirming the occurrence of the species in Australian waters. The stems of these specimens are simple, very slender, about 4 mm. in height, with 9 or 10 annulations at the base, 2 or 3 just below the hydrothecae, and occasionally others to the number of 3 at about mid-height. About 10 prominent crenations are ranged along the margin of each hydrotheca. Gonangia are absent.

Loc.—Mallacoota Inlet, Victoria. Previously recorded from Low Island (Great Barrier Reef), New Britain, and Japan.

Order: GYMNOBLASTEA.

Family: PENNARIIDAE.

Genus **Pennaria** Goldfuss.

Pennaria wilsoni Bale, 1913.

(Figs. 8, 9.)

Halocordyle australis Bale, Proc. Roy. Soc. Vic., n.s., vi., 1893, p. 94.

Pennaria wilsoni Bale, Proc. Roy. Soc. Vic., n.s., xxvi., 1913, p. 116.

This species was originally described, without figures, from small mounted portions which had been dredged in Port Phillip Bay. Since it has now been collected abundantly in shallow water near Cowes, it is possible to figure this species and make some necessary additions to the description.

The number of filiform tentacles was stated by Bale to be between 8 and 10; here the range is from 6 to 9. The superior capitate tentacles, as he says, in mature specimens are either 4 or 5 in number. Gonophores, when present, 1 or 2 in number, exact structure indeterminable from mounted specimens. Hydranths red in colour. Length of hydranth pedicels, from 1.5 to 3 mm.

The specimens from Cowes attain an average height of 5 or 6 cm. They are completely monosiphonic, with the main branches arising alternately at more or less regular intervals. As in Bale's specimens the hydranth-pedicels differ in their disposition from most other species of *Pennaria* in being biserially arranged and more or less alternately disposed along the branches.

Loc.—Cowes (Westernport). Previously recorded from Port Phillip Bay.

Family: BOUGAINVILLIDAE.

Genus **Bimeria** Wright.

BIMERIA AUSTRALIS sp. nov.

(Figs. 10-12.)

Stem monosiphonic, arising from a thick creeping hydrorhiza, and giving rise to hydranths (about 3 to 5) in number, at the ends of fairly long branches. Branches a little thinner than the stem, generally forming a fairly wide angle with it. Stems and branches wrinkled, generally very strongly. Hydranths each possessing a single circlet of about 10 or 11 filiform tentacles, the perisarc of the stem extending upwards to sheath each tentacle for more than half its length. Gonophores fixed sporosacs, each encased in a perisarcal envelope, connected by short peduncles to the stem or branches; the radial canals at the proximal end of each gonophore rise upwards and around the more distal globular generative mass to the region of its equator.

As appears to be the case with most species of *Bimeria*, the actual extent of the perisarc upon the tentacles is difficult to determine accurately; it definitely rises to more than half the length of each tentacle, and in many cases appears to envelop it completely.

This form is so far represented only by the single occurrence at Cowes of a luxuriant growth on the stem of a colony of *Pennaria wilsoni*, and the seaweed to which it was attached. The average height of the shoots is about 5 mm. In this size, as well as in the number of tentacles, the species appears to approximate most closely to *B. pusilla* Fraser; but apart from the characteristic wrinkling of the stem and branches, the nature of the branching and the extent of the perisarc upon the hydranths are quite distinct features.

Loc.—Cowes (Westernport).

Genus ?**Wrightia** Allman.

?Wrightia sp.

(Figs. 13, 14.)

These specimens were obtained from Mallacoota Inlet; they are in rather poor condition, and exhibit no gonophores whatever. For this reason it is impossible to assign them to either the genus *Wrightia* or the genus *Perigonimus*, both of which occur typically as simple stems arising from a more or less undifferentiated hydrorhiza. The extreme slenderness of the stems, however, appears rather more comparable with the descriptions and figures of *Wrightia arenosa* Alder, the only recorded species of this genus, than with any species of *Perigonimus*. The gonophore will require to be obtained and studied before any more definite diagnosis can be made.

Stems slender, unbranched, about 2 mm. in height, arising from a simple tubular hydrorhiza; hydranths clavate, each with a subconical hypostome and a single circlet of 10 or 11 slender filiform tentacles. Gonophores not present.

Family: CLAVIDAE.

Genus **Turritopsis** McCrady.

Turritopsis dohrni (Weismann, 1883).

(Figs. 15, 16.)

Dendroclava dohrni Weismann, Entstehung d. Sexualzellen b.d. Hydromedusen, Jena, 1883, pp. 26, 215, pl. XII., figs. vi.-ix.; *idem*, du Plessis, Recueil Zool. Suisse, iv., 1888, p. 531; *idem*, Zoja, Boll. Cs. Pavia., Anno, 13, N. iii.-iv., 1891; *idem*, Pictet, Revue Suisse Zool., i., 1893, p. 6, pl. I., figs. i., ii., pl. III., fig. liv.; *idem*, Goette, Zeits. f. wiss. Zool., lxxxvii., 1907, p. 42, pl. IV., figs. lxxviii.-lxxxiv.; *idem*, Neppi, Pub. Staz. Zool. Napoli, ii., i., 1917, p. 42, fig. xiv.

Cordylophora dohrni (Weismann), Motz-Kossowska, Arch. Zool. exp. gen., (4), iii., 1905, p. 63.

Turritopsis dohrni (Weismann), Stechow, Zool. Jahrb., Syst., xlvii., 1923-24, p. 53.

?*Turritopsis nutricula* McCrady, Brooks, Mem. Boston Soc. Nat. Hist., iii., 1886, p. 387, pl. I.; *idem*, Mayer, Medusae of the World, 1910, p. 143, text-fig. lxxvi.; *idem*, Fraser, Washington, D.C. Dept. Comm. Lab. Bull. Bur. Fish., xxx., 1912, p. 345, text-fig. i.; *idem*, Stechow, Zool. Jahrb., Syst., xlii., 1919, p. 12.

These polyps from Westernport at first sight appear to belong to the genus *Tubiclava* but when in one of the mounted specimens a definite polysiphonic structure was found it became obvious that a further diagnosis must be sought. This specimen, which also bore gonophores, was dredged off Tooradin, whereas the other from the Pt. Leo reef was only very slightly branched, with no suggestion of polysiphonism, and bore no gonophores;

the very characteristic undulations of the internal perisarc, however, as well as the character of the hydranths, made it clear that they both belonged to the same species. This double wall of perisarc, with the internal layer strongly undulated, is noted by Zoja in his specimens from Naples, while Pictet and Goette draw special attention to the polysiphonism. Other characteristic features are the conspicuous rose-red hydranths, which are cylindrical in extension and clavate in contraction, and each bearing about 12 to 18 filiform tentacles scattered over the whole surface; and the gonophores, springing from below the hydranths in the number of 2 to 5, each attached by a short peduncle and encased in a more or less loose envelope of perisarc. The actual nature of the gonophores is not apparent in the mounted specimens, but there are indications that they are medusoid in character, as described by Weismann, Pictet, Goette, Zoja and Neppi. The polysiphonic character in the Tooradin specimen is almost exactly as described by Pictet, except that while he found 3 or 4 stem-fasciculations enclosed in a common third layer of perisarc there appears in this case to be only 2. The general resemblance is thus very striking; and these Westernport occurrences add another species to the Australian list.

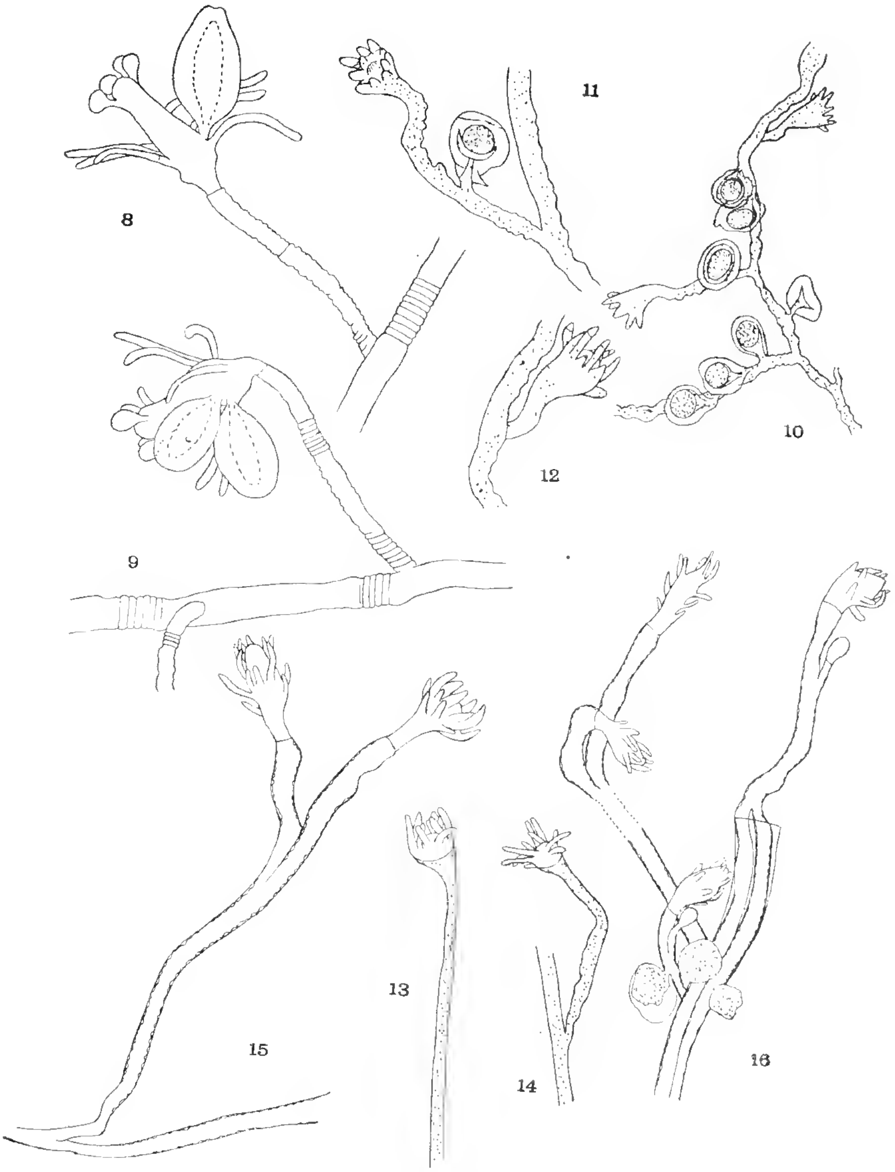
Neppi and Stechow appear to regard the polyp of *Turritopsis nutricula* McCrady as belonging to this species. In Brooks' figure there is no indication of internal perisarcal undulation or of fasciculation, though in other respects it strongly resembles *T. dohrni.*

Loc.—Tooradin, Pt. Leo (Westernport). Previously recorded from the Mediterranean, Amboyna, and also Carolina if *T. nutricula* is admitted.

Addendum.

In a former publication (Proc. Roy. Soc. Vic., n.s., xlix., 1937, p. 365, fig. i.) the present author described a Hydrozoan species as new under the name of *Ophiodissa fragilis;* this he has since found to be identical with *Phylactotheca armata* Stechow, 1924 (Zool. Anz., lix., p. 59). It is intended to include a further discussion upon this species in a paper now in preparation.

Figs. 1-7. Fig. 1, *Sertularella robusta* Coughtrey, (× 15); Fig. 2, *Hincksella cylindrica* Bale, (× 15); Fig. 3, *Dynamena crisiodes* Lamouroux, (× 15); Figs. 4, 5, *Halecium buchananae*, sp. nov., (× 15); Fig. 6, *Obelia australis* von Lendenfeld, (× 15); Fig. 7, *Clytia delicatula* Thornley, (× 15).



Figs. 8-16. Figs. 8, 9, *Pennaria wilsoni* Bale, (× 15); Fig. 10, *Bimeria australis*, sp. nov., (× 15); Figs. 11, 12, *Bimeria australis*, sp. nov., (× 30); Figs, 13, 14, ?*Wrightia* sp. (× 15); Figs. 15, 16, *Turritopsis dohrni* Weismann, (× 15).

[Proc. Roy. Soc. Victoria, **50**, Pt. 1., 1937.]

Art. X.—*Fossil Wood from Upper Devonian Rocks at Mansfield, Victoria.*

By ISABEL C. COOKSON, D.Sc.

[Read 10th June, 1937; issued separately, 29th December, 1937.]

Introduction.

Amongst a collection of plant-fragments made by Mr. H. B. Hauser, M.Sc., from sediments of the South Blue Range, Mansfield, Victoria, is a well-preserved sample of fossil wood. Since nothing is known of the secondary woods of the precarboniferous rocks of Australia, a brief description of the structure of this specimen appears to be justified. My thanks are due to Mr. Hauser for the opportunity of examining and deseribing his specimen.

The following note as to the age of the plant-containing beds was kindly provided by Mr. Hauser. "About 2 miles to the south of Mansfield, a line of hills stretches in a south-easterly direction for about 6 miles to the Delatite River. This range of hills, called the South Blue Range, was originally marked on the Geological Survey maps as Lower Carboniferous and was thought to be the western limit of the Lower Carboniferous basin at Mansfield.

"The rocks in the range consist of shales, sandstones, breccias, and conglomerates, dipping in a north-easterly direction at an angle of about 45°, thus forming a hogback with a north-west and south-west trend. The sedimentary series is accompanied by a suite of acid volcanic rocks.

"The dips given by the survey officers was 5° to the north-east, and this conforms to the dips of the Lower Carboniferous in the Mansfield district, but investigation has proved that the rocks have a much higher dip, and the igneous rocks are not pre-Lower Carboniferous.

"At the northern end of the range the sediments are fossiliferous. The heavy conglomerates which are the highest beds in the area, rest on a series of shales which contain plant remains which are too fragmental for determination. These clays in turn rest on the igneous rocks. Immediately underneath the igneous rocks is a series of clayey breccias and sandstones which contain plant and fish remains. The fish remains have been determined by Dr. Hills as *Bothriolepis* and *Phyllolepis*, thus proving the sediments to be of an age not later than Upper Devonian. The plant remains provided were found under the sandstone bearing fish remains."

The specimen (M.U.G.D. No. 1630) is in a coarse-grained sandstone. It represents portion only of a woody cylinder and no tissues external to the wood are preserved. The greater part of the central area including the region of the primary wood is missing. It is preserved as a partial petrifaction, the walls of the elements composing it having more or less retained their original character while their cavities are filled with a fine matrix. The result is a petrified wood which is soft and extremely porous. The diameter of the sample is 2.5 cm. and its length is 5 cm.

The study of its structure has been made entirely from film-pulls obtained from ground and slightly polished surfaces. It was advantageous to give a transverse surface a short preliminary treatment with a dilute solution of hydrochloric acid, before the application of the cellulose acetate solution. With a longitudinal surface either radial or tangential, the pull usually removed sufficient organic material without previous etching. The film-pulls were subsequently treated with hydrofluoric acid to remove the matrix, and after washing in water and alcohol were dehydrated in turpineol and mounted in Canada Balsam.

Description of Specimen.

Pulls taken from transversely ground surfaces (Plate XI., fig. 1) show that the wood consists of narrow wedges of radially arranged tracheides which are separated by medullary rays. The tracheides are usually rectangular with their greater extension in the radial direction, but may be square. Frequently they are five or six sided but some are almost triangular, and when situated on the edge of the tracheidal wedge the base abuts on a medullary ray cell. The radial walls of the tracheides vary in length from 24-76μ and the tangential from 24-56μ. The tracheidal walls are from 6-12μ in thickness. Often they are incompletely preserved, the middle lamella being most generally affected by the processes of decay. The secondary wall also may be partially or completely decomposed, leaving only the tertiary layer to show the cell outlines. The tracheides are pitted on all walls (Plate XI., fig. 3), but structural details of the pits cannot be determined from transverse pulls. The medullary rays are prominent and extend across the pull. They are composed of 1-4 rows of radially elongated parenchymatous cells. There is no evidence of the occurrence of annual rings.

A portion of a pull from a surface ground in the radial longitudinal plane is shown in Plate XI., fig. 2. The radial walls seen in surface view are completely and uniformly covered with bordered pits. These are arranged in three to five alternating rows and, owing to their crowded position, have an hexagonal outline. The pits are elongated at right angles to the length of the tracheides, and have a width of from 12-16μ and a depth of from 8-10μ. The pores of the pits are elongated in the same direction and are more or less obliquely placed. In the majority of cases the complete wall between two tracheides is not preserved so that the relationship of the pit openings of adjacent tracheides to one another cannot be determined. Such a wall shows in surface view a number of oval pores all inclined in the same direction. More rarely, a complete wall is similarly viewed when the pores are seen to cross one another (Plate XI., fig. 7). The complete length of an individual tracheide has not been determined but as shown in Plate XI., fig. 2, the ends of the tracheides of one radial row all reach the same level. The medullary rays run at right angles to the tracheides and have a considerable depth. The individual ray cells are brick-shaped and fairly thin walled. They measure from 120-224μ in a radial direction and a single cell covers from 2-6 tracheides. As far as can be ascertained there is no distinct structural differentiation of any particular region of a medullary ray. The end walls are either curved, oblique, or quite straight. The pitting of the ray cells in relationship to the tracheides has not been seen.

A small area of a pull taken from a surface ground in the tangential plane is shown in Plate XI., fig. 4. The tangential walls of the tracheides are here seen in surface view, and appear to be similarly pitted to the radial walls. The critical evidence on this point is shown in Plate XI., fig. 5, where portion of a tangential wall of a tracheide which is adjacent to a medullary ray viewed in true cross section is enlarged 400 diameters. The wall is uniformly covered with oval pits which are indistinguishable from those of the radial walls. The medullary rays vary both in depth and width. They range from 1-5 cells in width and from 1-32 cells in depth. The preservation of the wood is extremely unequal, and for this reason the deeper medullary rays are almost always incompletely shown on the pull. The vertical depth given is therefore only approximate, and it is probable that some rays have an even greater depth than it suggests. The majority of rays are from 2-3 cells wide.

Brown spherical thin-walled vesicles which range in diameter from 12.5-55μ are frequently associated with the cells of the medullary rays (Plate XI., figs. 8, 9). They are seen in pulls taken from all planes, but have been most abundant in the tangential pulls. They mainly appear to lie in the cavities of the cells. In one instance (Plate XI., fig. 8), delicate brown hyphae, 2.5μ broad, occur in the same cell as a number of small vesicles, but their actual attachment to any of the vesicles cannot be seen. In both size and form the latter approximate closely to some of the fungal vesicles or thin-walled resting spores of *Palaeomyces* sp. (Kidston and Lang, 1921) found in the Rhynie chert. The association of hyphae and vesicles in the present sample suggests that the vesicles were possibly organs of a fungus which was perhaps responsible for the decay of the wood before fossilization.

Conclusion.

The sample of wood from Upper Devonian rocks at Mansfield consists of tracheides unmixed with parenchyma other than the medullary rays; its tracheides are uniformly pitted on all walls, the pits being hexagonal in form with apertures tangentially extended and obliquely placed. The medullary rays are numerous, usually 2-3 cells broad and often attain a considerable depth.

In the absence of any information regarding the position and nature of the primary wood not even generic identification of the specimen is possible. Only generalized comparisons with other examples of secondary woods from rocks of closely approximating geological periods can be made.

The occurrence of pits on all the tracheidal walls is a characteristic feature of only a few types of wood, and it is these which naturally suggest themselves for comparison. The most clearly known stem with wood of this type is *Palaeopitys Milleri,* McNab (Kidston and Lang, 1923) from the Middle Old Red Sandstone of Scotland. In this species the wood is composed of tracheides with multiseriate bordered pits on all walls, the pits being oval with transversely extended pores which coincide with one another. In two of these features there is close agreement with the tracheides of the Mansfield specimen, but these can be distinguished by the more oblique position of the pits and the crossing of their apertures. The medullary rays of *P. Milleri* are not as closely comparable as are the tracheides. They are distinctly broader in the Victorian wood, the majority being 2-3 cells broad, whereas in *P. Milleri* they are usually one cell broad except possibly in the outer zones where, according to Kidston and Lang, there "are indications but not conclusive evidence that some of the rays in the outer part of the wood were 2-4 cells broad." In spite of the more parenchymatous composition of the Victorian sample it can be considered as of the same general type of wood as that of *P. Milleri.*

An almost equally close comparison can be made with the wood of *Aneurophyton germanicum* from the Middle Devonian of Germany which has been described by Krausel and Weyland (1923, 1926). The tracheides of this wood have multiseriate bordered pits on all their walls and the medullary rays are uniseriate becoming biseriate in the outer zones of the wood. Here, as in the case of *Palaeopitys,* it is the size of the medullary rays which chiefly distinguishes the wood of *Aneurophyton* from the Victorian wood.

An interesting comparison can be made with the "secondary" wood of *Schizopodium Davidi* Harris (1929) an Australian genus from the Middle Devonian of Queensland. In *Schizopodium* the tracheides composing the so-called "secondary" wood agree with those of the Mansfield specimen in having multiseriate bordered pits with obliquely placed crossed pits on both radial and tangential walls. The medullary rays, however, are quite distinct for in *Schizopodium* they are tracheidal whereas in the Victorian specimen they are purely parenchymatous.

A specimen of secondary wood which is very similar to the Mansfield wood has been described by Walkom (1928) from the Lower Carboniferous (Kuttung series) of New South Wales under the name *Pitys? Sussmilchi.* The medullary rays agree in being numerous and 1-4 seriate and the relative proportions of parenchymatous to tracheidal tissue appear practically identical in both forms. The chief distinction between them is the typical restriction of the pits to the radial walls in *Pitys?* although Walkom mentions their occasional occurrence on the tangential walls. Since Walkom does not specify the position of the pit openings it appears likely that the elongated pores of adjacent pits coincided with one another. If this is so, it provides another variance between the two types of tracheides.

In the possession of crossed pits the Upper Devonian wood from Mansfield agrees with the wood of *Dadoxylon*, species of which have been recorded from the Upper and Middle Devonian of America (Penhallow, 1900) as well as the Middle Devonian of Britain (Lang, 1929). In *Dadoxylon* however, the pits are definitely restricted to the radial walls of the tracheides and the shorter and narrower medullary rays are an additional distinction.

It will be seen from the above comparisons that the Victorian wood does not agree exactly with any of the more closely comparable types of secondary wood. In the absence of complete stems any further speculations as to its affinities will be unprofitable. Until such examples are available Mr. Hauser's specimen must remain simply a piece of secondary wood of rather distinctive character.

In conclusion, I wish to thank Professor W. H. Lang, F.R.S., for his interest in this investigation and to acknowledge my indebtedness to Mr. E. Ashby of the Barker Cryptogamic Laboratory, University of Manchester, for his assistance in the making of film-pulls and with the photographic illustrations of the paper.

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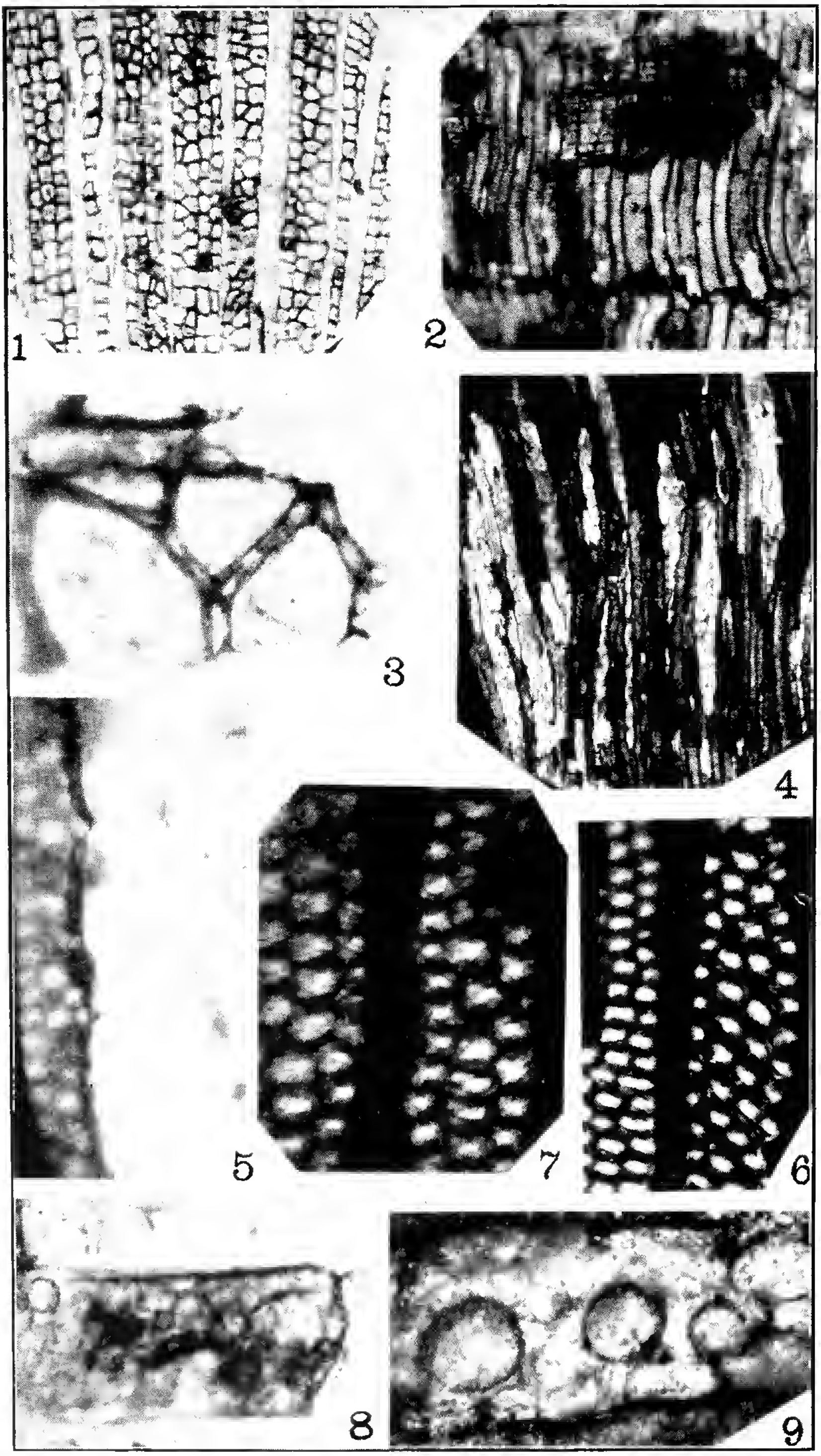
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Explanation of Plate XI.

All figures are from untouched negatives.

C. before a number denotes author's collection.

Fig. 1.—Portion of a transverse pull showing radial rows of tracheides and medullary rays. × 50. C.15.

Fig. 2.—Secondary xylem in a radial longitudinal plane. × 50. C.16.

Fig. 3.—Tangential pull showing tracheides and numerous medullary rays. × 50. C.24.

Fig. 4.—Tracheides from a transverse pull showing pits on all walls. × 400. C.17.

Fig. 5.—Pitted tangential wall of tracheide adjacent to medullary ray. × 400. C.18.

Fig. 6.—Portion of two tracheides showing transversely elongated pits on radial wall. × 400. C.20.

Fig. 7.—A tracheide with crossed pits on radial wall. × 530. C.21.

Fig. 8.—Radial view of medullary ray cell containing fungal hyphae and vesicles. × 300. C.23.

Fig. 9.—Tangential view of medullary showing 3 vesicles. × 430. C.22.

[Proc. Roy. Soc. Victoria, **50** (N.S.), Pt. I., 1937.]

Art. XI.—*Notes on Australian and New Zealand Foraminifera. No. 3: Some Species of the Family Polymorphinidae*

By WALTER J. PARR, F.R.M.S., and ARTHUR C. COLLINS.

[Read 10th June, 1937; issued separately, 29th December, 1937.]

Introduction.

Prior to the publication of Cushman and Ozawa's paper "An Outline of a Revision of the Polymorphinidae" in 1928, the genus *Polymorphina* was used to include, as its name would suggest, a series of foraminifera presenting great diversity of form. Cushman and Ozawa found that the genus included forms which had developed along a number of lines and showed that most of the species hitherto placed in *Polymorphina* should be distributed among a number of genera, several of which had been for many years disused, and other new genera which they erected.

The "Outline" was followed in 1930 by their publication of "A Monograph of the Foraminiferal Family Polymorphinidae, Recent and Fossil." In this work, probably the largest and most comprehensive ever devoted to a single family of the foraminifera, Cushman and Ozawa reviewed the known species of the family and described many others, including a number from the Australian region.

The publication of the "Monograph" has made the present work possible and the writers acknowledge their indebtedness to its authors, one of whom, to the great loss of all workers on the foraminifera, has since passed away.

In this paper, the writers give the results of the study of several thousand specimens of the Polymorphinidae, both fossil and Recent, from Australia and New Zealand. A representative set of samples from the Victorian Tertiary deposits has been examined as well as a quantity of material from the Tertiary of New Zealand. Eight genera and 35 species and varieties are recorded, including ten species and varieties described as new. The new forms are—

Guttulina regina (Brady, Parker, and Jones), var. *chapplei*, var. nov.
Guttulina clifdenensis, sp. nov.
Pyrulina crespinae, sp. nov.
Pseudopolymorphina doanei (Galloway and Wissler), var. *beaumarisensis*, var. nov.
Pseudopolymorphina tasmanica, sp. nov.
Polymorphina myrae, sp. nov.
Sigmomorphina haeusleri, sp. nov.
S. wynyardensis, sp. nov.
S. batesfordensis, sp. nov.
Sigmoidella novozealandica, sp. nov.

All of these new forms are restricted in their distribution, and the fossil forms should therefore be of value to the micro-palaeontologist.

Description of the Species.

Family POLYMORPHINIDAE d'Orbigny, 1846.

Sub-family POLYMORPHININAE Brady, 1881.

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

GUTTULINA PROBLEMA d'Orbigny.

(Plate XII., Fig. 1.)

Guttulina problema d'Orbigny, 1826, p. 266, No. 14. Cushman and Ozawa, 1930, p. 19, pl. ii., figs. 1-6; pl. iii., figs. 1*a-c*.

According to Cushman and Ozawa, this species has a very wide distribution, both geographically and geologically. The earliest record given by these authors is from the Cretaceous and it is noted as occurring upwards to present-day seas. They give records from the Miocene of the Filter Quarry, Batesford, and from Bird Rock Cliffs and Danger Point, both at Torquay, Victoria.

Localities.

Upper Eocene.—New Zealand: Motutara Point, Kawhia Harbour (from Whaingaroa Series).

Oligocene.—New Zealand: Otiake; Gore; Waitaki Valley.

Miocene.—Victoria: Lake Wellington bore, 1,100-1,138 feet; Vic. Geol. Survey bore, Parish of Meerlieu, 1,200 feet; Mines Department bore, Parish of Nuntin, 1,453 feet; Castle Cove (upper beds); road cut, Ford River, west of Cape Otway; Point Danger, Torquay; The Ledge, Bird Rock Cliffs, Torquay; Rocky Point, north end of Bell's Beach, Torquay; Waurn Ponds; Lower Beds, Muddy Creek; Vic. Geol. Survey bore, Hamilton, 80-85 feet; Filter Quarry, Batesford; Maude (upper bed); Western Beach, Geelong; shell lime pit, east of Longford; Robertson's Quarry, Longford; Vic. Geol. Survey bore, Parish of Moormurng, 716 feet; railway cutting, Neumerella; Flinders; west side of mouth of Curdie's Inlet. Tasmania: Table Cape. Western Australia: Cape Range.

Pliocene.—Victoria: Beaumaris; Jemmy's Point, Lakes Entrance; Forsyth's, Grange Burn.

Recent.—Victoria: San Remo. Tasmania: Oyster Bay; east of Cape Pillar, 100 fms.

GUTTULINA IRREGULARIS (d'Orbigny).

(Plate XII., Fig. 2.)

Globulina irregularis d'Orbigny, p. 226, pl xiii., figs. 9, 10.

Guttulina irregularis (d'Orb.): Cushman and Ozawa, 1930, p. 25, pl. iii., figs. 4, 5; pl. vii., figs. 1, 2.

Typical examples are of frequent occurrence. A costate form of this species was met with in a bore sample from Mines Department boring, Parish of Nuntin, near Longford, Victoria, depth 1,453 feet.

The time range of *G. irregularis* is stated by Cushman and Ozawa to be from Eocene to Recent and it has also a wide geographical distribution. They record it as a fossil from the Miocene of Victoria and as a Recent form from Bass Strait and from around New Zealand.

Localities.

Upper Eocene.—New Zealand: Motutara Point, Kawhia Harbour (Whaingaroa Series).

Oligocene.—New Zealand: Clifden, Southland (Horizons 4 and 6c).

Miocene.—Victoria: sea floor, Apollo Bay; Castle Cove (upper beds); Alkemade's Quarry, Kawarren; Flinders; Filter Quarry, Batesford; lower beds, Muddy Creek; Mines Department bore, Parish of Nuntin, 1,453 feet (costate var.); Beaumaris (lower beds). Tasmania: Table Cape. New Zealand: Orakei Bay, Auckland.

GUTTULINA YABEI Cushman and Ozawa.

(Plate XIII., Figs. 3, 4*a-c*; Plate XIII., Figs. 4*a-c*.)

Polymorphina oblonga Brady (non *P.* (*Guttulina*) *oblonga* d'Orb.), 1884, pl. lxxiii., figs. 2, 3.

Guttulina yabei Cushman and Ozawa, 1929, p. 68, pl. xiii., fig. 2; pl. xiv., fig. 6; 1930, p. 30, pl. iv., figs. 6, 7.

This species varies a good deal in shape, apparently being affected by its environment. Very large characteristic examples occur in the Oligocene (Hutchinsonian) of Otiake, New Zealand. The Recent specimens we have are, with the exception of some from off the east coast of Tasmania, smaller and slenderer, but the general arrangement of the chambers is as in the more typical form of *G. yabei*. A particularly slender form is figured from off Black Rock, Victoria (Plate XII., figs. 4*a-c*). At this locality all of the foraminifera are undoubtedly affected by the discharge of fresh water from the River Yarra into Hobson's Bay as they are thin shelled and otherwise atypical. Chapman (1909, Pl. X., fig. 2) has figured the same form from shore sand, Beaumaris, under the name of *Polymorphina thouini* d'Orb. *P. thouini* is, however, now placed in *Pyrulina*.

G. yabei was described from the Upper Pliocene, Sawane, Island of Sado, Japan, and Cushman and Ozawa record it from two *Albatross* soundings, at depths of 44 and 114 fathoms respectively, off Japan. The specimens figured by Brady in the above reference as *Polymorphina oblonga* were from Bass Strait, 38-40 fathoms, and Port Jackson, 6 fathoms.

Localities.

Oligocene.—New Zealand: Gore, Southland; Clifden, Southland (Horizons 6*a* and 6*c*): Otiake.

Pliocene.—New Zealand: Maraekakaho, Hawkes Bay.

Recent.—Victoria: Shore sand, San Remo; shallow water, Black Rock. Tasmania: Oyster Bay. New South Wales: Watson's Bay, Port Jackson. New Zealand: 60 miles east of Lyttleton, 100 fathoms; 14 miles north-east of Auckland Island, 95 fathoms; off the Snares, 60 fathoms.

GUTTULINA sp.

(Plate XIII., Figs. 1*a-c*.)

The only example of this species is from the Upper Cretaceous of Gingin, Western Australia. It appears to be new, but its naming has been deferred until more material is available. The test is fusiform and the chambers are arranged in a quinqueloculine series; the sutures are depressed. The specimen is 1.18 mm. in length, with a major diameter of 0.56 mm. and a minor diameter of 0.54 mm. It resembles *G. woodsi* Cushman and Ozawa from the Upper Cretaceous of England, but that species is more regularly fusiform and tapers sharply to each end.

GUTTULINA REGINA (Brady, Parker, and Jones).

(Plate XII., Fig. 5; Text-figs. 1-7.)

Polymorphina regina Brady, Parker, and Jones, 1870, p. 241, pl. xli., figs. 32*a*, *b*; Chapman, 1909, p. 132, pl. x., fig. 4.

Guttulina regina (B., P., & J.): Cushman and Ozawa, 1930, p. 34, pl. vi., figs. 1, 2.

This species was described from Storm Bay, Tasmania, and it is a common form in moderately shallow water on the eastern and southern coasts of Australia. Cushman and Ozawa note it also occurs in the Philippines. It may be observed that *G. regina* does not appear to have ever been recorded from New Zealand waters. Several other species, notably *Sigmoidella kagaensis*, and probably also *S. elegantissima*, are similarly confined in Recent seas, to Australian and Eastern Asiatic waters.

As a rule *G. regina* is fairly consistent in form, any variation being in the direction of a more attenuated shell, or in the degree of fineness of the costation. In a number of shore gatherings, made at Barwon Heads, Victoria, by Mr. W. Baragwanath, the Director of the Geological Survey of Victoria, the specimens of

G. regina exhibit a number of unusual variations, some of which are figured (Text-figs. 1-7). It will be noted that *Pseudopolymorphina-* and *Polymorphinella*-like forms are present. The only explanation of these curious forms is that the River Barwon discharges into Bass Strait at this point, and that the influx of fresh water has affected the normal growth of *G. regina* in the vicinity.

Localities.

Oligocene.—New Zealand: Clifden, Southland (Horizons 4 and 6*c*).

Miocene.—Victoria: Road cut, Ford River, west of Cape Otway; Vic. Geol. Survey bore, Hamilton, 80-85 feet. Tasmania: Table Cape.

Pliocene.—Victoria: Beaumaris.

Recent.—Victoria: Inverloch; Barwon Heads; Point Lonsdale; Altona Bay. New South Wales: Watson's Bay, Port Jackson. Queensland: *Challenger* Stn. 185, off Raine Island, 155 fathoms. Tasmania: Burnie; Devonport. South Australia: Glenelg. Western Austraila: *Bonthorpe* sounding, Great Australian Bight, lat. 33° 14′ S., long. 126° 16′ E., 89 fathoms.

GUTTULINA REGINA (Brady, Parker, and Jones), var. CRASSICOSTATA Cushman and Ozawa.

(Plate XII., Fig. 6.)

Guttulina regina, var. *crassicostata* Cushman and Ozawa, 1930, p. 35, pl. xi., figs. 5*a-c*.

This variety was separated from *G. regina* because of the very broad, coarse costae and more regularly fusiform test, with the chambers less inflated than in the typical form. It was described from the Lower Pliocene of Beaumaris, Victoria. The present specimens are from the type sample. This variety of *G. regina* is of common occurrence in the Lower Pliocene of Beaumaris, but has not been met with elsewhere.

GUTTULINA REGINA (Brady, Parker, and Jones), var. CHAPPLEI, var. nov.

(Plate XII., Figs. 7*a-c*.)

The variety differs from typical *G. regina* in the very short, thick test, more embracing chambers, less depressed sutures, and heavy costae, as coarse as those of var. *crassicostata*.

Length of holotype of variety, 0.95 mm.; breadth, 0.83 mm.; thickness, 0.70 mm.

Holotype (Parr Coll.) from Lower Miocene, Fisher's Point, west of Cape Otway, Victoria, collected by Rev. E. H. Chapple, in honour of whom the variety is named. This form has only been met with at the type locality, and is of rare occurrence.

Guttulina costulata (Cushman).

(Plate XII., Figs. 9*a-c*.)

Polymorphina cuspidata Brady, var. *costulata* Cushman, 1922, p. 133, pl. xxxi., fig. 1.

Guttulina costulata (Cush.): Cushman and Ozawa, 1930, p. 48, pl. xii., figs. 3*a*, *b*.

Cushman reported *G. costulata* from the Lower Oligocene, Mint Spring Marl, Mint Spring Bayou, Vicksburg, Missouri, U.S.A. Cushman and Ozawa note that specimens which seem identical occur in the Lower Pliocene of Beaumaris, Victoria. Our examples are from the same locality, where it is common.

Guttulina lactea (Walker and Jacob).

(Plate XII., Fig. 8.)

Serpula lactea Walker and Jacob (*fide* Kanmacher), 1798, p. 634, pl. xiv., fig. 4.

Guttulina lactea (W. & J.): Cushman and Ozawa, 1930, p. 43, pl. x., figs. 1-4.

The present examples compare well with specimens from Dog's Bay, Ireland. The maximum dimensions given by Cushman and Ozawa for the species—viz., length, 0.85 mm.; breadth, 0.40 mm.; thickness, 0.28 mm.—are exceeded by those of the figured specimen. These, given in the same order, are 1.08 mm.; 0.65 mm.; 0.38 mm.

Cushman and Ozawa's records of *G. lactea* are nearly all from the Atlantic Ocean and Tertiary deposits in Europe. Pacific records are, however, given by them from the Philippine Islands (Recent) and Japan (Pliocene).

Localities.

Lower Pliocene.—Victoria: Beaumaris (fistulose examples).

Recent.—Victoria: Shore sand, Barwon Heads.

Guttulina lactea (Walker and Jacob), var. earlandi Cushman and Ozawa.

(Plate XV., Figs. 9*a* and *c*.)

Guttulina lactea (Walker and Jacob), var. *earlandi* Cushman and Ozawa, 1930, p. 45, pl. x., fig. 5.

This variety differs from typical *G. lactea* in being attached instead of free. According to Cushman and Ozawa, it has been found Recent in the Mediterranean and at Selsey, England, and as a fossil in the Pliocene (Crag) of Sutton, England. The present example is from the Lower Miocene of Muddy Creek, Victoria.

Guttulina yamazakii Cushman and Ozawa.

(Plate XIII., Figs. 5*a-c*.)

Guttulina yamazakii Cushman and Ozawa, 1930, p. 40, pl. viii., figs. 3, 4.

The present specimens, from the Lower Pliocene of Beaumaris, Victoria, agree well with Cushman and Ozawa's figures and description of this species, from off Cape Tsuika, Japan, and also recorded as a fossil from the Pliocene of Japan.

Guttulina clifdenensis, sp. nov.

(Plate XV., Figs. 7*a-c*.)

Test roughly triangular in front view, with rounded edges and angles, except the pointed apertural end; chambers embracing, elongated, and narrowing towards the apertural end, arranged in a quinqueloculine series; sutures distinct, not depressed; wall smooth, thick; aperture radiate.

Length of holotype, 1.15 mm.; width, 0.85 mm.; thickness 0.55 mm.

Holotype (Parr Coll.) from Oligocene (Hutchinsonian), Horizon 6*a*, Clifden, Southland, New Zealand, collected by Dr. C. R. Laws.

In end view this species resembles *G. lehneri* C. and O., but is otherwise quite different. *G. irregularis* (d'Orb.), var. *nipponensis* C. and O., is somewhat similar in side view, but is triangular in section.

The only specimens of *G. clifdenensis* are from the type locality.

Guttulina seguenzana (Brady).

(Plate XII., Figs. 10*a* and *c*.)

Polymorphina seguenzana Brady, 1884, p. 50, pl. lxxii., figs. 16, 17.

Guttulina (Sigmoidina) seguenzana (Brady); Cushman and Ozawa, 1930, p. 50, pl. xxxvii., figs. 8, 9 (after Brady).

A very typical example of this rare species is figured. *G. seguenzana* also occurs in Bass Strait, where the specimens are more robust, but otherwise typical, only three chambers being visible and the lower ends of the two outside chambers embracing the base of the third chamber.

The only previous records of this species appear to be those given by Brady, viz., off the Ki Islands, south-west of New Guinea, 129 fathoms, and Port Jackson, New South Wales, 2-10 fathoms, in dredgings made by H.M.S. "Challenger."

Localities.

Recent.—Victoria: Shore sand, Inverloch and San Remo. Tasmania: Shore sand, Devonport. New South Wales: Dredgings, 22 miles east of Narrabeen, 80 fathoms.

GUTTULINA SILVESTRII Cushman and Ozawa.

(Plate XII., Fig. 11.)

Guttulina (Sigmoidina) silvestrii Cushman and Ozawa, 1930, p. 51, pl. xxxvii., figs. 6, 7.

This species was described from the Lower Miocene of the Filter Quarry, Batesford, Victoria, and also recorded by Cushman and Ozawa as a Recent form from South Australia and New Zealand. The only specimen we have met with resembling *G. silvestrii* is figured. This is from the type locality and is fairly close to the type figure. It is possible that other specimens have been confused with *Sigmoidella elegantissima,* from which it is difficult to separate without examining the shell from both sides.

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

PYRULINA FUSIFORMIS (Roemer).

(Plate XIII., Figs. 2*a-c*, 3*a-c*; Plate XIV., Figs. 5*a-c*.)

Polymorphina fusiformis Roemer, 1838, p. 386, pl. iii., fig. 37.

P. angusta Brady (*non* Egger), 1884, p. 563, pl. lxxii., figs. 1-3; Chapman and Parr, 1926, p. 392, pl. xxi., fig. 75.

Pyrulina fusiformis (Roemer): Cushman and Ozawa, 1930, p. 54, pl. xiii., figs. 3-8.

Cushman and Ozawa's figures and synonomy indicate a considerable range of variation. A stout form comparable with their figure 8, and a slender form near their figure 4, are represented on Plate XIII., figs. 2 and 3 respectively. The slender form was recorded by Chapman and Parr (*loc. cit.*) under the name of *Polymorphina angusta* from the Tertiary (Balcombian) of the Altona Bay coal shaft.

Plate XIV., Fig. 5, represents what appears to be a species of *Pseudopolymorphina,* near *P. jonesi* C. and O. The arrangement of the early chambers indicates, however, that it is the slender form of *P. fusiformis,* but with the addition of two uniserial chambers. In end view the two forms are identical. They invariably occur together, but the pseudopolymorphine type of shell is rarely met with.

Localities.

Oligocene.—New Zealand: Clifden, Southland (Horizon 6*c*).

Miocene.—Victoria: Castle Cove (upper beds); road cut, Ford River, west of Cape Otway; Vic. Geol. Survey borings, Hamilton, 80-85 feet. and Parish of Meerlieu, 1,200 feet; Flinders; Mines Department bore, Parish of Nuntin, 1,453 feet; Grice's Creek; Altona Bay coal shaft; The Ledge, Bird Rock Cliffs, Torquay. Tasmania: Table Cape.

Pyrulina cylindroides (Roemer).

(Plate XIII., Figs. *7a-c.*)

Polymorphina cylindroides Roemer, 1838, p. 385, pl. iii., fig. 26.

P. rugosa d'Orbigny, var. *horrida* Chapman and Parr (*non Globulina horrida* Reuss), 1926, p. 392, pl. xxi., figs. 78, 79.

Pyrulina cylindroides (Roemer): Cushman and Ozawa, 1930, p. 56, pl. xiv., figs. 1-5.

As a rule this species has a smooth wall and is not fistulose, but the greater number of specimens here attributed to *P. cylindroides* from the Miocene of Victoria have the wall covered with short prickles, and the apertural end of the test is fistulose. Cushman and Ozawa have figured a somewhat similar example from the Cretaceous, Cambridge greensand, of Cambridge, England. This is apparently megalospheric, while the specimen here figured is probably microspheric. Both smooth and prickly forms occur together at Western Beach, Geelong, in beds of Miocene age. The smooth forms are similar to Cushman and Ozawa's Figs. 1 and 2.

Localities.

Miocene.—Victoria: The Ledge, Bird Rock Cliffs, Torquay (smooth form); Vic. Geol. Survey borings, Parish of Moormurng, 716 feet (prickly form), and Hamilton, 80-85 feet (prickly form); Curlewis (prickly form); Orphanage Hill, Geelong (smooth form); Western Beach, Geelong (smooth and prickly forms); Red Bluff, Shelford (prickly form); Grice's Creek (prickly form); Kackeraboite Creek (prickly form); Balcombe Bay (prickly form).

Pliocene.—Victoria: Beaumaris (smooth form).

Recent.—New Zealand: 60 miles east of Lyttleton, 100 fathoms; 14 miles north-east of Auckland Island, 95 fathoms (all smooth).

Pyrulina crespinae, sp. nov.

(Plate XIV., Figs. 1*a-c.*)

Test cylindrical, elongated, rounded at the base; chambers about two and a half times as long as wide, very slightly inflated, at first arranged in a quinqueloculine series but becoming biserial in the later portion of the shell, each succeeding chamber removed further from the base; sutures little, if at all, depressed, distinct; wall smooth, translucent; aperture radiate.

Length of holotype, 1.40 mm.; major diameter, 0.35 mm.; minor diameter, 0.26 mm.

Holotype (Parr Coll.) from Lower Pliocene, Beaumaris, Victoria, collected by W. J. Parr.

This slender species recalls *Pyrulina thouini* (d'Orbigny), but is widest in the later part of the test and does not take on the biserial character as soon as d'Orbigny's species.

One finely costate example of *P. crespinae* was met with. The species is named in honour of Miss Irene Crespin, B.A., the Commonwealth Palaeontologist. It has occurred only in the Lower Pliocene of Beaumaris.

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

GLOBULINA GIBBA d'Orbigny.

(Plate XII., Fig. 12.)

Globulina gibba d'Orbigny, 1826, p. 266, No. 10, Modèles No. 63; Cushman and Ozawa, 1930, p. 60, pl. xvi., figs. 1-4.

Cushman and Ozawa state that, unlike many species of foraminifera, this species died out in the Pacific region and only persisted in the Atlantic and Mediterranean. *G. gibba* is very well represented in the Tertiary of Victoria and the examples attain a length of as much as 2.9 mm. As a rule, the large specimens exhibit traces of having been apically fistulose.

Localities.

Miocene.—Victoria: Mines Department bore, Parish of Nuntin, 1,453 feet; sea floor, Apollo Bay; Point Danger, Torquay; The Ledge, Bird Rock Cliffs, Torquay; Rocky Point, north end of Bell's Beach, Torquay; Vic. Geol. Survey borings, Parish of Meerlieu, 1,200 feet, Parish of Moormurng, 716 feet, and Hamilton, 80-85 feet; Castle Cove (upper beds); road cut, Ford River, west of Cape Otway; Flinders; Filter Quarry, Batesford; Waurn Ponds; Western Beach, Geelong; Grice's Creek; Altona Bay coal shaft; railway cutting, Neumerella; cliffs, west side of mouth of Curdie's Inlet; Beaumaris (lower beds). Tasmania: Table Cape.

Pliocene.—Victoria: Beaumaris; McDonald's, Muddy Creek.

GLOBULINA GIBBA d'Orbigny, var. GLOBOSA (Münster).

(Plate XII., Fig. 13.)

Polymorphina globosa von Münster in Roemer, 1838, p. 386, pl. iii., fig. 33.

Globulina gibba d'Orbigny, var. *globosa* (v. Münster): Cushman and Ozawa, 1930, p. 64, pl. xvii., figs. 8, 9.

Cushman and Ozawa give the geological range of this compressed modification of *G. gibba* from Eocene to Recent. Their fossil records are from Europe and North America. The only Indo-Pacific record given by these authors is as a Recent form from shore sand, Torquay, Victoria. What appears to be the same form is of common occurrence in shore sands at Torquay, Barwon Heads, and Point Lonsdale, Victoria. We have other examples, also from shore sands, from Burnie and Devonport, Tasmania, and Glenelg, South Australia.

Genus **Pseudopolymorphina** Cushman and Ozawa, 1928.

PSEUDOPOLYMORPHINA DOANEI (Galloway and Wissler).

(Plate XIV., Figs. 2*a-c*.)

Polymorphina doanei Galloway and Wissler, 1927, p. 54, pl. ix., fig. 8.
Pseudopolymorphina doanei (G. & W.): Cushman and Ozawa, 1930, p. 95, pl. xxiv., figs. 5*a*, *b*.

The figured specimen is shorter than others which have since been obtained, also from the Lower Pliocene of Beaumaris. These closely match Cushman and Ozawa's figures of this species. Previous records have been from the Pleistocene and Pliocene of California. We have examples from one of Galloway and Wissler's localities, viz., San Pedro, California, and all of the present specimens agree with these.

Localities.

Oligocene.—New Zealand: Otiake.

Lower Pliocene.—Victoria: Beaumaris.

PSEUDOPOLYMORPHINA DOANEI (Galloway and Wissler), var. BEAUMARISENSIS, var. nov.

(Plate XIV., Fig. 3.)

Variety differing from the typical form of *P. doanei* in having the earlier two-thirds of the test covered with fine longitudinal striae.

Length of figured specimen, 1.35 mm.; breadth, 0.60 mm.; thickness, 0.45 mm.

Holotype of variety (Parr Coll.) from Lower Pliocene of Beaumaris, Victoria, collected by W. J. Parr. It appears to be confined to this locality, and is of rare occurrence.

PSEUDOPOLYMORPHINA TASMANICA, sp. nov.

(Plate XIV., Figs. 6*a-c*.)

Test about two and a half times as long as broad, almost circular in section, rounded at both ends; chambers rounded, only slightly embracing, arranged at first in a quinqueloculine series, becoming biserial in the later part of the test; sutures strongly depressed, distinct; wall smooth; aperture radiate.

Length of holotype, 1.40 mm.; breadth, 0.50 mm.; thickness, 0.45 mm.

Holotype (Parr Coll.) from Lower Miocene (*Crassatella* bed), Table Cape, Tasmania, collected by W. G. Parr.

This species resembles *P. doanei*, but differs from that species in having a more loosely built test, with longer chambers. The chambers in the guttuline series are less embracing whilst those in the biserial portion extend across the test almost to the other side, instead of only to the vicinity of the median line, as in *P. doanei.*

The only specimens of *P. tasmanica* are from the type locality, where it is rare.

PSEUDOPOLYMORPHINA RUTILA (Cushman), var. PARRI Cushman and Ozawa.

(Plate XIV., Figs. 4*a-c*.)

Pseudopolymorphina rutila (Cushman), var. *parri* Cushman and Ozawa, 1930, p. 100.

Test compressed, elongate, fusiform, with the initial end pointed; chambers elongated, not much embracing, alternating in the later part of the test; sutures distinct, slightly depressed; wall with a few strong longitudinal costae; aperture radiate.

Length of figured specimen, 1.43 mm.; breadth, 0.45 mm.; thickness, 0.25 mm.

This form differs from *P. rutila*, of the Lower Oligocene (Byram Marl) of the United States, in its broader test and coarser costae. It was described, but not figured, by Cushman and Ozawa from material sent to Dr. Cushman by Parr. The specimens now recorded are from the type sample, collected by Parr from the soapy clay bed occurring in the polyzoal limestone at Rocky Point, Torquay. This is not the Rocky Point known to most visitors to Torquay, on the south side of the mouth of Spring Creek, but is at the north end of Bell's Beach, about 1 mile south of Bird Rock. Owing to an error on Parr's part, the type locality was stated by Cushman and Ozawa to be Danger Point, which is about 2 miles to the north-east, at the south end of the bathing beach, Torquay.

We have seven specimens of this variety from the type locality but have not met with it elsewhere.

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

POLYMORPHINA LINGULATA Stache.

(Plate XIV., Figs. 7*a* and *c*.)

Polymorphina lingulata Stache, 1864, p. 255, pl. xxiv., figs. 1*a*, *b*.
P. pernaeformis Stache, 1864, p. 256, pl. xxiv., figs. 2*a*, *b*.
P. cognata Stache, 1864, p. 257, pl. xxiv., figs. 3*a*, *b*.
P. contorta Stache, 1864, p. 257, pl. xxiv., figs. 4*a*, *b*.
P. marsupium Stache, 1864, p. 258, pl. xxiv., figs. 5*a*, *b*; Chapman, 1926, p. 67, pl. v., figs. 5*a*, *b* (after Stache).
P. sacculus Stache, 1864, p. 259, pl. xxiv., figs. 6*a*, *b*.
P. gigantea Stache, 1864, p. 262, pl. xxiv., figs. 9*a*, *b*.
P. regularis Münster, var. *lingulata* Stache: Chapman, 1926, p. 67, pl. v., figs. 1, 3, 4, 6 (after Stache).
P. regularis Münster, var. *pernaeformis* Stache: Chapman, 1926, p. 67, pl. v., fig. 2 (after Stache).
P. regularis Chapman (*non* Münster), 1926, p. 67, pl. v., figs. 9*a*, *b*.
P. lingulata Stache: Cushman and Ozawa, 1930, p. 120. pl. xxxi., figs. 7*a*, *b* (after Stache).

Stache described the species given in the above synonomy from the Tertiary of Whaingaroa Harbour, New Zealand. All of the original specimens of these, with the exception of *P. gigantea*, were examined in Vienna by Ozawa, who was satisfied that the difference among the species is not more than the range of variation of individuals of one species. *P. gigantea*, although not seen by Ozawa, is undoubtedly identical with *P. lingulata*, the only difference between Stache's figures of the two species being that *P. gigantea* is more rhomboid in section.

The thirteen examples now recorded as *P. lingulata* are all of the *P. gigantea* type, with the exception of one which is similar to Stache's figure of *P. contorta*. This species is apparently of very limited occurrence, as we have never been successful in finding it elsewhere than in the Oligocene (Hutchinsonian) of Gore, Southland, New Zealand. We have searched through a number of samples of material kindly sent by Professor J. A. Bartrum from Whaingaroa (now known as Raglan) and beds, also in the Whaingaroa Series, at Motutara Point, Kawhia Harbour, but did not meet with any examples of the genus *Polymorphina*.

POLYMORPHINA HOWCHINI Cushman and Ozawa.

(Plate XIV., Fig. 8.)

Polymorphina compressa Brady (*pars*) (*non P. compressa* d'Orb.), 1884, pl. lxxii., figs. 9, 10.

P. howchini Cushman and Ozawa, 1930, p. 121, pl. xxxi., figs. 9*a*, *b*.

The figured specimen, from the Post-Tertiary of Vic. Geol. Survey bore, No. 5, Parish of Wannaeue, Boneo, near Rosebud, 177-187 feet, is a very well preserved one, measuring 1.70 mm. in length, and with the costae better developed than usual. Frequently the wall is almost smooth.

Cushman and Ozawa described this species from the Lower Pliocene of McDonald's, Muddy Creek, Hamilton, Victoria. We have a number of examples from the type sample. The species also occurs as a living form in Bass Strait. The two specimens figured by Brady (*loc. cit.*) on Plate LXXII. (Figs. 9, 10) of the *Challenger* Report as *P. compressa* d'Orb., from off East Moncoeur Island, Bass Strait, 38-40 fathoms, are considered by the writers to be *P. howchini*.

Localities.

L. Pliocene.—McDonald's, Muddy Creek, Victoria.

Post-Tertiary.—Vic. Geol. Survey bore, No. 5, Parish of Wannaeue, 177-187 feet.

Recent.—Victoria: Shore sand, Anderson's Inlet and Barwon Heads.

Polymorphina myrae, sp. nov.

(Plate XV., Figs. 4*a-c*.)

Test much compressed, fusiform in outline, both ends rounded; chambers compressed, elongated, arranged at first in an anti-clockwise sigmoid series, then biserially; sutures depressed, distinct; wall fairly thick, covered with fine longitudinal costae; aperture radiate.

Length of holotype, 2.85 mm.; breadth, 0.90 mm.; thickness, 0.30 mm.

Holotype (Parr Coll.) from Lower Pliocene, Beaumaris, Victoria, collected by W. J. Parr.

This very beautiful species attains a length of over 4 mm. and is therefore one of the largest known. It cannot be mistaken for any previously known form.

The only examples of *P. myrae* are from the type locality, at which it is not uncommon.

Genus **Sigmomorphina** Cushman and Ozawa, 1928.

Sigmomorphina wynyardensis, sp. nov.

(Plate XV., Figs. 3*a-c*.)

Test compressed, lanceolate, greatest breadth in the upper half, tapering towards the base, margin subacute; chambers elongated and inflated, but variable in this respect, arranged in an open clockwise sigmoid series, each succeeding chamber much further removed from the base; sutures distinct, depressed, almost straight; wall smooth; aperture radiate.

Length of holotype, 2.14 mm.; breadth, 0.80 mm.; thickness, 0.45 mm.

Holotype (Parr Coll.) from Lower Miocene, *Crassatella* bed, Table Cape, Wynyard, Tasmania, collected by W. G. Parr.

This species resembles *S. nysti* (Reuss), described from the Crag of Antwerp, Belgium, but may be distinguished from that species by its much greater size, its inflated chambers, the inflation giving a lobulate margin to the test in side view, and the larger and more distinct chambers in the earlier half of the test.

S. wynyardensis is not known to occur elsewhere than at the type locality, where it is common.

Sigmomorphina haeusleri, sp. nov.

(Plate XV., Figs. 1*a-c*.)

Test ovate, compressed, margin acute; chambers elongated, of even width, arranged in a clockwise sigmoid series, each succeeding chamber removed farther from the base; sutures distinct, very slightly depressed; wall smooth, thick; aperture radiate.

Length of holotype, 1.68 mm.; breadth, 1.23 mm.; thickness, 0.63 mm.

Holotype (Auckland Museum Coll.) from Upper Eocene (Whaingaroa Series), Motutara, Kawhia Harbour, New Zealand, from collection of the late Dr. Rudolf Haeusler.

This species resembles in outline *Polymorphina marsupium* Stache, which was described from beds of the same age at Whaingaroa, but the chambers are arranged in a sigmoid series throughout. Had it not been that Ozawa had examined the type specimen of *P. marsupium* and found it to be a true *Polymorphina*, the writers would have identified the present form with Stache's species, because of the frequency with which this Sigmomorphine type of shell occurs in the Whaingaroa Series.

Localities.

Eocene.—New Zealand: Motutara Point, Kawhia Harbour.

Oligocene.—New Zealand: Gore, Southland.

Miocene.—Victoria: Point Danger, Torquay; Rocky Point, north end of Bell's Beach, Torquay; Vic. Geol. Survey bore, Hamilton, 80-85 feet; Filter Quarry, Batesford; railway cutting, Neumerella. Tasmania: Table Cape.

Sigmomorphina chapmani (Heron-Allen and Earland).

(Plate XV., Figs. *2a-c.*)

Polymorphina chapmani Heron-Allen and Earland, 1924, p. 163, pl. x., figs. 60-63.

Sigmomorphina chapmani (H.-A. & E.): Cushman and Ozawa, 1930, p. 124, pl. xxxii., figs. 4, 5 (after Heron-Allen and Earland.)

This species was described by Heron-Allen and Earland from the Lower Miocene of the Filter Quarry, Batesford, Victoria. Our figured specimen, an immature one from the same locality, was the only one available when the plate was drawn, but we have since collected many fine examples from the marl overlying the limestone in the Filter Quarry and have other typical specimens from borings in Gippsland. *S. chapmani* is, as far as at present known, confined to the lower portion of the Miocene in Victoria.

Localities.

Miocene.—Victoria: Filter Quarry, Batesford; Lake Wellington bore, 1,130-1,138 feet; Vic. Geol. Survey bore, Parish of Moormurng, 716 feet; Mines Department bore, Parish of Nuntin, 1,453 feet; shell lime pit, east of Longford.

Sigmomorphina batesfordensis, sp. nov.

(Plate XV., Figs. *6a-c.*)

Test compressed, ovate, both ends subacute, margins rounded; chambers elongate, slightly inflated, arranged in an anti-clockwise sigmoid series, each succeeding chamber further removed from the base; sutures slightly depressed, distinct; wall smooth, fairly thin; aperture radiate.

Length of holotype, 0.83 mm.; breadth, 0.50 mm.; thickness, 0.28 mm.

Holotype (Parr Coll.) from Lower Miocene, marl above limestone, Filter Quarry, Batesford, Victoria, collected by W. J. Parr.

This does not resemble closely any described species, the nearest being apparently *S. undulosa* (Terquem), in which the chambers are narrower as well as more embracing and numerous.

The figured specimen is megalospheric; the microspheric form is of similar dimensions but there are more chambers in the first half of the test and they are arranged in a more sharply-twisted sigmoid series, the outer margins of which protrude as ridges on both faces of the test.

This species is apparently restricted to beds of about the same age as the Batesford limestone.

Localities.

Miocene.—Victoria: Filter Quarry, Batesford; lower beds, Muddy Creek; Vic. Geol. Survey borings, Hamilton, 80-85 feet, and Parish of Meerlieu, 1,200 feet; Robertson's Quarry, Longford; Castle Cove (upper beds); Alkemade's Quarry, Kawarren.

SIGMOMORPHINA WILLIAMSONI (Terquem).

(Plate XV., Fig. 5.)

Polymorphina lactea (Walker and Jacob), var. *oblonga* Williamson (*non P. oblonga* d'Orb.), 1858, p. 71, pl. vi., figs. 149, 149*a*.

P. williamsoni Terquem, 1878, p. 37.

Sigmomorphina williamsoni (Terq.): Cushman and Ozawa, 1930, p. 138, pl. xxxviii., figs. 3, 4. Parr, 1932, p. 12, pl. i., fig. 20.

This species was described from shallow water off the British Isles and has been recorded by Sidebottom (as *Dimorphina milletti*) from off the coast of New South Wales and by the writer from shallow water at Black Rock and Williamstown, Victoria

Localities.

Recent.—Victoria: Black Rock; Williamstown. Tasmania: Devonport. New Zealand: Off the Snares, 60 fathoms.

Genus **Sigmoidella** Cushman and Ozawa, 1928.

SIGMOIDELLA ELEGANTISSIMA (Parker and Jones).

(Plate XIV., Fig. 9.)

Polymorphina elegantissima Parker and Jones, 1865, p. 438; Brady, Parker, and Jones, 1870, p. 231, pl. xl., figs. 15*b, c* (*non a*). Chapman, 1909, p. 132, pl. x., fig. 3.

Sigmoidella elegantissima (P. & J.): Cushman and Ozawa, 1929, p. 76, pl. xvi., figs. 10, 11; 1930, p. 140, pl. xxxix., figs. 1*a-c*.

Typical examples of this species are common. This is perhaps the most distinctive species of the Polymorphinidae found in Recent Australian seas. It is noteworthy that it has not occurred in any of the Recent material we have examined from around New Zealand, where its place appears to be taken by the species here described as *S. novozealandica*. Although Cushman and Ozawa had material from a number of localities in the New Zealand area, their only record of *S. elegantissima* from that region was from Dusky Sound. We have, however, small, but what appear to be otherwise typical, examples of *S. elegantissima* and *S. kagaensis*, which also does not seem to occur living off New Zealand, from the Oligocene (Hutchinsonian) of Clifden, Southland, New Zealand.

Localities.

Oligocene.—New Zealand: Clifden, Southland (Horizon 6*c*).

Miocene.—Victoria: Point Danger, Torquay; The Ledge, Bird Rock Cliffs, Torquay; Rocky Point, north end of Bell's Beach, Torquay; Filter Quarry, Batesford; Vic. Geol. Survey bores, Hamilton, 80-85 feet, and Parish of Moormurng, 716 feet; Waurn Ponds; Skinner's, Mitchell River, Bairnsdale; Robertson's Quarry, Longford; Pound Creek Reserve, Bairnsdale; railway cutting, Neumerella; Western Beach, Geelong; Balcombe Bay, Mornington; cliffs just west of mouth of Curdie's Inlet. Western Australia: Cape Range.

Pliocene.—Victoria: Beaumaris; Forsyth's, Grange Burn, Hamilton.

Post-Tertiary.—Victoria: Vic. Geol. Survey bore No. 5, Parish of Wannaeue, Boneo, near Rosebud, 177-187 feet.

Recent.—Victoria: Cowes; San Remo; Barwon Heads. Tasmania: Oyster Bay; east of Cape Pillar, 100 fathoms. New South Wales: 12½ miles east of Cape Byron, 111 fathoms; Watson's Bay, Port Jackson. Queensland: Off Masthead Island, 20 fathoms. Western Australia: Geraldton Harbour; *Bonthorpe* sounding. Great Australian Bight, lat. 33° 15′ S., long. 126° 10′ E., 70 fathoms.

SIGMOIDELLA KAGAENSIS Cushman and Ozawa.

(Plate XIV., Fig. 10.)

Polymorphina elegantissima Brady, Parker, and Jones, 1870 (*pars*), p. 231, pl. xl., fig. 15*a*.

Sigmoidella kagaensis Cushman and Ozawa, 1928, p. 19, pl. ii., fig. 14; 1929, p. 76, pl. xiii., fig. 15; pl. xvi., fig. 9; 1930, p. 141, pl. xxxix., figs. 2, 5.

Cushman and Ozawa note the close relationship of this species to *S. elegantissima* and state that it probably represents a cool water relative of that species. This is, however, not the case, as we have typical examples of both species occurring together in warm water off Masthead Island, Queensland, and specimens of *S. kagaensis* from *Challenger* Station 185, off Raine Island, 155 fathoms.

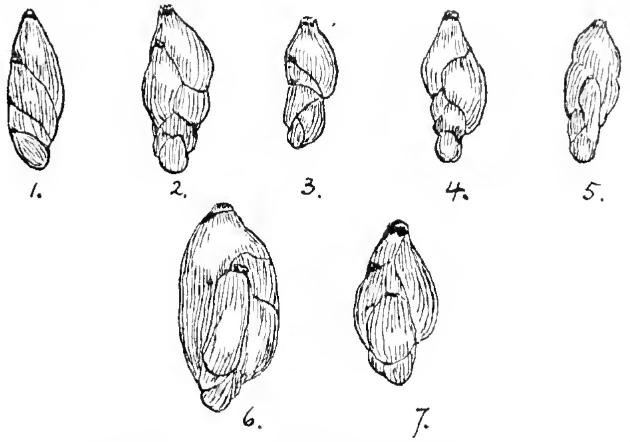
Localities.

Oligocene.—New Zealand: Clifden, Southland (Horizon 6*c*).

Miocene.—Victoria: Point Danger, Torquay; The Ledge, Bird Rock Cliffs, Torquay; Rocky Point, north end of Bell's Beach, Torquay; Filter Quarry, Batesford; Vic. Geol. Survey bore, Hamilton, 80-85 feet; Castle Cove (upper beds); Robertson's Quarry, Longford; railway cutting, Neumerella; cliffs just west of mouth of Curdie's Inlet.

Pliocene.—Victoria: Beaumaris; Forsyth's, Grange Burn, Hamilton; McDonald's, Muddy Creek, Hamilton.

Recent.—Tasmania: East of Cape Pillar, 100 fathoms. New South Wales: 12½ miles east of Cape Byron, 111 fathoms. Queensland: Off Masthead Island, 20 fathoms; *Challenger* Station 185, off Raine Island, 155 fathoms. Western Australia: *Bonthorpe* sounding, Great Australian Bight, lat. 33° 50′ S., long. 125° 17′ E., 40 fathoms.



Text-figs. 1-7.—*Guttulina regina* (B., P. & J.). Shore sand, Barwon Heads, Vic. 1 and 3. *Polymorphinella*-like specimens. 2, 4. Specimens resembling *Pseudopolymorphina*. 5, 6. Other abnormal specimens. 7. Typical form of the species. All × 18.

SIGMOIDELLA NOVOZEALANDICA, sp. nov.

(Plate XV., Figs. 8*a-c*.)

Test compressed, sub-triangular in side view, margins sub-acute; chambers elongate, overlapping, arranged in a clockwise sigmoid series and slowly increasing in width; sutures distinct, not depressed; wall smooth, translucent; aperture radiate.

Length of holotype, 1.25 mm.; breadth, 0.90 mm.; thickness, 0.50 mm.

Holotype (Auckland Museum Coll.) from dredgings, north-east of Auckland Island, south of New Zealand, 95 fathoms.

This species occurs abundantly in dredgings from around the Subantarctic Islands of New Zealand and also off the South Island of New Zealand. The most closely related species is probably *S. elegantissima*, in which the chambers are curved and more embracing at the base, and the margin is angulate.

Localities.

Recent.—New Zealand: Off Puysegur Point, 100 fathoms; 60 miles east of Lyttelton, 100 fathoms; 14 miles north-east of Auckland Island, 95 fathoms; 10 miles north of Enderby Island, 85 fathoms; off the Snares, 50 fathoms.

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

GLANDULINA LAEVIGATA (d'Orbigny).

(Plate XIII., Figs. 6*a* and *c*.)

Nodosaria (Glandulina) laevigata d'Orbigny, 1826, p. 252, No. 1, pl. x., figs. 1-3; Chapman and Parr, 1926, p. 378, pl. xvii., fig. 20.

Polymorphina glandulinoides Fornasini: Chapman and Parr, 1926, p. 392,, pl. xxi., fig. 76.

Glandulina laevigata (d'Orb.): Cushman and Ozawa, 1930, p. 143, pl. xl., figs. 1*a*, *b*.

Cushman and Ozawa state that this species is derived from *Pyrulina* and that examples of it from two of d'Orbigny's localities, viz., the Tertiary of the environs of Siena, Italy, and the Miocene of the Vienna Basin, have shown this relationship. The specimen here figured is evidently microspheric and indicates a polymorphine relationship. As a rule, the Australian Tertiary specimens are uniserial throughout. This is in agreement with Cushman and Ozawa's description of the megalospheric form.

Localities.

Miocene.—Victoria: Sea floor, Apollo Bay; Point Danger, Torquay; The Ledge, Bird Rock Cliffs, Torquay; Filter Quarry, Batesford; Vic. Geol. Survey borings, Hamilton, 80-85 feet, Parish of Meerlieu, 1,200 feet, and Parish of Moormurng, 716 feet; Castle Cove (upper beds); Robertson's Quarry, Longford;

Waurn Ponds; Orphanage Hill, Geelong; Western Beach, Geelong; Balcombe Bay; Grice's Creek; Kackeraboite Creek; Altona Bay coal shaft; west side of mouth of Curdie's Inlet; Beaumaris (lower beds). Tasmania: Table Cape.

Pliocene.—Victoria: Jemmy's Point, Lake Entrance.

Recent.—Tasmania: Oyster Bay.

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Explanation of Plates.

(a, b, side views; c, basal view, except Plate XIV., fig. 4*c*, which is apertural view.)

PLATE XII.

Fig. 1.—*Guttulina problema* d'Orb. Oligocene (Hutchinsonian), Otiake, South Island, N.Z. × 20.
Fig. 2.—*G. irregularis* (d'Orb.). Oligocene (Hutchinsonian), Horizon 6a, Clifden, Southland, N.Z. × 25.
Fig. 3.—*G. yabei* Cushman and Ozawa. Oligocene (Hutchinsonian), Otiake, N.Z. × 20.
Fig. 4*a-c*.—*G. yabei* C. & O. Dredgings off the Snares, N.Z., 60 fms. × 40.
Fig. 5.—*G. regina* (Brady, Parker, and Jones). Shallow water, Port Jackson, N.S.W. × 25.
Fig. 6.—*G. regina*, var. *crassicostata* Cushman and Ozawa. Lower Pliocene, Beaumaris, Vic. × 25.
Fig. 7*a-c*.—*G. regina*, var. *chapplei*, var. nov. Holotype of variety. Lower Miocene, Fisher's Point, W. of Cape Otway, Vic. × 30.
Fig. 8.—*G. lactea* (Walker and Jacob). Dredgings off the Snares, N.Z., 60 fms. × 25.
Fig. 9*a-c*.—*G. costulata* (Cushman). Lower Pliocene, Beaumaris, Vic. *a, b*. × 30; *c*, × 40.
Fig. 10*a* and *c*.—*G. seguenzana* (Brady). Dredgings 22 miles E. of Narrabeen, N.S.W. × 25.
Fig. 11.—*G. silvestrii* Cushman and Ozawa. Lower Miocene, marl above limestone, Filter Quarry, Batesford, Vic. × 40.
Fig. 12.—*Globulina gibba* d'Orb Lower Miocene, marl above limestone, Filter Quarry, Batesford, Vic. × 15.
Fig. 13.—*G. gibba*, var. *globosa* (v. Münster). Shore sand, Point Lonsdale. ×15.

PLATE XIII.

Fig. 1*a-c*.—*Guttulina* sp. Upper Cretaceous, Gingin, W.A. *a, b*, × 30; *c*, × 40.
Fig. 2*a-c*.—*Pyrulina fusiformis* (Roemer). L. Miocene, The Ledge, Bird Rock Cliffs, Torquay, Vic. × 30.
Fig. 3*a-c*.—*P. fusiformis*. L. Miocene, marl above limestone, Filter Quarry, Batesford, Vic. × 35.
Fig. 4*a-c*.—*Guttulina yabei* C. & O. Slender form. Shallow water off Black Rock, Vic. × 25.
Fig. 5*a-c*.—*G. yamazakii* Cushman and Ozawa. Lower Pliocene, Beaumaris, Vic. *a, b*, × 30; *c*, × 40.
Fig. 6*a* and *c*.—*Glandulina laevigata* (d'Orb.). Microspheric form. Miocene, Grice's Creek, Vic. × 30.
Fig. 7*a-c*.—*Pyrulina cylindroides* (Roemer). Prickly and fistulose specimen. Miocene, Grice's Creek, Vic. × 30.

PLATE XIV.

Fig. 1*a-c*.—*Pyrulina crespinae*, sp. nov. Holotype. Lower Pliocene, Beaumaris, Vic. × 30.
Fig. 2*a-c*.—*Pseudopolymorphina doanei* (Galloway and Wissler). Lower Pliocene, Beaumaris, Vic. × 25.
Fig. 3.—*P. doanei*, var. *beaumarisensis*, var. nov. Holotype of variety. Lower Pliocene, Beaumaris, Vic. × 30.
Fig. 4*a-c*.—*P. rutila* (Cushman), var. *parri* Cushman and Ozawa. Lower Miocene, Rocky Point, Torquay. *a, b*, × 30; *c*., × 40.
Fig. 5*a-c*.—*Pyrulina fusiformis* (Roemer). Example with uniserial chambers. Miocene, Grice's Creek, Vic. *a, b*, × 25; *c*., × 35.
Fig. 6*a-c*.—*Pseudopolymorphina tasmanica*, sp. nov. Holotype. Lower Miocene, Table Cape, Tas. *a, b*, × 25; *c*., × 30.

Fig. 7*a-c*.—*Polymorphina lingulata* Stache. Oligocene (Hutchinsonian), Chatton Sands, near Gore, South Island, N.Z. × 20.

Fig. 8.—*P. howchini* Cushman and Ozawa. Post-Tertiary, Vic. Geol. Survey bore No. 5, Parish of Wannaeue, near Rosebud, Vic., 177-187 ft. × 20.

Fig. 9.—*Sigmoidella elegantissima* (Parker and Jones). Lower Pliocene, Beaumaris, Vic. × 18.

Fig 10.—*Sigmoidella kagaensis* Cushman and Ozawa. Lower Pliocene, Beaumaris, Vic. × 20.

PLATE XV.

Fig. 1*a-c*.—*Sigmomorphina haeusleri,* sp. nov. Holotype. Upper Eocene (Whaingaroa Series), Motutara Point, Kawhia Harbour, N.Z. × 20.

Fig. 2*a-c*.—*S. chapmani* (Heron-Allen and Earland). Lower Miocene, marl above limestone, Filter Quarry, Batesford, Vic. × 30.

Fig. 3*a-c*.—*S. wynyardensis,* sp. nov. Holotype. Lower Miocene, Table Cape, Tas. *a, b,* × 20; *c,* × 25.

Fig. 4*a-c*.—*Polymorphina myrae,* sp. nov. Holotype. Lower Pliocene, Beaumaris, Vic. *a, b,* × 18; *c,* × 25.

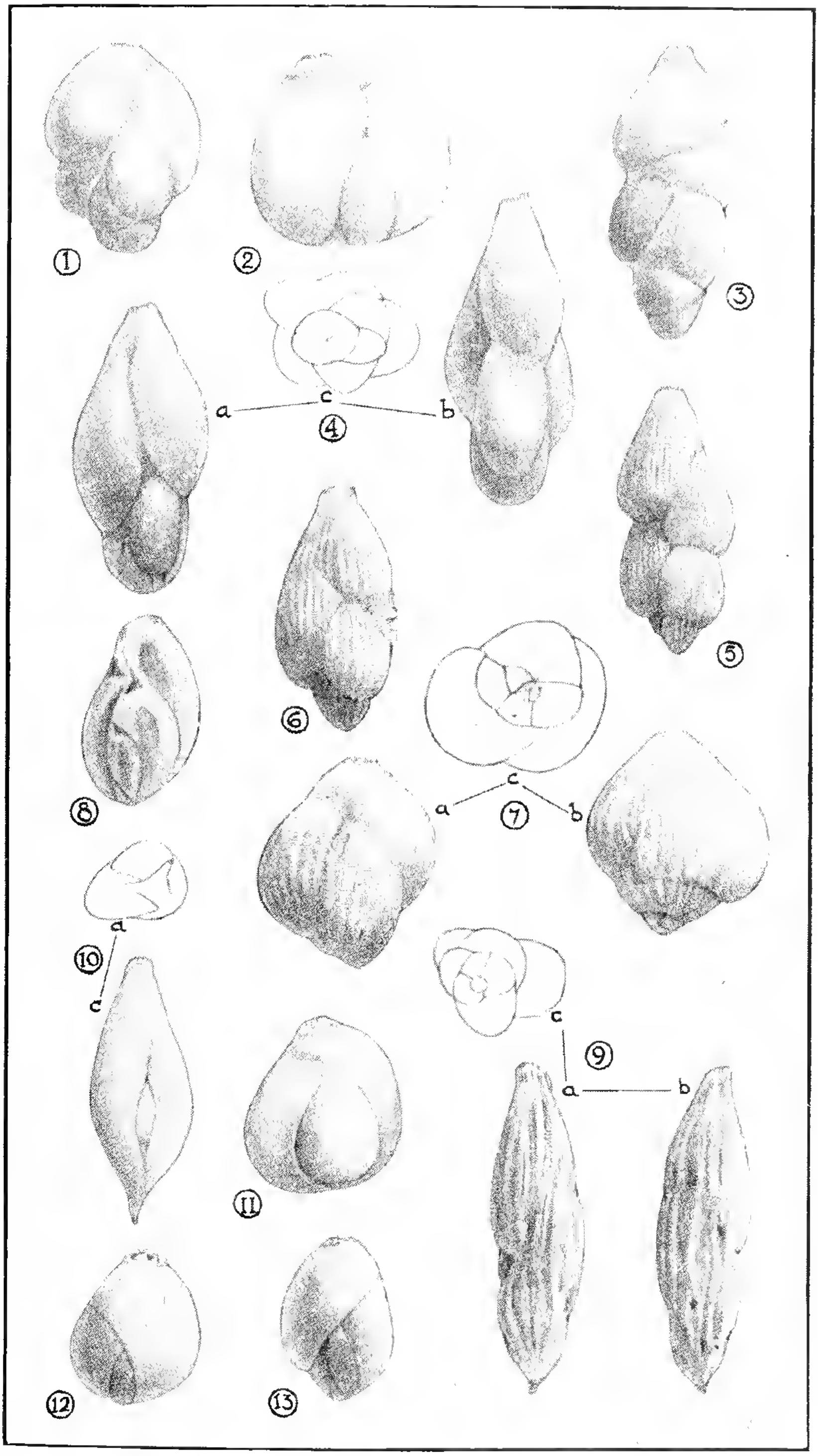
Fig. 5.—*Sigmomorphina williamsoni* (Terquem). Dredgings off the Snares, S. of New Zealand, 60 fms. × 40.

Fig. 6*a-c*.—*S. batesfordensis,* sp. nov. Holotype. Lower Miocene, marl above limestone, Batesford, Vic. × 40.

Fig. 7*a-c*.—*Guttulina clifdenensis,* sp. nov. Holotype. Oligocene (Hutchinsonian), Horizon 6a, Clifden, Southland, N.Z. × 25.

Fig. 8*a-c*.—*Sigmoidella novozealandica,* sp. nov. Holotype. Dredgings N.-E. of Auckland Island, S. of New Zealand, 95 fms. × 25.

Fig. 9*a* and *c*.—*Guttulina lactea,* var. *earlandi* Cushman and Ozawa. Lower Miocene, Muddy Creek, Vic. × 80.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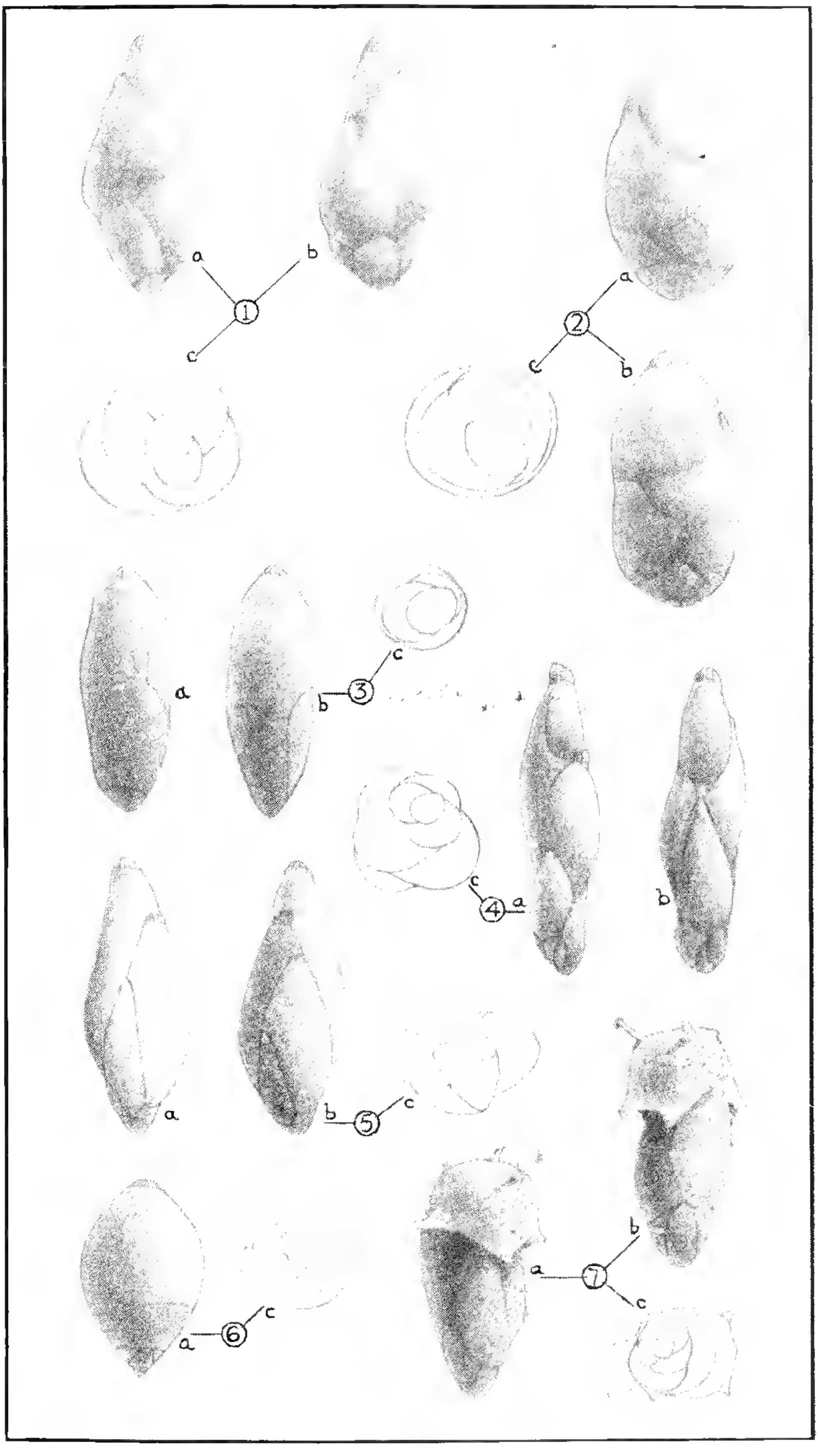

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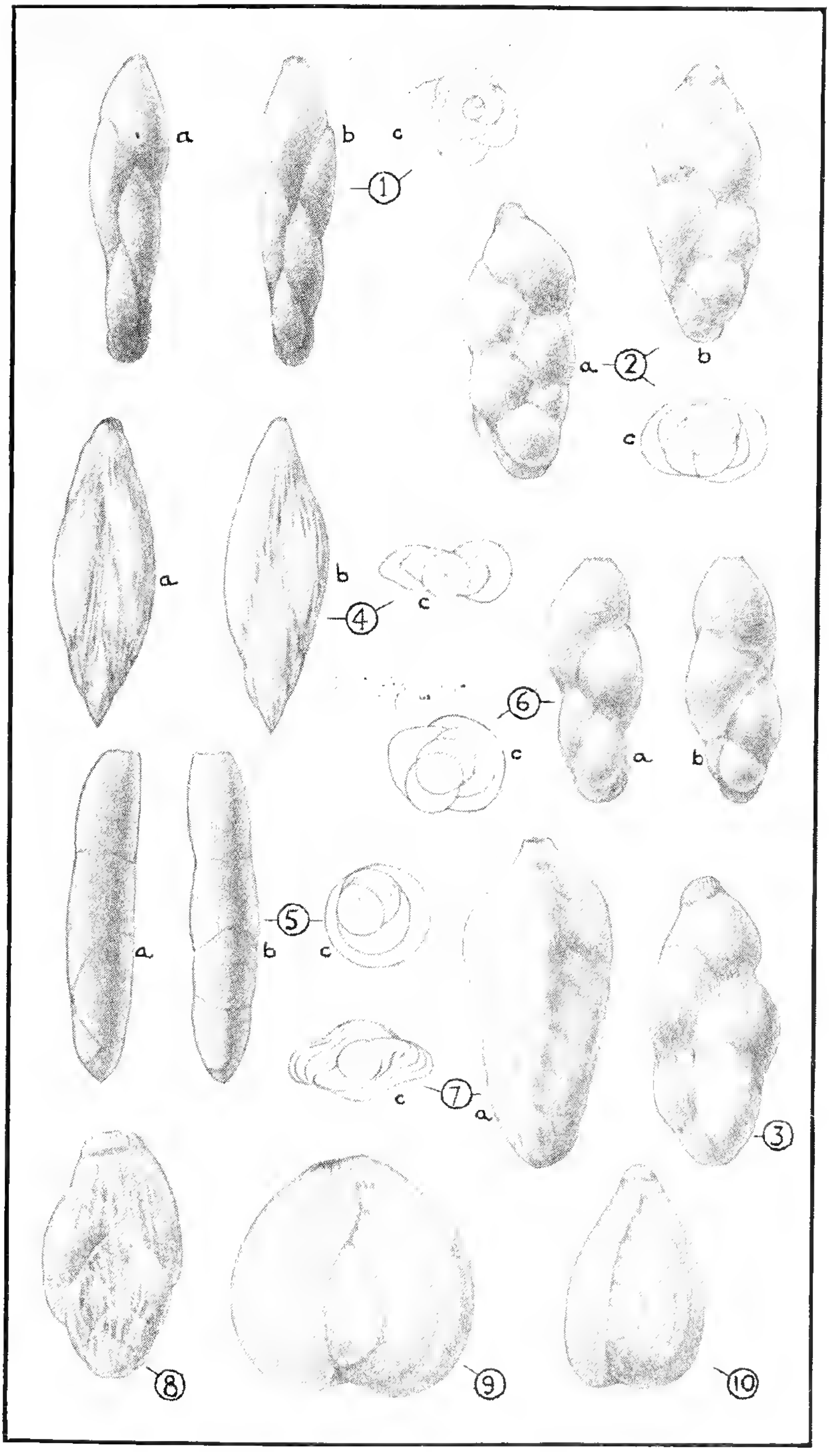
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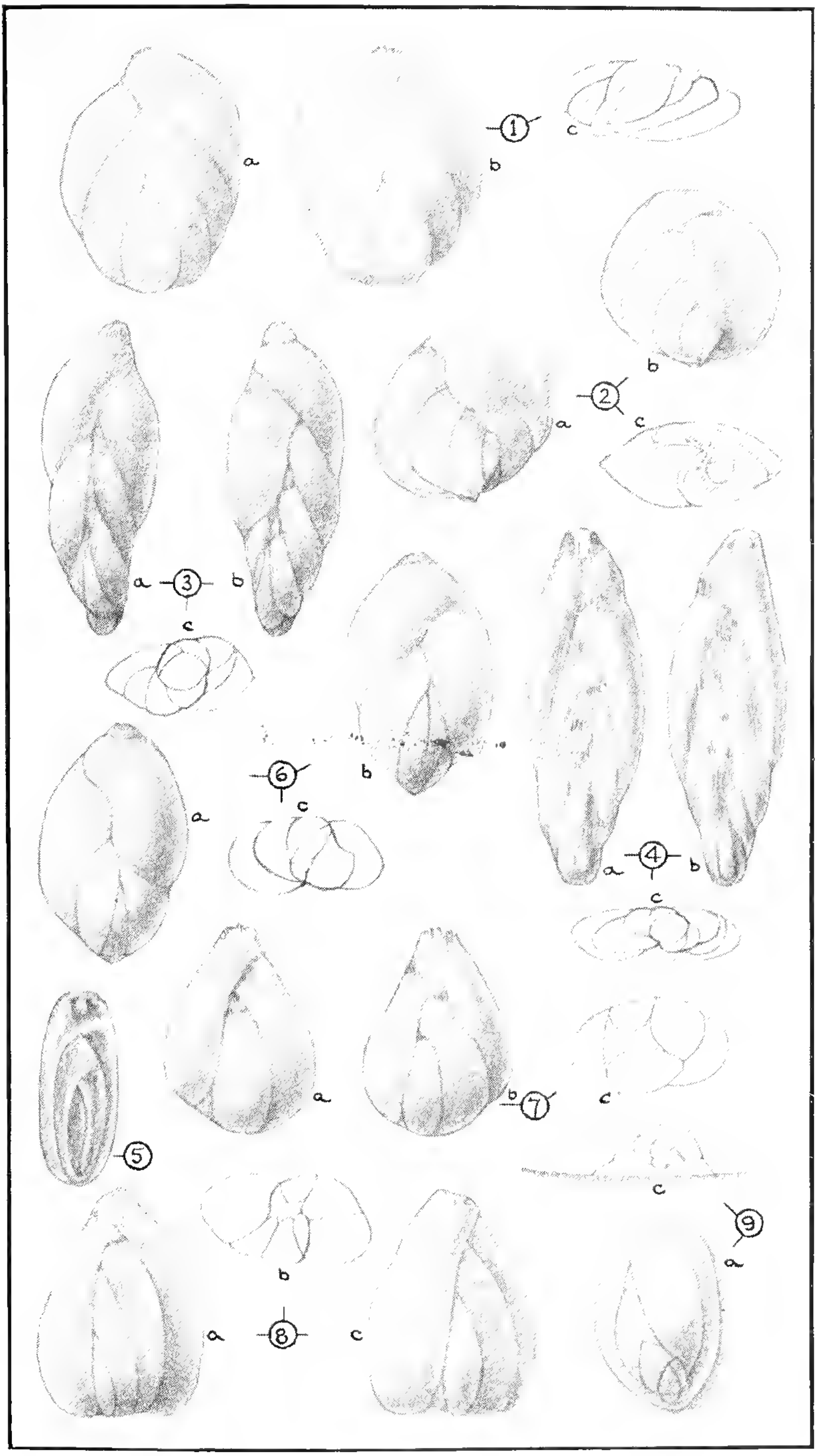
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[Proc. Roy. Soc. Victoria, **50** (N.S.), Pt. II., 1938.]

Art. XII.—*Notes on the Middle Palaeozoic Stromatoporoid Faunas of Victoria.*

By ELIZABETH A. RIPPER, M.Sc., Ph.D.

[Read 14th October, 1937; issued separately, 23rd May, 1938.]

Contents.

Introduction.

The writer has, in a recent series of papers, described the stromatoporoid faunas of the Yeringian limestones of Lilydale (1933, 1937), Loyola (1937), and of the Middle Devonian limestones of the Buchan district (1937), and it now seems appropriate to attempt analyses of these faunas, arriving thereby at a comparison with one another and with the faunas of other regions. In summing up the characteristics of the assemblages after describing the species contained in them, the main stress was laid on the occurrence and relative abundance of those species which had previously been described from other regions. After the examination of some of the typical Silurian and Devonian assemblages, however, it seems possible to trace progressive changes in certain genera which may be employed in assessing the evolutional stages reached by the various Victorian assemblages. It is thus possible, in an analysis based on evolutional considerations, to include the new species, which are, as far as at present known, confined to Victoria, and so complete the summaries of faunal characteristics given in earlier papers.

The Genus ACTINOSTROMA.

The species of the genus *Actinostroma* fall into three well-defined groups, which are distinguished on account of the varying relations between the laminae and pillars.

1. GROUP OF *A. intertextum* Nich.

The radial pillars are fairly long, and give off at intervals whorls of lateral processes which are united to form the irregular, discontinuous horizontal laminae. Tangential sections show a fairly complete "hexactinellid" mesh with angular interspaces, and the radial pillars are rarely isolated even in the interlaminar spaces.

Species[1]:

A. intertextum Nicholson	T
A. intertextum var. *suevicum* Nich.	T
A. astroites (von Rosen)	T
A. tenuissimum Parks.	
A. franklinense Parks.	
A. schmidtii (von Rosen)	S
A. podolicum Yavorsky.	
A. intermedium Yavorsky.	
A. perisum Yavorsky.	
A. perforatum Parks.	
?*A. mirum* Parks.	
A. whiteavesii var. *niagarense* Parks.	

These species are all of Silurian age. A single Devonian species, *A. whiteavesii* Nich. and the Yeringian species *A. altum* Ripper also show these characters.

2. GROUP OF *A. clathratum* Nich.

The radial pillars are rather short, undulating, and give off whorls of lateral processes, as in the species of the first group. These coalesce and form fairly well defined horizontal laminae. Tangential sections show the mesh on the levels of the laminae to be imperfectly "hexactinellid", but the radial pillars are frequently isolated in the interlaminar spaces.

Species:

A. clathratum Nich.	T
A. bifarium Nich.	T
A. hebbornense Nich.	T
A. verrucosum (Goldfuss)	S
?*A. fenestratum* Nich.	T
A. vastum Počta	
A. frustulum Počta	
A. expansum (Hall and Whitfield)	S

These species are all of Devonian age. *A. compactum* Ripper of the Victorian Yeringian also shows these characters.

[1] Throughout the lists of species in these groups, the letter T placed against a form indicates that the type material has been examined by the writer; S indicates that specimens of that species, but not the type material, have been examined. The other species have been grouped on the evidence of descriptions and figures only, and these groupings must be regarded as merely provisional.

3. Group of *A. stellulatum* Nich.

The radial pillars are long and regular; the horizontal laminae are straight, continuous and solid, usually with small perforations. The radial pillars in the interlaminar spaces are isolated. The skeletal fibre in some species may be finely porous, but this is observable only under exceptional conditions of preservation.

Species:

A. vulcanum Parks.	
A. tenuifilatum Parks.	
A. tenuifilatum var. *inflectum* Parks.	
A. tenuifilatum var. *cylindricum* Parks.	
A. matutinum Nich.	T
A. praecursum Parks.	
A. stellulatum Nich.	T
A. stellulatum var. *italica* Gortani.	
A. stellulatum var. *distans* Ripper.	T
?*A. perspicuum* Počta.	
?*A. contextum* (Barrande).	
A. tyrrelli Nich.	T
A. contortum Ripper.	T

Of these species *A. vulcanum* Parks, *A. tenuifilatum* Parks and its varieties, *A. matutinum* Nich. and *A. praecursum* Parks are Silurian; the rest are Devonian.

The specimens of *A. clathratum* identified by Nicholson from the Rough Range, opposite Mt. Krauss, Western Australia (Brit. Mus. Nat. Hist., Reg. Nos. P4463, P4965, P4967), in which the pillars are long and isolated in the interlaminar spaces, but connected by processes forming a perfect "hexactinellid" mesh on the levels of the laminae, are probably transients between groups 2 and 3.

The distribution of Silurian and Devonian species in these three groups suggests that those forms in which the construction of the laminae from the whorls of radiating fibres of the radial pillars is obvious are the more primitive. They are most abundant in the Silurian. The members of group 2 are possibly survivors of this group which have passed up in a modified form into the Devonian. The laminae become strengthened and the whorls of processes are restricted to more clearly defined levels, so that the radial pillars tend to become isolated in the interlaminar spaces. In group 3, consisting mainly of Devonian species, this tendency is still more marked, and the laminae are continuous and sometimes solid, the processes being completely fused to form perforated plates. The radial pillars are isolated in the interlaminar spaces. *A. stellulatum* itself has finely porous skeletal fibre, and forms having thickened, isolated pillars and fine, continuous laminae, e.g., *A. contextum* (Barrande), seem to have affinities with *Syringostroma*. The presence of some forms allied to *A. stellulatum* in the Silurian shows that the tendency towards thickening of the horizontal laminae, or of fusion of the fibres composing them, asserted itself at an early stage in the history of the genus *Actinostroma*.

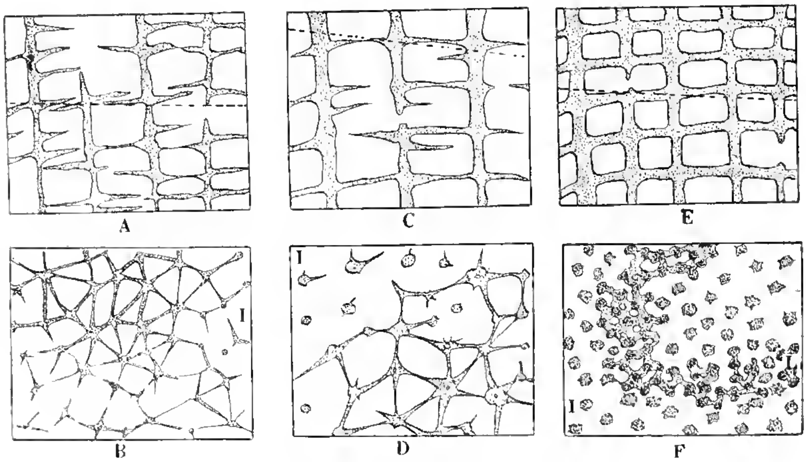

FIG. 1.—Diagrammatic sections illustrating the progressive thickening of the laminae in *Actinostroma*. The longer sides of the rectangles represent 1 mm. approximately. The dotted lines in the vertical sections indicate the approximate positions of the tangential sections. 1A.—*Actinostroma intertextum* Nich. Group of *A. intertextum*. Wenlock. Vertical section, showing long pillars with lateral processes given off in whorls at irregular intervals, forming ill-defined laminae. 1B.—Same species. Tangential section showing the presence of an imperfect "hexactinellid" mesh produced by the lateral processes given off from the pillars at all levels. The processes are, however, concentrated on the planes of the laminae (*l*), and a few isolated pillars are present in the interlaminar spaces (*i*). 1C.—*A. clathratum* Nich. Givetian. Group of *A. clathratum*. Vertical section showing pillars with lateral processes given off in whorls at more or less regular intervals, forming well-defined laminae. 1D.—Same species. Tangential section showing the increased concentration of the lateral processes on the planes of the laminae (*l*), and the presence of isolated pillars in the interlaminar spaces (*i*). 1E.—*A. stellulatum* Nich. Givetian. Group of *A. stellulatum*. Vertical section showing long, straight pillars and horizontal laminae formed by the fusion of lateral processes given off at extremely regular intervals, and almost completely restricted to those levels. 1F.—Same species. Tangential section showing the almost complete restriction of the lateral processes to the planes of the laminae (*l*), which become thick and perforated. The pillars in the interlaminar spaces (*i*) are usually isolated.

The Genus CLATHRODICTYON.

As recognized by Parks (1908) and Počta (1910) the species of *Clathrodictyon* may be grouped according to the relations between the radial pillars and the concentric laminae. Parks (1908) suggested the following groupings for the Niagara species of *Clathrodictyon,* but does not indicate the possible relations between them:

Group of *C. vesiculosum*, containing
- *C. vesiculosum* Nich. and Murie.
- *C. vesiculosum* var. *minutum* Parks.
- *C. vesiculosum* var. *astrodistans* Parks.
- *C. variolare* (von Rosen).

Group of *C. cystosum*, containing
- *C. cystosum* Parks.
- *C. cystosum* var. *lineatum* Parks.
- *C. cystosum* "folded variety" of Parks, passing into
- *C. fastigiatum* Nich.

Group of *C. striatellum*, containing
- *C. striatellum* (d'Orb.)
- *C. ostiolatum* Nich.
- *C. drummondense* Parks.
- *C. rectum* Parks.

Počta (1910) suggests a classification similarly based on the relation between the pillars and laminae. The first group, in which the straight parallel laminae are sharply separated from the pillars, contains:
- *C. regulare* (von Rosen).
- *C. striatellum* (d'Orbigny).
- *C. ostiolatum* Nich.
- *C. jewetti* Girty.
- *C. drummondense* Parks (pars).

The second group contains those species in which the skeletal mesh is vesicular:
- *C. vesiculosum* Nich. and Murie.
- *C. variolare* (von Rosen).
- *C. crassum* Nich.
- *C. fastigiatum* Nich.
- *C. confertum* Nich.
- *C. cystosum* Parks.
- *C. drummondense* Parks (pars).

Počta considers the structure of these species to be almost sufficiently distinct for their separation under another generic name, but adds that *C. striatellum* connects the two groups.

In a later work Parks (1936), as a result of further work on the North American faunas, traces certain evolutional changes in *Clathrodictyon* (p. 12). He suggests that the genus appears to have developed along two distinct lines in the Silurian and Devonian. In the first series of progressive changes the original form, *C. vesiculosum*, with pillars formed by inflections of the laminate, passes into species belonging to the new genus *Stictostroma*, which contains transients between *Clathrodictyon* and *Stromatoporella,* and by the acquisition of a perforate structure in the skeletal tissue into *Stromatoporella* itself. The second line of development indicated by Parks is that dealt with in a later section of the present paper: the strengthening of the laminae and the separation of the pillars as distinct skeletal elements in the species *C. striatellum*, *C. regulare*, *C. clarum* Počta and others. It is noteworthy, however, that Parks considers *C. striatellum* and two or three American species to be divergent types, in which the heads of the pillars break up into strands. This line of development may, according to Parks, give rise to species in the genera *Trupetostroma* and *Parallelopora*. Without venturing an opinion on the American species, however, it may be suggested that *C. striatellum* finds its place equally well in the series *C. vesiculosum*-*C. clarum*, in which the later members are produced by straightening of the laminae and definitions of the radial pillars.

The following classification of the species of *Clathrodictyon* is based on work on the Victorian faunas and is an extension of these two. Some attempt is also made to trace the relations between the various groups.

1. Group of *C. cystosum* Parks.

The skeletal mesh is completely vesicular, with no definite pillars or laminae. The group contains the following species:

C. cystosum Parks	Niagaran.
C. cystosum var. *lineatum* Parks ..	Niagaran.
C. cystosum, "folded variety" of Parks	Niagaran.
C. fastigiatum Nicholson	Wenlock. (T)
C. stylotum Parks	Chaleur Group (Silurian).
C. stylotum var. *crassum* Parks ..	Silurian.
C. cellulosum Nich. and Murie ..	Helderbergian. (T)

and possibly—

C. irregulare Boehnke	Silurian erratics of North Germany.

2. Group of *C. vesiculosum* Nich. & Murie.

This group contains those species of *Clathrodictyon* in which the laminae are thin and crumpled, and the pillars are oblique and indefinite.

C. vesiculosum Nich. and Murie ..	Wenlock. (T)
C. vesiculosum var. *minutum* Parks ..	Niagaran.
C. vesiculosum var. *astrodistans* Parks ..	Niagaran.
C. vesiculosum var. *laminatum* Riabinin ..	Silurian.
C. variolare (v. Rosen)	Ordovician, Silurian. (T)
C. variolare var. *vaigatschense* Yavorsky	Silurian.
C. crassum Nich.	Wenlock. (T)
C. linnarssoni Nich.	Wenlock. (T)
C. rosarium S. Smith	Valentian.
C. conophoroides Eth. fil.	Upper Silurian.
C. confertum Nich.	Middle Devonian. (T)

and possibly—

C. yavorskyi Riabinin	Lower part of Upper Devonian.

3. GROUP OF *C. striatellum* (d'Orbigny).

This group contains those species of *Clathrodictyon* in which the skeletal mesh is regular, with straight pillars formed more or less obviously by the downward inflection of the slightly crumpled laminae:

C. striatellum (d'Orb.)	Ordovician, Wenlock. (S)
C. regulare (v. Rosen)	Wenlock. (S)
C. ostiolatum Nich.	Niagaran. (T)
C. crickmayi Parks	Chaleur Group (Silurian).
C. drummondense Parks	Niagaran.
C. socium Počta	Ee2 of Bohemia (Wenlock).
C. salairicum Yavorsky	Silurian.
C. convictum Yavorsky	Oesel Group (Upper Silurian).
C. alternans Boehnke	Silurian erratics of North Germany.
C. spatiosum Boehnke	Silurian (N. Germany).
C. rectum Parks	Niagaran.
C. calamosum Ripper	Yeringian. (T)
C. regulare var. *cylindrifera* Ripper	Yeringian. (T)
C. regulare var. *carnica* Vinassa	Middle Devonian.
C. jewetti Girty	Helderbergian.
C. neglectum Počta	Ff2 (Lower Devonian).
C. subtile Počta	Ff2.
C. clarum Počta	Ff2.
C. katavensis Yavorsky	Upper part of Middle Devonian.
C. praeternum Yavorsky	Middle Devonian.
C. pseudostriatellum Yavorsky	Middle Devonian.
C. variabilis Riabinin	Upper Devonian.
C. aquisgranense Dantz	Upper Devonian.

and possibly—

C. retiforme Nich. and Murie	Hamilton. (T)

This large group is made up of a number of forms which in themselves admit of no very clear definition, since they are connected by an infinite number of transients, some of which, however, have been distinguished as separate species. Variation in two main features may be taken into account: the degree of crumpling of the laminae and the form of the radial pillars. Considered from this point of view, the group is seen to contain a few conspicuous and abundant forms, e.g., *C. striatellum*, *C. regulare*, *C. clarum* and *C. calamosum*, which are connected by a series of forms in which there is much individual variation. Nicholson in assigning wide limits of variation within those species defined by him showed his full appreciation of these relationships. The species of this group show an advance on those of groups 1 and 2 in the more complete differentiation of the laminae, and it is worthy of note that it contains a large number of Devonian species, while the first two are almost exclusively Silurian.

4. Group of *C. chapmani* Ripper.

This is a rather ill-defined group containing those species of *Clathrodictyon* in which the pillars and laminae are distinct, usually at right angles. The laminae are usually straight.

C. sajanicum Yavorsky	Cambrian.
C. chapmani Ripper	Yeringian. (T)
C. bohemicum Počta	Ee2 (Wenlock).
C. laxum Nich.	Helderbergian.
C. carnicum Charlesworth	Devonian.
C. tschusovensis Yavorsky	Lower part of Upper Devonian.
C. incubonum Yavorsky	Devonian.

and possibly—

C. laminatum Boehnke	Silurian (North Germany).
C. dirschkeimense Boehnke	Silurian (North Germany).

Though none of these groups can be correlated exclusively with a particular stratigraphical horizon, and the progressive changes within the genus *Clathrodictyon* are consequently less obvious than in *Actinostroma*, a general relationship between the prevailing type of skeletal mesh and the horizon can never-the less be discerned. The first two groups, in which the elements of the skeletal mesh are little differentiated contain mainly Silurian species; the second group, of *C. vesiculosum*, in which the pillars are more distinctly separated from the crumpled laminae, includes two Devonian species, one of which, however, is probably identical with *C. vesiculosum* itself. Further stages in the separation of the pillars and laminae are to be seen in group 3, where the laminae are straight, arched or crumpled only at the points where their downward inflections form the pillars. *C. striatellum* itself is a relatively primitive form in this group, in which the origin of the pillars from the laminae is still clearly recognizable. *C. calamosum* is similar, but has tubular pillars and passes gradually through *C. convictum* into *C. regulare* and *C. clarum*, in which the pillars are solid and the laminae gently arched or straight. This third group has a long range in time, for in addition to containing a large number of Devonian species, many of the forms are characteristic of the Wenlock, though some of these are known to occur at higher levels. *C. striatellum* has also been recorded from the Ordovician.

The type of skeletal structure seen in the species of the fourth group has a long range in time, being observed in the only known Cambrian species, *C. sajanicum* Yavorsky. *C. chapmani* itself appears to have an abnormal skeletal mesh; the laminae are straight, and distinct from the pillars, but the interlaminar spaces are filled with a finer mesh composed of subsidiary incomplete pillars and laminae, a feature suggesting that over-secretion of calcium carbonate has taken place. It is possible that the forms in this group are merely special phases derived from species in group 3 by the action of environmental causes.

The Genera SYRINGOSTROMA and STROMATOPORA.

The genus *Syringostroma* is in some respects intermediate between *Actinostroma* and *Stromatopora*, and some of its species form a complete series, first recognized by Parks (1909), passing by a thickening of the horizontal laminae from forms in which the horizontal and vertical skeletal elements are well differentiated, e.g., *S. nigarense* Parks, to those in which the skeletal mesh is reticulate, e.g., *S. barretti* Girty. The Victorian species of *Syringostroma*, which so far have been found only in the Yeringian fauna of Lilydale, correspond well with the North American species, being described as *S.* aff. *niagarense* Parks, *S.* aff. *ristigouchense* (Spencer) and *S. densum* Nicholson. The first two are early transients in the series, occupying positions between the two species with which affinities are suggested. The third, while approaching *Stromatopora* in the increasing reticulation of the skeletal mesh, is probably only remotely connected with the members of Parks' series, since the skeletal mesh is much finer, and the radial pillars are much more slender than in those species.

As noted in an earlier paper (Ripper, 1937), the species of *Stromatopora* fall into two more or less distinct groups. The group of *S. concentrica* Goldfuss contains many Silurian and Helderbergian species in which the coenosteum is usually latilaminar and in which the horizontal laminae are comparatively well developed. This group includes *S. foveolata* (Girty), *S. typica* von Rosen, *S. constellata* Hall and *S. concentrica* Goldfuss, all of which seem to show a continuation of the tendency towards the thickening of the laminae already seen in *Syringostroma*. This progressive change is well seen in the species of *Syringostroma* occurring at Lilydale (Ripper, 1937) and has been dealt with also by Parks (1909) in describing the Helderbergian species of North America.

The second group, of *Stromatopora hüpschii* (Bargatzky), contains those forms, usually characteristic of the Middle Devonian, in which the horizontal laminae are poorly developed, being reduced to sparsely distributed processes joining the relatively stout, straight radial pillars. Such species are *S. beuthii* Barg., *S. hüpschii* (Barg.), *S. bücheliensis* (Barg.), *S. gentilis* Gortani and *S. lilydalensis* Ripper. It is not at present possible to trace any evolutional connection between these two types of structure in the genus *Stromatopora*.

Evolutional Changes in the Stromatoporoidea.

At least two well defined evolutional changes, affecting four of the genera, are discernible in this group. The evidence for these has been obtained from the examination of British and Victorian material, and from a consideration of the stromatoporoid faunas occurring elsewhere. In the summary of results which follows frequent reference will be made to the classifications of the species of some of the genera, already given in an earlier section.

(*a*) *Thickening of the Horizontal Laminae.*—This change affects *Actinostroma* (see Fig. 1), *Syringostroma* and *Stromatopora* (see Fig. 2). The genus *Actinostroma* as at present known, includes three main types of skeletal mesh, and its species may consequently be grouped thus:—

1. Group of *A. intertextum* Nich.
2. Group of *A. clathratum* Nich.
3. Group of *A. stellulatum* Nich.

The first group, with dominant, though irregular, radial pillars, giving off at irregular intervals whorls of radiating horizontal processes which coalesce to form the discontinuous horizontal laminae, is almost exclusively Silurian, containing but one Devonian, and one Yeringian species. The second group has a more regular skeletal mesh, in which the laminae are thicker and more conspicuous. The radial pillars are short, undulating, and give off at more regular intervals whorls of lateral processes, which more frequently coalesce to form a horizontal lamina. The species in this group are all of Devonian age, and include one from the Yeringian of Victoria. The third group shows a still more complete development of the horizontal laminae. The radial pillars are long and regular, and the whorls of processes are no longer obvious, but are completely fused in the thickened lamina, which is continuous and solid, usually with small perforations. This group includes both Silurian and Devonian species. The three types of skeletal mesh are readily separated in tangential section. Species belonging to the group of *A. intertextum* usually show at all levels a fairly complete "hexactinellid" mesh, formed by the processes given off from the radial pillars. There is as yet little differentiation of the laminae. In *A. clathratum* and allied species belonging to the second group the tangential section shows an imperfect "hexactinellid" mesh on the levels of the laminae, but between the laminae the pillars tend to be isolated. *A. clathratum* itself is very variable in this respect, and obviously includes a number of transitional forms, in which the lateral processes are to varying extents restricted to definite levels, i.e., those of the laminae. Tangential sections of *A. stellulatum* and allied species (group 3) show a marked increase in the definition of the laminae, which are solid and retain no trace of the "hexactinellid" mesh. The radial pillars are isolated in the interlaminar spaces.

This change expresses itself in the genus *Actinostroma*, therefore, in the increasing concentration of the lateral horizontal processes, given off originally at indefinite intervals, on regularly spaced levels. The horizontal and vertical skeletal elements thus become progressively more distinct. The laminae formed by the fusion of the lateral processes become thicker and more regular, and, in the most advanced forms, little or no trace of the "hexactinellid" mesh formed by the processes in an imperfect state of fusion remains.

A similar progressive change can be traced in the species of *Syringostroma.* Beginning with the primitive form *S. niagarense* Parks of the Niagaran, in which the exceedingly thin, crowded laminae are crossed by long, thickened pillars, it is possible to arrange these forms in a series in which the laminae, at first concentrated in small groups, become thicker and coalesce. The small groups become separated by interspaces somewhat wider than the normal interlaminar space and occupied usually by astrorhizal canals, and the pillars tend to become restricted to the small groups, so that these are eventually transformed into the latilaminae characteristic of certain species of *Stromatopora.* In tangential sections the radial pillars of the earlier forms are still readily distinguishable and are connected, only on the levels of the laminae, by narrow lateral processes. In later forms the processes are broader and produce a vermiculate mesh in which the pillars are no longer readily distinguishable. The change thus has the effect, in this group of species, of destroying the identity of the laminae and pillars, as separate elements of the skeletal mesh.

This group of species belongs in part to *Syringostroma* and in part to *Stromatopora*, but it is difficult to determine the boundaries of these two genera. Parks (1909) has suggested that *Syringostroma* should include those species in which the thin laminae and round, isolated pillars are still easily recognizable as distinct skeletal elements, while those forms in which the laminae are thick and close together, and in which the radial pillars are no longer distinguishable in tangential section from their connecting processes should be placed in *Stromatopora.* The following is, with additions, the series suggested by Parks:—

Syringostroma niagarense Parks	..	Niagaran.
S. centrotum Girty ..	.. ..	Helderbergian.
S. ristigouchense (Spencer)	.. ..	Helderbergian.
S. consimile Girty ..	.. ..	Helderbergian.
S. microporum Girty ..	.. ..	L. Helderbergian.
S. barretti Girty ..	.. ..	L. Helderbergian.
S. densum Nicholson ..	.. ..	U. Helderbergian
Stromatopora constellata Hall ..	..	Niagaran.
S. typica von Rosen ..	.. ..	Wenlock.
S. foveolata (Girty) ..	.. ..	L. Helderbergian.
S. concentrica Goldfuss	.. ..	Givetian.
S. concentrica var. *colliculata* Nicholson		Givetian (M. Devonian).

The Victorian forms described as *Syr.* aff. *niagarense* Parks and *S.* aff. *ristigouchense* (Spencer) are early transients in this series. The first is somewhat more advanced than *S. niagarense* and the second has not yet reached the stage of thickening of the laminae seen in *S. ristigouchense.*

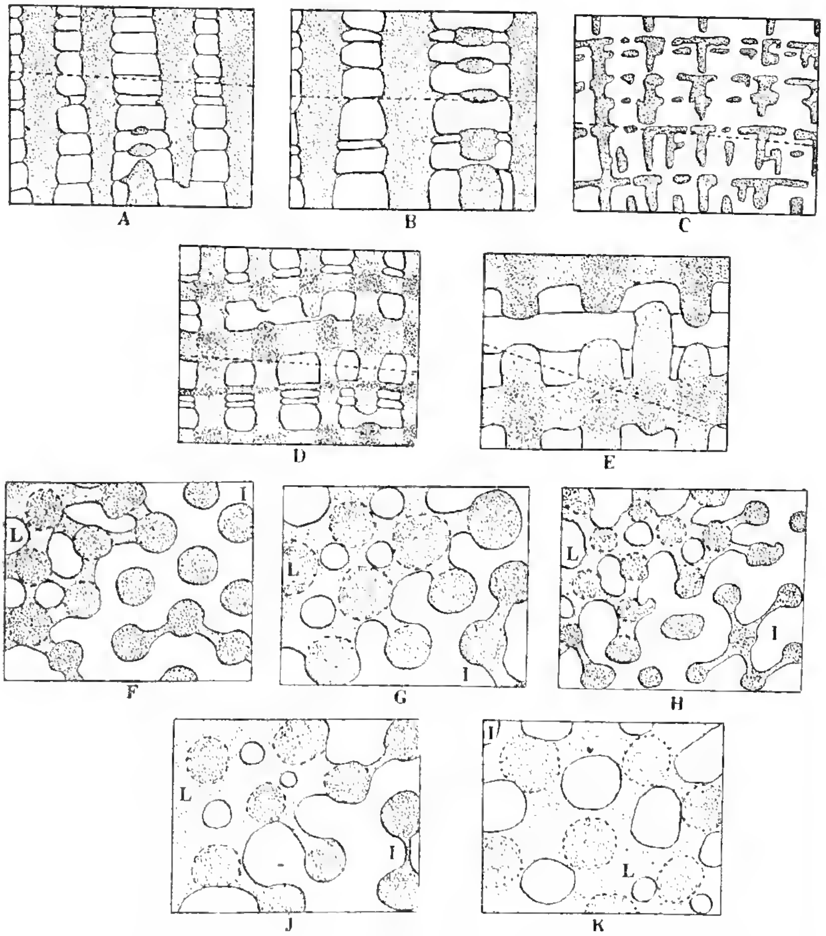

FIG. 2.—Diagrammatic section illustrating the progressive thickening of the laminae in the series *Syringostroma Stromatopora*. The dotted lines drawn across the vertical section show the approximate positions of the tangential sections. The longer sides of the rectangles represent approximately 1 mm. 2A.—*Syringostroma* aff. *niagarense* Parks. Yeringian. Vertical section. The thick, regular radial pillars traverse a great number of the thin, evenly-spaced laminae. 2B.—*S.* aff. *ristigouchense* (Spencer). Yeringian. Vertical section. The radial pillars have increased in thickness, and the laminae, though still thin, are arranged in small groups 2C.—*S. densum* Nich. Yeringian and Upper Helderbergian. Vertical section. The mesh is reticulate, made up of the irregular, broken radial pillars and the thickened, discontinuous laminae, which are grouped into latilaminae. This form, while illustrating the progressive change, is probably not closely related to the other members of the series. 2D. *Stromatopora foveolata* (Girty). Yeringian, Lower Helderbergian and Middle Devonian. Vertical section. The radial pillars are distinct, short, and the laminae are thickened and arranged in small groups, forming latilaminae. 2E.—*S. concentrica* Goldfuss. Givetian. Vertical section. The skeletal mesh

(*continued opposite*)

b. Progressive changes in *Clathrodictyon* (see Figs. 3 and 4).

The species of *Clathrodictyon* fall into four groups:—

1. Group of *C. cystosum* Parks
2. Group of *C. vesiculosum* Nich. & Murie
3. Group of *C. striatellum* (d'Orbigny)
4. Group of *C. chapmani* Ripper,

of which only the first three will be considered here, since the relations of the fourth are as yet imperfectly known. The mesh in the first group, which contains but one Helderbergian species, the rest being Silurian, is completely vesicular, the laminae are crumpled and the spaces of the skeletal mesh are irregular in size and shape, being formed by the downward inflection of the laminae at irregular intervals. In some forms, e.g., *C. cystosum* var. *lineatum* Parks, the laminae become straighter, but distinct radial pillars are still absent. The second group is similar, but the mesh is more regular, and the laminae are straighter, so that the vesicles of the skeletal mesh tend to be arranged in lines. Some forms included in *C. vesiculosum* by Nicholson appear to be transients towards the forms in group 1. This group is mainly Silurian, but includes two species occurring in the Devonian, of which one, *C. confertum* Nich., is probably the Devonian representative of *C. vesiculosum*. In the third group, which contains as well as some forms typical of the Wenlock a large number of Devonian species, the pillars are for the first time recognizable as distinct structures. The skeletal mesh is usually regular, the laminae are slightly crumpled, arched, or straight, and the pillars are complete and at right angles to them. In some of the species e.g., *C. striatellum* and *C. calamosum*, the pillars are still obviously formed by the downward inflection of the laminae, being thickened at their upper ends, conical or tubular. A number of forms occurring in the Victorian faunas may be regarded as being transitional between these species and those, e.g., *C. convictum*

is reticulate, but the radial pillars are still distinct and thick. The laminae are thickened and grouped into latilaminae. 2F.—*Syringostroma* aff. *niagarense* Parks. Tangential section. The radial pillars are usually isolated in the interlaminar spaces (*i*), and are connected by lateral processes on the levels of the laminae (*l*). In this and the following diagrams the positions of the pillars in the horizontal laminae are suggested by the dotted outlines and heavier shading. 2G.—*S.* aff. *ristigouchense* (Spencer). Tangential section. The pillars on the levels of the laminae (*l*) are connected by broader processes, and few are isolated, even in the interlaminar spaces (*i*). 2H.—*S. densum* Nich. Tangential section. Some pillars remain isolated in the interlaminar spaces (*i*). 2J.—*Stromatopora foveolata* (Girty). Tangential section. The radial pillars are sometimes isolated in the interlaminar spaces (*i*), and are connected on the levels of the laminae (*l*) by broad processes, so that the laminae are thick, with small perforations. 2K.—*S. concentrica* Goldfuss. Tangential section. The radial pillars are seldom isolated. The processes connecting them are broader on the levels of the laminae (*l*), so that these have small perforations. The interlaminar spaces (*i*) are thus ill-defined, and the mesh is reticulate.

Yavorsky, *C. regulare* and *C. clarum*, in which the derivation of the solid pillars from the laminae is not so obvious. Some of these forms are closest to *C. regulare* while showing affinities with *C. striatellum*, and others occupy a position between *C. convictum* and *C. calamosum*. These species of *Clathrodictyon* may thus be arranged in the following evolutional series, beginning with the most primitive form:—

C. striatellum (d'Orb.).
C. calamosum Ripper.
C. convictum Yavorsky.
C. regulare (von Rosen).
C. clarum Počta.

This evolutional change expresses itself in the genus *Clathrodictyon*, therefore, in the increasing regularity of the skeletal mesh observed on passing from lower to higher horizons, and in the progressive separation of the horizontal and vertical skeletal elements. The forms in groups 1 and 2, with a more or less completely vesicular mesh are very largely Silurian, though some species belonging to group 3 are also characteristic of Wenlock assemblages. This group, characterized by the regularity of its skeletal mesh, persists into the Devonian, and contains many species which are, as far as known, confined to that system.

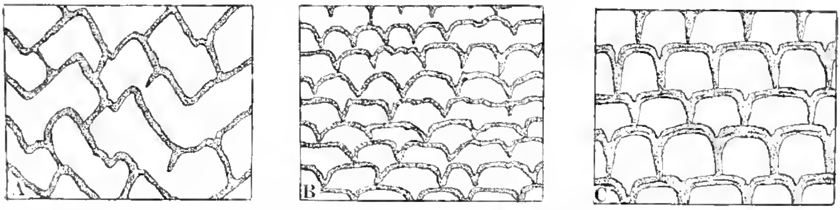

FIG. 3.—Diagrammatic vertical sections illustrating evolution in *Clathrodictyon*. The longer sides of the rectangles represent approximately 1 mm. 3A.—*C. fastigiatum* Nich. Wenlock. Group of *C. cystosum*. The laminae are irregularly crumpled and the radial pillars are imperfect. The skeletal mesh is irregularly vesicular. 3B.—*C. vesiculosum* Nich. & Mur. Wenlock. Group of *C. vesiculosum*. The laminae are minutely crumpled, forming imperfect radial pillars by their downward inflection at fairly regular intervals. The vesicles of the skeletal mesh tend to be arranged in lines. 3C.—*C. regulare* (von Rosen). Wenlock and Devonian. Group of *C. striatellum*. The laminae are arched between the pillars and form regular radial pillars by their downward inflection at regular intervals.

The stratigraphical significance of these progressive changes is shown by the occurrence in the Silurian of assemblages containing species of *Actinostroma* belonging to the group of *A. intertextum* Nich., species of *Clathrodictyon* belonging to the groups of *C. cystosum* Parks, *C. vesiculosum* Nich. and Murie and *C. striatellum* (d'Orb.) (early and intermediate forms), and early transients in the series *Syringostroma–Stromatopora*. *Act. intertextum*, *C. variolare* and *C. striatellum* appear also in the Ordovician, together with many forms of *Labechia*, a genus which, however, is not dealt with here. Species of *Stromatopora* belonging to the group of *S. concentrica*, e.g., *S. typica* von Rosen, are characteristic of Wenlock assemblages. Middle Devonian assemblages, on the other hand, contain few or none of the more primitive species, and are characterized by the presence of species of *Clathrodictyon* belonging to the group of *C. striatellum*, particularly the most advanced forms, *C. regulare* and *C. clarum*, species of *Actinostroma* belonging to the groups of *A. clathratum* and *A. stellulatum*, and species of *Stromatopora* belonging to the group of *S. hüpschii*. Of the group of *S. concentrica* only the most advanced form, *S. concentrica* itself, is abundant. *Syringostroma* is rare or absent, and of the species of *Clathrodictyon* having a vesicular skeletal mesh only *C. confertum* remains. The primitive group of *A. intertextum* has disappeared. Lower Devonian faunas are transitional, containing intermediate forms in the *Syringostroma–Stromatopora* series, some vesicular species of *Clathrodictyon* and the intermediate forms in the group of *C. striatellum*.

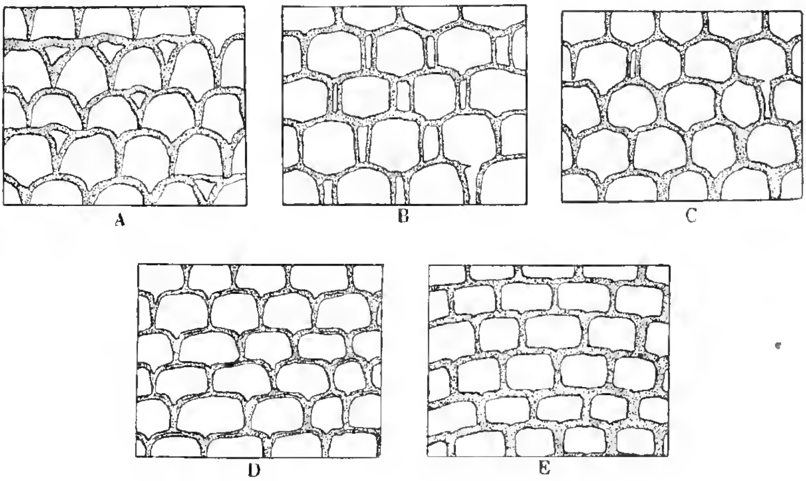

FIG. 4.—Diagrammatic vertical sections illustrating evolution within the group of *Clathrodictyon striatellum* (d'Orb.). The longer sides of the rectangles represent approximately 1 mm. 4A.—*C. striatellum* (d'Orb.). Wenlock. The horizontal laminae are arched, crumpled, and form fairly regular radial pillars which may be conical. 4B.—*C. calamosum* Ripper. Yeringian. The horizontal laminae are becoming straighter, and form by their downward inflection fairly regular pillars which are often tubular. 4C.—*C. convictum* Yavorsky. Upper Oesel Group and Middle Devonian. The horizontal laminae are straight or slightly crumpled; the radial pillars, which are occasionally tubular, are regular. 4D.—*C. regulare* (von Rosen). Wenlock and Devonian. The laminae are arched and form by their downward inflection regular radial pillars which are usually solid. 4E.—*C. clarum* Počta. Devonian. The laminae are straight, rarely crumpled. The radial pillars are straight, solid, complete, and are not obviously formed by the downward inflection of the laminae.

Distribution of Species Occurring in Victoria.

The following list gives the stromatoporoid species so far described from Victoria and the localities at which they occur.

Species.	Localities.						
	Yeringian.		M. Devonian.				
	Loyola.	Lilydale.	Rocky Camp.	Nr. Hicks'.	Citadel Rocks.	Cameron's Quarry.	Heath's Quarry.
Act. verrucosum (Goldf.)	..	x	..	..	..	..	..
A. altum Ripper	..	r.	..	..	..	..	..
A. compactum Ripper	..	c	c	..	..	..	cc
A. stellulatum var *distans* Ripper ..	..	..	..	..	..	..	cc
A. contortum Ripper	..	..	c	x	..	..	x
Cl. regulare (v. Rosen)	cc	x	..	x	..	..	r
C. regulare var *cylindrifera* Ripper ..	..	fc	..	..	..	..	..
C. calamosum Ripper	..	fc	..	..	..	..	..
C. chapmani Ripper	aff	r	..	..	..	..	..
C. convictum Yavorsky	..	..	..	..	..	..	x
C. convictum var. *delicatula* Ripper ..	..	..	r	..	..	c	..
C. clarum Počta	..	..	c	x	..	x	..
Syr. aff. *niagarense* Parks	..	fc	..	..	..	..	..
S. aff. *ristigouchense* (Spencer)	..	c	..	..	..	..	..
S. densum Nich.	..	r	..	..	..	..	..
Str. typica von Rosen	cc	..	..	..	..	..	..
S. foveolata (Girty)	..	fc	..	..	..	..	..
S. aff. *foveolata* (Girty)	..	..	r	..	..	..	..
S. concentrica Goldfuss	..	..	c	c	x	cc	fc
S. concentrica var. *colliculata* Nich. ..	..	..	x	fc	..	..	fc
S. hüpschii (Barg.)	..	..	?	..	x	..	..
S. aff. *hüpschii* (Barg.)	..	r	..	..	..	..	..
S. bücheliensis (Barg.)	r	c	..	..	..	..	..
S. bücheliensis var. *digitata* Nich.	..	r	..	..	..	..	..
S. lilydalensis Ripper	..	cc	..	..	..	..	..
Hermatostroma episcopale Nich.	..	r	..	..	..	..	r
H. episcopale var. *buchanensis* Ripper ..	..	..	..	fc	..	..	..
Stromatoporella granulata Nich.	..	r	..	..	..	..	..
S. cf. *damnionensis* Nich.	..	r	..	..	..	..	..
S. sp. indet.	r	..	..	..	..	..	..
Idiostroma oculatum Nich.	..	cc	..	..	..	..	..

In this table :— x indicates the occurrence of a species.
r indicates that it is rare.
fc indicates that it is fairly abundant.
c indicates that it is abundant.
cc indicates that it is very abundant.

Analysis of Victorian Stromatoporoid Faunas.

The fauna of each Victorian locality is analyzed separately. The evolutional stages reached by some of the species, taking into consideration the changes already described, and their stratigraphical significance are then discussed. As seen in a previous section, the species of four genera may be grouped according to the evolutional stages reached along two lines of development. No evolutional connection beween the species of different genera, with the exception of those of *Syringostroma* and *Stromatopora*, is suggested, however. By placing the Victorian species in their appropriate groups, and determining the proportions of these groups in each fauna by a percentage method, the evolutional stages reached by the assemblages have been evaluated. These data provide the basis for a comparison of the Victorian faunas with one another.

The Yeringian Fauna of the Lilydale Limestone (Ripper, 1933, 1937).—From the point of view of the evolutional stages reached by some of the species, the following analysis of the fauna may be suggested. In this analysis, as well as those which follow, the letter A placed before a group indicates that it has reached an advanced evolutional stage. Those groups marked P are primitive, and the rest occupy intermediate positions in the groups to which they are assigned. The relative proportions of each group in the fauna are indicated by the percentages, which are based on an assemblage of 58 specimens.

1. *Actinostroma.*

	%	
P. Group of *A. intertextum* Nich. ..	1.5	*A. altum* Ripper.
A. Group of *A. clathratum* Nich. ..	10	*A. verrucosum* Goldf. *A. compactum* Ripper.

2. *Clathrodictyon.*

A. Group of *C. striatellum* (d'Orb.) ..	14	*C. calamosum* Ripper. *C. regulare* (v. Rosen) and var. *cylindrifera* Ripper.
Group of *C. chapmani* Ripper	1.5	*C. chapmani* Ripper.

3. *Syringostroma–Stromatopora* transients.

	14	*Syr.* aff. *niagarense* Parks. *S.* aff. *ristigouchense* (Spencer). *S. densum* Nich.
	5	*Str. foveolata* (Girty).

These are early and moderately advanced transients in this series.

4. *Stromatopora.*

	%	
A. Group of *S. hüpschii* (Barg.) ..	34	*S.* aff. *hüpschii* (Barg). *S. bücheliensis* (Barg.) and var. *digitata* Nich. *S. lilydalensis* Ripper.

The Yeringian Fauna of the Limestone at Griffith's Quarry, Loyola (Ripper, 1937).—This small fauna contains as far as at present known, only four species, of which three have already been described from other regions: The fourth is closely allied to *Clathrodictyon chapmani* Ripper of the Lilydale limestone. The presence of such typically Silurian species as *C. regulare* and *Stromatopora typica,* and the rarity of the Devonian species *S. bücheliensis* suggests that this fauna may well be somewhat older than that of Lilydale. The percentages in the following table, showing the relative abundance of these species, are based on an assemblage of 17 specimens, excluding a few of doubtful affinities.

Species.	Horizon.	Percentage.	Other Localities.
		%	
Cl. regulare (v. Rosen) ..	Wenlock ..	29	Great Britain, Gotland
C. aff. *chapmani* Ripper ..	Yeringian ..	17·5	Lilydale
Str. typica v. Rosen ..	Wenlock ..	35	Great Britain, Gotland
S. bücheliensis (Barg.) ..	Givetian ..	6·5	Devon. Eifel. Paffrath

THE DEVONIAN FAUNAS OF THE BUCHAN DISTRICT (Ripper, 1937).—In an earlier paper, stromatoporoid faunas were described from five localities in this district. The stromatoporoids are abundant and of varied types, but the faunas are usually made up of a relatively small number of species.

Citadel Rocks, Murrindal River.—Only two species, *Stromatopora concentrica* Goldf. (1 example) and *S. hüpschii* (Barg.) (2 examples), both occurring also in the Middle Devonian limestone of the Torquay district, S. Devon, and in the Givetian of the Eifel, Germany, have so far been found.

Near Hicks', Murrindal.—The evolutional stages reached by those species in which they are determinable, and the relative abundance of those species, are shown in the following analysis of the fauna. The percentages are based on an assemblage of 19 specimens.

1. *Actinostroma.*

A. Group of *A. stellulatum* Nich. ..	*A. contortum* Ripper ..	5

2. *Clathrodictyon.*

A. Group of *C. striatellum* (d'Orb) ..	*C.* cf. *clarum* Počta ..	5
	C. regulare (v. Rosen)	5
Group of *C. chapmani* Ripper	*C.* aff. *chapmani* Ripper	5

3. *Stromatopora.*

A. Group of *S. concentrica* Goldfuss ..	*S. concentrica* Goldf. ..	37·
	and var. *colliculata* Nich.	16

These are the end-terms of the series *Syringostroma Stromatopora.* This assemblage is definitely Middle Devonian in aspect, since the majority of the species occur on this horizon elsewhere, and of the three most abundant forms, *S. concentrica*, *S. concentrica* var. *colliculata* and *Hermatostroma episcopale* var. *buchanensis* Ripper (26 per cent. of the assemblage), the first two are probably restricted to this horizon. *Cl. regulare*, a species typical of the Wenlock, has been found in the Lower-Middle Devonian of France (Le Maitre, 1934), and this form is also present in the limestones at Heath's Quarry, Buchan.

Cameron's Quarry.—This fauna is a small one, containing only four species, whose relative abundance is shown below. The percentages are based on an assemblage of 15 specimens.

	%
Clathrodictyon clarum Počta	20
C. confertum Nicholson	7
C. convictum var. *delicatula* Ripper	33
Stromatopora concentrica Goldfuss	40

Of these, *C. confertum* and *S. concentrica* are well-known Middle Devonian forms in Europe, and *C. clarum* is abundant in the Lower Devonian (Ff2) of Bohemia. The remaining form is closely allied to *C. convictum* Yavorsky of the Upper Oesel (Upper Silurian) of Kattripank, Oesel, and occurs also, though rarely, in the limestone at Rocky Camp, Buchan.

Rocky Camp, Commonwealth Quarries.—The fauna consists of 9 species, of which 5 also occur in other faunas:—

Clathrodictyon clarum Počta	Ff2—Bohemia.
Stromatopora foveolata (Girty) ..	Helderbergian—New York.
S. concentrica Goldfuss	Givetian—Devon, Eifel.
S. concentrica var. *colliculata* Nich. ..	Givetian—Devon, Eifel.
S. hüpschii (Barg.)	Givetian—Devon, Eifel.

The affinities of the remaining species, and their relative abundance, may best be indicated in an analysis of the fauna, showing the evolutional stages reached by some of the species. The percentages are based on an assemblage of 40 specimens.

		%
1. *Actinostroma.*		
A. Group of *A. clathratum* Nich. ..	*A. compactum* Ripper	7.5
A. Group of *A. stellulatum* Nich. ..	*A. contortum* Ripper	42.5
2. *Clathrodictyon.*		
A. Group of *C. striatellum* (d'Orb.) ..	*C. regulare* (v. Rosen)	2.5
	C. convictum var. *delicatula* Ripper.	2.5
	C. clarum Počta	12.5
3. *Stromatopora.*		
A. Group of *S. concentrica* Goldfuss ..	*S.* aff. *foveolata* (Girty)	2.5
	S. concentrica Goldfuss	20
	and var. *colliculata* Nich.	7.5
A. Group of *S. hüpschii* (Bargatzky) ..	*S. hüpschii* (Barg.)	2.5

The fauna is seen to contain species of *Actinostroma* of Devonian type, in which the laminae have reached a fairly advanced stage of thickening, species of *Clathrodictyon* in which the radial pillars are well separated from the laminae, and the higher transients, belonging to the group of *S. concentrica,* in the series *Syringostroma–Stromatopora.* This assemblage of stromatoporoids is typical of horizons between the Lower and Middle Devonian, the most abundant species being *A. contortum, C. clarum,* and *S. concentrica.*

Heath's Quarry.—The fauna, though rich in individuals, is relatively poor in species, owing to the great abundance of certain forms which dominate the assemblage. Of the 8 species so far described 5 are present in other faunas, and the remaining species are so far known only from Victoria. Their affinities are indicated in the analysis of the fauna, which shows also the relative abundance, expressed in percentages of an assemblage of 60 specimens, of the species.

			%
1. *Actinostroma.*			
A. Group of *A. clathratum* Nich.	..	*A. compactum* Ripper	38
A. Group of *A. stellulatum* Nich.	..	*A. stellulatum* var. *distans* Ripper	30
		A. contortum Ripper	5
2. *Clathrodictyon.*			
A. Group of *C. striatellum* (d'Orb.)	..	*C. regulare* (v. Rosen)	1.5
		C. convictum Yavorsky	5
3. *Stromatopora.*			
A. Group of *S. concentrica* Goldfuss	..	*S. concentrica* Goldf.	10
		and var. *colliculata* Nich.	.9
4. *Hermatostroma.*			
H. episcopale Nicholson	..	..	1.5

The most abundant forms, *A. stellulatum* var. *distans, S. concentrica* and its variety *colliculata* are well-known Middle Devonian species while *A. compactum,* also occurring, though less abundantly, in the Yeringan limestone of Lilydale, is of the same type as *A. clathratum* Nich. of Middle Devonian age in Europe. The whole assemblage indicates, therefore, a Middle Devonian age, while containing a small proportion of forms usually occurring at lower horizons, e.g., *C. regulare* and *C. convictum.* Continued work on stromatoporoid faunas seems to show that certain species, while attaining a maximum development at definite horizons, may not be restricted to these horizons, but may appear in decreasing numbers in later assemblages. It is obvious, therefore, that, as in other groups of fossils, the assemblage of stromatoporoids must be considered as a whole, laying particular stress on the evolutional stages reached by certain groups of species, and on the first appearance of new types of skeletal structure.

Comparison of Victorian Stromatoporoid Faunas with one another.

The foregoing analyses of the Victorian stromatoporoid faunas show that they all should probably be placed in the Devonian. The larger of the two Yeringian faunas, that from Lilydale, contains a high proportion of Lower and Middle Devonian species, and the Silurian element, i.e., the early *Syringostroma–Stromatopora* transients, the more primitive members of the group of *Clathrodictyon striatellum* and the members of the group of *Actinostroma intertextum*, is inconspicuous. The other Yeringian assemblage, from Loyola, is poor in species, and may perhaps be on a lower horizon, since of the four forms recognized only one is known to occur in Middle Devonian formations elsewhere, while the two most abundant forms, *C. regulare* (von Rosen) and *Stromatopora typica* von Rosen, are characteristic of the Wenlock of Great Britain and Europe. The marked difference between the assemblages at Lilydale and Loyola may be due largely to differences in facies, since the small size and laminar and encrusting habit of the coenostea at Loyola suggest that they grew under unfavorable conditions. The coenostea at Lilydale, though usually fragmentary, reach a larger size and are frequently massive in habit, but at no time do they approach in size the masses found at some localities in the Buchan district. It is probable, however, that the Yeringian in reality includes a number of calcareous horizons which can be correlated with horizons in Great Britain ranging from the Aymestry Limestone to the Middle Devonian. R. S. Allan (1929) in dealing with the occurrence of the coral genus *Pleurodictyum* in New Zealand, and consequently with its occurrence in the Yeringian of Victoria, also draws attention to this point, and notes that the Yeringian "is not a clearly defined unit, and any exact correlation with the Silurian sequence of Great Britain must be considered entirely provisional."

The five faunas from the Buchan district have definite Middle Devonian affinities, but their relative positions within the Middle Devonian cannot be decided on the evidence of the stromatoporoids alone. As will be seen from the table showing the distribution of the species (p. 236), the faunas are all very similar, though only one species, *Stromatopora concentrica* Goldfuss, is common to all. Other species occurring at two or more of the localities are:—

Actinostroma compactum Ripper.
A. contortum Ripper.
Clathrodictyon regulare (von Rosen).
C. convictum var. *delicatula* Ripper.
C. clarum Počta.
Str. concentrica var. *colliculata* Nich.
S. hüpschii (Barg.).

It may be stated with some reserve that the Rocky Camp fauna may, on account of the presence of *Stromatopora* aff. *foveolata* (Girty) and fairly abundant *C. clarum* Počta, be on a somewhat lower horizon than the rest.

The Buchan faunas are distinct from the Yeringian faunas so far examined on account of the greater abundance of Middle Devonian species. *Actinostroma* is much more abundant than at Lilydale, and is represented, with one exception, by different species. The primitive group of *A. intertextum* Nich, represented by *A. altum* Ripper at Lilydale, and the early *Syringostroma–Stromatopora* transients have disappeared; the latter are replaced by the group of *Str. concentrica,* containing the end-terms of that series. Of this group only a more primitive form, *Str. foveolata* (Girty) is present at Lilydale. Of the species of *Clathrodictyon* only one, *C. regulare,* is common to the two groups of faunas. The others, with the exception of *C. confertum* Nich., occurring at Cameron's Quarry, Buchan, and *C. chapmani* Ripper, occurring at Lilydale, and in a modified form at Loyola, belong to the group of *C. straitellum* (d'Orb.). The abundance of the advanced form, *C. clarum* Počta in the Buchan limestones, is evidence that these are on a higher horizon than that of Lilydale.

The two groups of faunas have the following species in common:—

Act. compactum Ripper.
Cl. regulare (von Rosen).
Str. foveolata (Girty).
Hermatostroma episcopale Nicholson.

H. episcopale, a typical Middle Devonian species, is rare in all faunas, but occurs more frequently, as the variety *buchanensis,* in the Buchan district. *Act. compactum* is much more abundant in the Buchan faunas than at Lilydale. *Cl. regulare,* fairly common at Lilydale and abundant at Loyola, is rare in the Buchan district, as is *Str. foveolata,* of which only one example, differing somewhat from the typical form found at Lilydale, was collected.

The evidence of the stromatoporoid faunas suggests, therefore, that while all the assemblages, with the possible exception of that of the Loyola limestone, have Devonian affinities, the Lilydale fauna should be placed on a lower horizon than those from the Buchan district, which are in the main Middle Devonian.

Summary.

In this paper a comparison of the Victorian stromatoporoid faunas described in earlier papers with one another and with the faunas of other regions is attempted. The data for such a comparison are derived from a consideration of the evolutional changes which can be traced in certain genera. The known species of *Actinostroma, Clathrodictyon, Syringostroma,* and *Stromatopora* are discussed in some detail, and are grouped according to their skeletal structure. The stratigraphical distribution of these groups is outlined, and from this the probable course of evolutional changes within these genera can be deduced. The most important progressive changes, and those likely to be

of stratigraphical importance, are the thickening of the laminae and increasing definition of the pillars in *Actinostroma,* the increasing reticulation of the mesh of species of *Syringostroma* and *Stromatopora,* continuing through the Lower and Middle Devonian, and the straightening of the laminae and the separation of the radial pillars as distinct skeletal elements in the genus *Clathrodictyon.* The Victorian faunas are then analysed, considering the evolutional stages reached by each assemblage. The evidence suggests that the Victorian faunas with the possible exception of the Yeringian fauna of the Loyola limestone, which has Silurian affinities, are of Devonian type, and should probably be placed in the Middle Devonian. The Yeringian fauna of Lilydale contains a higher percentage of types characteristic of the Lower Devonian, and is thus rather older than the Buchan faunas, which are mainly Middle Devonian.

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[Proc. Roy. Soc. Victoria, 50 (N.S.), Pt. II., 1938.]

Art. XIII.—*The Bacteriological Examination of Drinking Water in Victoria*

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[Read 14th October, 1937; issued separately, 23rd May, 1938.]

Introduction.

This paper is intended to put forward a standard routine method for the examination of drinking water in Victoria. Most Victorian drinking waters are derived from catchment areas in the watersheds, many of which have been rendered, or are naturally free from human pollution. For this reason, no special treatment (filtration or chlorination) is used as a rule, and in consequence the bacterial count may be relatively high. In such areas, the native fauna is abundant, faecal contamination, as indicated by the presence of organisms of the coli-aerogenes group is also much greater than would be allowed in most countries, but organisms derived from this source are not significant, as they are not of human origin. If the normal bacterial content of a particular water is known from many previous tests, gross changes in the bacterial flora will be easily detected, but results must always be considered in conjunction with the conditions prevailing in the watersheds at the time of sampling.

Collection of Samples.

Water samples should be collected in dry sterile bottles of about 200 c.c. capacity and fitted with rubber stoppers. These should be filled by quickly immersing them about 6 inches below the surface of the stream or reservoir with the mouth toward the current, if any; in still water they should be moved forward so that there will be no risk of contamination from the hand or dipstick.

It is the usual practice to return samples to the laboratory as soon as possible after collection, and, unless they can be examined within a few hours of collection, they must be packed in ice. The following information should be supplied with the sample:—

1. The purpose for which the water is required.
2. The source of the sample, e.g., river, pool, reservoir.
3. The state of the watershed from which it is derived, together with any information regarding purification treatment.
4. Weather conditions at, and prior to the time of sampling; particulars of recent floods or droughts in the area.
5. Date and time of sampling.

Laboratory Examination.

The Plate Count.

Though the publications of the British Ministry of Health (1936) and the American Public Health Association (1933), do not include the plate count in their standards of purity, both recommend its use when the water is examined regularly, in which case a greatly increased count requires further investigation. It is also of use in studying the efficacy of filtration plants wherein inefficiency may be shown by a high plate count though the coli-aerogenes count be low. In Victorian waters, examined at this laboratory the 20°C. count is usually slightly higher than, but rarely more than four times as high as, the 37°C. count.

The counts are made by placing 0.5 c.c. of the water sample in each of four sterile petri dishes, and adding thereto 10 c.c. of nutrient agar which has previously been melted, and kept at 45°C. for ten minutes prior to pouring. The plate is then rocked gently to and fro and from side to side five or six times in each direction; rotation causes the colonies to be massed near the circumference of the plate, and therefore difficult to count. Two of the plates are incubated at 37°C. and two at 20°C. for two days. They are then counted, with reflected light, using a lens of approximately 2½ diameters magnification. It was the practice to incubate the 20°C. plates for three days, but frequently the count was spoiled by spreading growths, so a 48-hour period has been adopted. Wilson et al. (1936) have pointed out that the mathematical error in the plate count is of the order of 50 per cent. when two plates are used. When we consider also that personal error plays a large part in the count, and that in any case, its actual value is limited, a close approximation is all that is desired. The publication of the American Public Health Association recommends that, "in order to avoid fictitious accuracy and yet to express the numerical results by a method consistent with the precision of the work, the number of colonies of bacteria per ml. shall be recorded as follows:—

Number of bacteria per ml.

1 to 50 shall be recorded as found.
51 to 100 shall be recorded to the nearest 5
101 to 250 shall be recorded to the nearest 25
251 to 500 shall be recorded to the nearest 50
501 to 1,000 shall be recorded to the nearest 100"

and so on. This recommendation was adopted in routine practice. Both the American Public Health Association and the British Ministry of Health publications recommended also that plates containing between 30 and 300 colonies should be selected for counting unless the plates from undiluted water contain less than 30. Natural Victorian waters usually fall within these limits, excepting after flood rains, so that dilution is unnecessary, and a count of over 300 requires some explanation.

The Coli-aerogenes Count.

This is regarded as the best available method of detecting pollution in water samples, though it is recognized as being quantitatively inaccurate. The test is divided into two parts, the presumptive test, and the confirmatory test, in which those tubes giving a positive presumptive test are examined for the presence of the coli-aerogenes group.

The Presumptive Test.

A number of media have been suggested for the presumptive test using lactose fermentation as their criterion. It has been claimed in America and England that certain media, e.g., Dominick and Lauter's medium, brilliant green bile, and MacConkey broth—are highly selective for the coli-aerogenes group. Lactose broth, which had been used in this laboratory up to the time of the present investigation, is well known to give false reactions, i.e. lactose fermentation in the absence of the coli-aerogenes group, and so a confirmatory test is necessary to establish the presence of these organisms. In the hope that a medium might be obtained which would eliminate the laborious and time consuming confirmatory test, four media, MacConkey broth, the crystal violet medium of Salle, a synthetic medium, and Dominick and Lauter medium, were tried in comparison with lactose broth. Each tube showing gas within 48 hours was subjected to a complicated confirmatory test.

The results of these experiments are contained in another paper (Atkinson and Wood 1938*a*) and show that lactose broth is more sensitive to the coli-aerogenes group than any of the other media tried. It gives a larger total number of confirmed positives, and a higher coli-aerogenes count on the majority of samples tested. No medium was found which materially reduced the number of false positives—a result apparently due to the nature of the bacterial flora in Victorian water, as shown by Atkinson and Wood (1938*a*). The conclusion was therefore reached that lactose broth is the most suitable medium for the presumptive test.

The Confirmatory Test.

It has been decided that no confirmatory test is necessary for tubes which give acid and gas within 24 hours because, of 251 tubes examined, none failed to confirm. These tubes are therefore called "presumptive positives" according to the American definition, with the modification that acid as well as gas production is required. This amended definition is that a presumptive positive is a tube which gives acid and more than 10 per cent. gas within 24 hours. The American Public Health Association defines a doubtful test as a tube which gives gas in 48 hours but not in 24 hours, and we have found that, as they suggest, all these tubes require confirmation, as only 524 tubes confirmed out of

1,056 tubes tested. The technique of the confirmatory test consists of plating a loopful of the tube to be tested on to a suitable medium which will inhibit non-lactose fermenters and thus facilitate the isolation of members of the coli-aerogenes group. Colonies are then picked off from this plate into lactose broth, which should give acid and gas within 48 hours at 37°C. if the tube under test is a true positive. To decide upon the most suitable plating medium, MacConkey agar, Endo, eosin methylene blue, and violet red bile salt agar were tested in parallel and E.M.B. agar was found to be by far the most selective medium. It was therefore adopted for routine use.

The Technique of the Coli-aerogenes Test.

In Victorian waters, organisms of the coli-aerogenes group frequently occur in 1 c.c. and at other times in 0.1 c.c. quantities of the sample, so it is necessary for these quantities to be examined in every test. For the presumptive test, five tubes of double strength lactose broth are inoculated with 10 c.c. of the sample, and five tubes of single strength lactose broth with 1 c.c. and five with 0.1 c.c. These are incubated for 24 hours at 37°C. and all tubes giving acid and more than 10 per cent. gas are recorded as presumptive positives and discarded. The remaining tubes are incubated for a further 24 hours and all tubes showing gas irrespective of acid are recorded as doubtful tests and are subjected to a confirmatory test.

We have found that, owing to the presence of organisms capable of reducing the indicator, non-appearance of acid does not denote the absence of coliform organisms.

The confirmatory test is carried out by sowing a loopful of the doubtful test on to E.M.B. agar as soon as possible after the commencement of gas formation. The plates are then incubated at 37°C. for from 24 to 48 hours and typical colonies—those having black centres and purple translucent margins—are picked off into lactose broth. If no such colonies are present, all types of colony are sown into lactose broth. The lactose broth tubes are incubated for 48 hours, and those showing acid and at least 10 per cent. gas are recorded as confirmed or completed tests according to the American definition.

The Expression of Results of the Coli-aerogenes Test.

A considerable literature exists on the statistical accuracy of the dilution method of estimating bacterial populations. Greenwood and Yule (1917) brought forward a formula for expressing such results as the most probable number of organisms present in a given quantity of water, and McCrady (1918) has published a series of tables from which this can be read off. More recently, Halvorsen and Ziegler (1933-5) have gone thoroughly into the question of accuracy and have shown that the use of five tubes for each quantity of sample gives a result with a deviation of + 260 per cent. and — 70 per cent. while this deviation decreases rapidly till the number of tubes used is 60 when it becomes almost constant at ±40 per cent. It is impracticable in this laboratory to use more than five tubes of each quantity, so that the error of sampling is very great. The writers have carried out actual experiments on this sampling error and find that it falls within the limits set by Halvorsen and Ziegler from mathematical considerations. To state an actual case—a sample in which the most probable number as determined by using 40 tubes of each dilution was actually 250 organisms per 100 c.c. gave results ranging from 80 to 650 organisms per 100 c.c. when tested in batches of five tubes per dilution. Similarly in another case where the mean of 30 tubes of each dilution gave 17 organisms per 100 c.c. the extremes of five tube tests were 4 and 45 per 100 c.c. Thus a result of 4 followed by one of 45 organisms per 100 c.c. does not necessarily mean any change in the bacterial flora of the water. It seems preferable therefore to adopt a method of expression which will have wide though admittedly arbitrary divisions and in which, moreover, these divisions may be used as an indication of the quality of the water analysed in Victoria. Such divisions are given by the following scheme, in which the number only of positive tubes is taken into account, and not the quantity of water which they contain:—

1. 0 tubes positive out of 15 inoculated ..	B. coli not found in 50 c.c.
2. 1 or 2 tubes positive out of 15 inoculated	B. coli present in 50 c.c.
3. 3-7 tubes positive out of 15 inoculated	B. coli present in 10 c.c.
4. 8-12 tubes positive out of 15 inoculated	B. coli present in 1 c.c.
5. 13-15 tubes positive out of 15 inoculated	B. coli present in 0.1 c.c.

The first two divisions of this table lie close to the standards of purity required in Britain and America; the third is considered permissible in Victoria in waters from sources free from human habitation, the fourth requires some explanation such as heavy rain, the last should be regarded with suspicion.

False Positive Reactions.

These have been shown (Atkinson and Wood 1938*b*) to be due to masked positives, anaerobes in symbiosis with gram negative bacilli, and synergic reactions involving a pair of organisms, which may be either a Gram negative bacillus plus a streptococcus, or two Gram negative bacilli. It is worthy of note that in Victorian waters there is a tendency for the smaller quantities, 1 c.c. and 0.1 c.c. to yield organisms of the coli-aerogenes group which the 10 c.c. tubes do not. This seems too frequent to be due to chance, and is possibly due to a masking effect, a supposition very difficult to prove; but in such samples it must be borne in mind that the coli-aerogenes count may be higher than that given by the completed test.

Differentiation between Members of the Coli-aerogenes Group.

The advisability of differentiating so-called faecal from non-faecal B. coli has not been decided. Work here (Atkinson, 1934) points to the conclusion that differentiation is of little value and Bardsley (1934) concurs with this view. Until further evidence in favour of differentiation is brought forward, it is not thought advisable further to complicate the examination by adopting it in Victoria.

Summary of Procedure for the Routine Laboratory Test.

1ST DAY.—Inoculate each of four 4-inch petri dishes with 0.5 c.c. of water sample, add agar at 45°C., mix thoroughly and incubate two plates at 37°C. and two at 20°C. for 48 hours. Inoculate five tubes of double-strength lactose broth with 10 c.c., five tubes of single-strength lactose broth with 1 c.c. and five with 0.1 c.c. of sample, and incubate for 24 hours.

2ND DAY.—Read the lactose broth tubes and record those giving acid and more than 10 per cent. gas as presumptive positives. Discard these. Re-incubate remaining tubes for a further 24 hours.

3RD DAY.—Count all the plates. Record all tubes giving gas in lactose broth as doubtful positives, and stroke a loopful of each on to E.M.B. agar in 3-inch plates and incubate the plates for 24-48 hours. Discard all negative lactose broth tubes.

4TH DAY.—Select colonies from any plates showing typical positive colonies (black centres and purple translucent margins) and transfer to lactose broth and incubate at 37°C. for 48 hours.

5TH DAY.—Select colonies from remainder of plates, taking all types of colony when no typical lactose fermenters are present, and transfer to lactose broth and incubate for 48 hours.

6TH AND 7TH DAYS.—Record all lactose tubes giving acid and more than 10 per cent. gas in 48 hours as completed tests. The total number of positive tests consists of the presumptive positives + the positive completed tests.

Summary.

Certain aspects of the bacteriology of Victorian drinking waters are discussed and a method of bacteriological analysis is described, which it is suggested might be adopted as a standard, and which is essentially a modification of the method suggested in the publication of the American Public Health Association.

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[Proc. Roy. Soc. Victoria, 50 (N.S.), Pt. II., 1938.]

Art. XIV.—*The Basalts of the Geelong District.*

By ALAN COULSON, M.Sc.

[Read 14th October, 1937; issued separately, 23rd May, 1938.]

Introduction.

By reason of their association with fossiliferous sedimentary rocks, the ages of the basalts of the Geelong district can be determined with more accuracy than those of similar rocks elsewhere.

The area investigated extends from Footscray westerly to Meredith, then southerly to Airey's Inlet, and is bounded on the east by the sea. The Geological Map of Victoria, published by the Mines Department in 1902, shows the extent of the flows and the positions of the vents.

About 300 rock sections were made at the Geology Department of the University of Melbourne, and the author is indebted to Professor Skeats and his staff for the use of the apparatus. Dr. A. B. Edwards suggested the investigation, and has given much assistance with the petrology.

Cainozoic Succession.

Recent alluvium, beach sand, &c.

Holocene river gravel, dune sand, shell beds.

Pleistocene freshwater limestone.

Newer volcanic series (main flows).

(?) *Upper Pliocene* basalt of Durham Lead.

Upper Pliocene (Werrikooian) calcareous sands.

Lower Pliocene (Kalimnan) sands and ferruginous sands.

Lower Miocene limestones and clays.

Lower Miocene Older Basalt of Maude.

Older volcanic series (main flows).

Oligocene carbonaceous marls of Anglesea, &c.

Oliogocene tuffs of Anglesea.

Age Relations of the Basalts.

Older Volcanic Series.

1. *Anglesea.*

On the beach about ½ mile south of Anglesea is a bed of yellow decomposed tuff known as the Soapy Rock. It is overlain by or interbedded with, carbonaceous marls regarded as Lower Oligocene (Chapman and Crespin, 1935).

2. *Airey's Inlet, Curlewis and Bellarine Hills.*

Older Basalt and tuff underlie Lower Miocene limestone at Airey's Inlet (Chap. & Cresp., 1935) and Curlewis (Singleton, 1935). Two outcrops of limestone near Bellarine (Quarter Sheet 23 S.E.) are probably Lower Miocene, and they overlie Older Basalt.

3. *Waurn Ponds and Mt. Moriac West.*

Small rounded pebbles of decomposed basalt, presumably Older Basalt, have been discovered embedded in the Lower Miocene limestone at Waurn Ponds Old Quarry, Waurn Ponds north quarry in allotment 6, Barrabool, and Cochrane's, allotment 5, Barrabool. The source of this basalt is not clear. The pebbles are obviously resting on the Miocene shoreline, and were derived from a land mass of Older Basalt not far distant, as some of the pebbles attain 4 inches diameter.

West of Mount Moriac, in Prowse's, allotment 17, Modewarre, is a marl pit in Lower Miocene limestone, at the base of which is a layer of basalt pebbles, presumably related to the Older Basalts mentioned above.

4. *Maude.*

At this locality, a flow of Older Basalt is intercalated with beds of Lower Miocene limestone (Singleton, 1935).

Newer Volcanic Series.

The earlier Newer Volcanic lavas filled the river valleys of those times forming "confined lava fields" (Keble, 1918), while the later flows formed the "extended lava fields" of the Western District. The absence of sediments between the flows points to the shortness of the interval between their extrusion.

Generally the lavas rest upon sands or ferruginous sands of Lower Pliocene (Kalimnan) age. Fossils of this age are known from five localities, viz., Shelford (Dennant and Mulder, 1897), Moorabool Viaduct, west bank, (Pritchard, 1897), Lake Connewarre (Coulson, 1935), Cowie's Creek (Stach, 1934) and in allotment 18, Gheringhap, the fossils from the latter being regarded by Mr. R. A. Keble as Kalimnan (personal communication). Recently it has been suggested (Jutson and Coulson, 1937) that the upper unfossiliferous portions of these sandy beds may range up into the Pleistocene. At the Moorabool Viaduct, east bank, there is a limited deposit of calcareous sands containing Upper Pliocene (Werrikooian) fossils (Mulder, 1902) resting on the Kalimnan beds.

1. *Durham Lead (Leigh River).*

Three flows of basalt occur in this lead (Etheridge and Murray, 1874), the lower being separated by 15 feet of sand, and the upper by 7 feet of clay. The valley was eroded through Lower Pliocene sands and Ordovician bedrock. The lowest flow is probably Upper Pliocene. It differs considerably from the others, which are akin to the surface Newer Basalts around Anakie, which are shown later to be Pleistocene in age.

2. *Shelford Lower Flow.*

This may be a southern extension of the Durham Lead system, and has been described by Dennant and Mulder (1898). Although these authors state (p. 88) that the flow is overlain in places by Lower Pliocene sands, the author found that landslips were responsible for this phenomenon, and concludes that the basalt is one of the early Newer Basalts, which it petrologically resembles. The basalt fills a valley eroded in Lower Pliocene sands, and is overlain by the later flows of Newer Basalt.

3. *Batesford Lower Flow.*

Extending from a few miles north-west of the Dog Rocks to beyond Fyansford is a basalt-filled valley of the former Moorabool. It forms the much-discussed lower-level flow along the west side of the present Moorabool River. Its relatively low position is to be attributed to the fact that it flowed over a severely eroded surface, and not to faulting along the course of the Moorabool as previously suggested (Fenner, 1918). The erosion took place in the superimposed valley of the ancestral Moorabool, which developed great scouring power after passing through the granite gorge of the Dog Rocks, and removed the Pliocene sands from the western bank. Bores by the Australian Cement Company at Batesford prove that no north-south fault exists, since the Lower Pliocene beds were found to occur at the same level on both sides of the river.

4. *She Oaks (Moranghurk).*

This confined early flow is described on Quarter Sheet 19 S.W. in Note 2. It is about 2 miles long, and is sectioned in several places by the Moorabool River, exposing a sub-basaltic gravel bed regarded by the Survey as Upper Pliocene in age, but probably Pleistocene. The lower flow is covered by later lava of very similar composition, but with a more holocrystalline texture due to slower cooling.

5. *Anakie Flows.*

These are stratigraphically the most important of the Newer Basalts. For the most part they overlie Lower Pliocene sands, but on the east bank of the Moorabool Viaduct the basalt overlies Upper Pliocene (Werrikooian) calcareous sands (Mulder, 1902), which in turn overlie Lower Pliocene beds. This isolated Werrikooian bed was probably formed in an estuary on the surface of the rising Kalimnan sediments.

Freshwater limestone of Pleistocene age (Pritchard, 1895) overlies the Anakie flows at Lara (Quarter Sheet 24 N.E.) and at the Eastern Beach and Limeburner's Point, Geelong (Quarter Sheet 24 S.E.).

6. *Mt. Duneed Flows.*

These flows overlie Lower Pliocene sands, and the scoria contains fragments of Lower Miocene limestone and of ferruginous sand, probably Lower Pliocene (Coulson, 1935). An error appears in a note on Quarter Sheet 28 N.E. near Mt. Duneed, which states that the supra-basaltic deposits are marine. These deposits are clearly fluviatile.

Along the coast from Bream Creek to Barwon Heads the basalt is overlain by dune sandstones, the lower parts of which are probably as old as Pleistocene, while the upper parts are Recent.

7. *Other Flows.*

The flows from other vents, such as Bald Hill (Balliang), Spring Hill, Mt. Mary, Green Hill (Elaine), Mt. Mercer, Mt. Lawaluk, Mt. Hesse, Mt. Gellibrand, Mt. Pollock, Wurdi Buloc, Mt. Moriac, &c., all overlie Lower Pliocene sands, and are not covered by other formations except Recent alluvium in the river valleys.

Petrographic Types.

Older Volcanic Series.

1. *Iddingsite Titanaugite Labradorite Basalt.*

This type outcrops in the shore platform at Portarlington east of the pier, and is associated with purple tuffs. The texture is somewhat coarse, and the rock consists of large phenocrysts of olivine partially altered to iddingsite, large purple titanaugites ophitic with laths of labradorite and grains of iron ore. Glass is absent. This flow is lowest in the Bellarine Hills suite, and is presumably the oldest.

2. *Olivine Labradorite Basalt.*

This is the commonest type among the Older Volcanics. It occurs in the volcanic neck at Curlewis (Coulson, 1932), is the main flow in the Bellarine Hills (sampled in allotment 24, Bellarine) and occurs at Maude (allotment 17, Darriwil). The rock is black, non-vesicular, and consists of medium-sized phenocrysts of olivine thinly rimmed with golden iddingsite, divergent laths of labradorite and intersertal zoned felspar, intergranular short prisms of pale violet augite, large grains of iron ore, and some green serpentinic glass.

A chilled variety occurs among tuff in a quarry in allotment 8, Bellarine. The lava blocks consist of basalt of hemi-crystalline texture, showing small phenocrysts of olivine, short single laths of (?)labradorite, and much intersertal brown glass full of minute grains of iron ore. This quarry is close to one of the old vents. Keble (1918) regarded the Bellarine lavas as infilling an ancient valley trending from north to south, but to account for the tuff, and the disturbed Jurassic bedrock (Daintree, 1862) it is necessary to postulate local centres of eruption.

A peculiar type, limited to Harding's Hill, allotment 15, Bellarine, is a dark-grey basalt consisting of microphenocrysts of olivine completely replaced by skeletal iron ores, which in many cases retain the euhedral outline of the original olivine, in an intergranular base of plagioclase laths. There has been an introduction of calcite, and a little epidote has formed. This flow is the uppermost of the Bellarine suite, and presumably the youngest.

3. *Olivine Labradorite Basalt.*

At Airey's Inlet, the Older Basalt underlies Lower Miocene limestone, but east of Split Point it is replaced by tuffs, which disappear below sea level about 1 mile from the point. The basalt is medium grained, black, non-vesicular, and consists of small phenocrysts of olivine partly serpentinized, long laths of labradorite and large square grains of magnetite set in an intergranular groundmass of felspar laths and pyroxene prisms.

4. *Olivine Labradorite Titanaugite Basalt.*

This titaniferous basalt is exposed along the east bank of the Moorabool River between Maude and Russell's Bridge, from allotment 12A to 5C, Darriwil. The olivine forms abundant phenocrysts up to 5 mm. diameter, generally partially serpentinized or altered to chlorophaeite. These are set in a relatively coarse groundmass of sub-ophitic intergrowths of crystals of titanaugite and labradorite laths, interspersed with patches of green felspathic glass, rods of iron ore, and needles of apatite.

Newer Volcanic Series.

1. *Olivine Labradorite Basalt (Footscray Type).*

Specimens for microscopic examination were taken at close intervals on the Newer Basalt plains, but except at the vents none was found which could not be included in the "Footscray" type (Edwards, 1937). Rather wide variations of texture are allowed in this group to include the effects produced by different rates of cooling. The holocrystalline rock from the central portions of flows, obtained rather rarely in river sections or deep quarries, is a grey vesicular basalt consisting of large allotriomorphic and corroded olivines, heavily margined with reddish-brown iddingsite, laths of labradorite (Ab_{50}), much intersertal zoned felspar with undulose extinction, some corroded crystals of (?)anorthoclase, ophitic colourless or pale violet augite, or occasionally titanaugite, long rods of ilmenite and some grains of magnetite.

Much more common is the variety which contains glass. The introduction of glass usually means a reduction in the amount of iddingsite and intersertal zoned felspar, a change to greenish augite, and the inclusion of skeletal iron ores in the brown glass.

On the upper and lower margins of flows, more than half the rock section may consist of black glass full of minute grains of iron ores, with phenocrysts of idiomorphic olivine, sharply defined laths of labradorite or andesine, and sub-ophitic colourless augite.

2. *Olivine Basalt (Ballan Type).*

At the actual vents throughout the area, and in very short flows about them, a dense grey basalt occurs, with microphenocrysts of olivine heavily rimmed with red-brown iddingsite, fine groundmass of very short laths of andesine and indeterminate felspar, minute granular colourless, sometimes pale violet, augites, and extremely small grains of iron ore. This description conforms with that of the Ballan type (Edwards, 1937). It occurs at the Anakies, Bald Hill and Spring Hill (Balliang), Green Hill (Elaine), Green Hill (Cargerie), Mt. Duneed, Mt. Moriac, Pettavel, Waurn Ponds, Wurdi Boluc, Mt. Pollock, Staughton's Bridge (Werribee River), Mt. Cotterill, Mt. Kororoit, Greek Hill, McDiarmid's Hill, &c.

At the Anakies and Mt. Kororoit, scoriaceous and tachylitic rocks are associated with the Ballan type. They contain large phenocrysts of olivine lightly iddingsitized, occasional phenocrysts of anorthoclase and indeterminate felspar with undulose extinction, and extremely minute grains of black glass or iron ore.

The Wurdi Boluc specimen from a 550-foot hill south of Lake Wurdi Boluc, is unusual, consisting of small rounded crystals of olivine partly iddingsitized, and abundant small grains of iron ore set in an extremely fine groundmass of felspathic laths and pyroxene crystals.

Mt. Pollock, described by Hall (1910) as a lava-capped outlier, is composed of Ballan type basalt, quite different from the surrounding lava plain, and the rock at its summit contains inclusions of Tertiary sandstone. It is therefore a true volcano.

The Durham Lead basalt is of coarse felspathic rock with abundant laths of oligoclase and much intersertal plagioclase with undulose extinction, small clear olivines without iddingsite, some titaniferous augite, thin rods of iron ore, and some yellow cloudy glass.

Summary.

Pleistocene	Olivine Basalt (Ballan type). Olivine Labradorite Basalt (Footscray type).
Upper Pliocene	Olivine Oligoclase Titanaugite Basalt (Durham Lead).
Lower Miocene	Olivine Labradorite Basalt (Maude).
Lower Miocene or Oligocene	Olivine Labradorite Titanaugite Basalt. Olivine Labradorite Basalt. Iddingsite Labradorite Titanaugite Basalt.
Oligocene	Tuffs (Anglesea).

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[Proc. Roy. Soc. Victoria, 50 (N.S.), Pt. II., 1938.]

Art. XV.—*Dacites and Associated Rocks at Arthur's Seat, Dromana.*

By GEORGE BAKER, M.Sc.

[Read 9th December, 1937; issued separately, 23rd May, 1938.]

Introduction.

Arthur's Seat (1,031 feet) is a prominent hill of igneous rocks 44 miles south of Melbourne. It is situated near Dromana, and presents a bold, steep face to the eastern shore of Port Phillip Bay (fig. 1). It consists of granite capped with hornblende dacite, rhyodacite and Tertiary river gravels. The granite is overlain by basalt to the south-west of Arthur's Seat, and granitic gravel covers the eastern flanks.

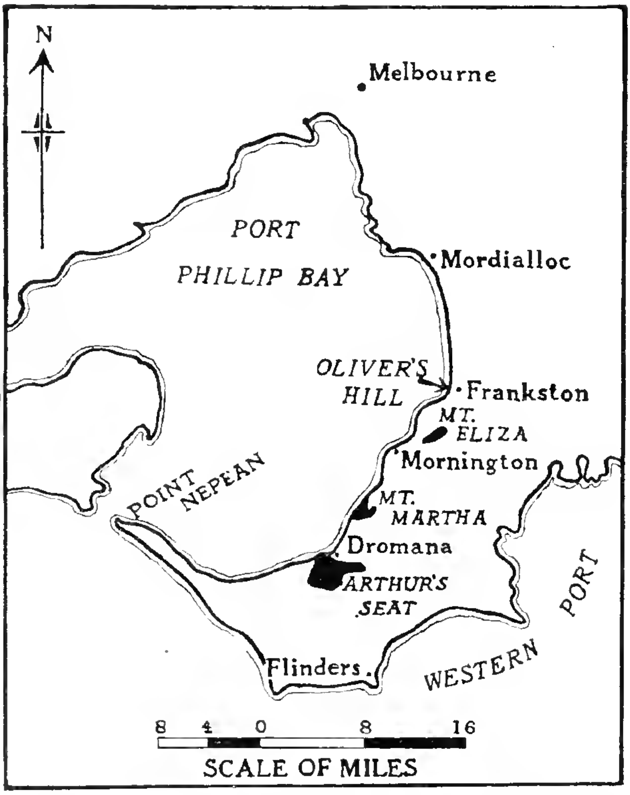

Fig. 1. Sketch map of the Mornington Peninsula showing outcrops of granitic rocks in black.

The granitic rock was originally described as syenite (12, p. 219), and later as granodiorite (15, p. 136). The geological map accompanying this paper was taken from a map prepared by R. A. Keble, of the Geological Survey of Victoria, and to his map the dacite and aplite outcrops recently discovered on Arthur's Seat have been added.

The main ridges in the area, which consist of granite and older basalt, strike in a north-south direction; on the east and west, these ridges slope into plains of Pleistocene and Recent deposits. The main drainage of the area is effected by Splitter's Creek. This creek rises near the Lookout Tower, and flows in a southerly direction to join Main Creek, which empties into Bass Strait about 7 miles west of Flinders. Small, deep gullies drain the northern sides of Arthur's Seat, and their trend has been determined by the strike of the more prominent dykes and joints in the granite.

It is difficult to judge how far faulting has affected the topography of the Arthur's Seat area. A suggestion was made by Professor J. A. Bartrum during the 1935 excursion of the Australian and New Zealand Association for the Advancement of Science to this area, that the bold seaward face of Arthur's Seat might represent the recently uncovered wall of a stock rather than an escarpment formed along Selwyn's Fault Zone. There are, however, more indications of faulting along the seaward face of Arthur's Seat than elsewhere. Numerous slickensides and granulation of the rocks in several narrow shear zones occur near and along the joint planes of the igneous rocks. The presence of very numerous, closely spaced joints along the northern (seaward) face is suggestive of movements in Selwyn's Fault Zone. Still more definite evidence of faulting is present in quarry 5, at The Rocks in the north-west portion of the area, where a dyke of felspar hornblende porphyrite has been step faulted sixteen times in a distance of 50 feet. The faulting is post-Devonian in age, and may perhaps be associated with Tertiary to Pleistocene or Recent movements which caused the elevation of the conglomerate and sands at The Rocks.

Dacites.

The dacite series occurs within an area of a little more than a quarter of a square mile around the summit of Arthur's Seat, and comprises hornblende dacite on the east and rhyodacite on the west (fig. 2). The contact between the two types of dacite is masked by detritus and soil. Occasional contacts between the hornblende dacite and the granite are observable, and a few small, rounded sedimentary xenoliths occur in the hornblende dacite east of the Lookout Tower. Rhyodacite has been exposed in contact with the granite in road cuttings along Tower Road between Murray Memorial and Chapman Memorial (fig. 2), and it extends south-eastwards to the summit of Arthur's Seat. West of the road cuttings, it extends down steep slopes for 100 feet below the level of the road. A small outcrop of rhyodacite occurs above the road cutting at Murray Memorial, isolated from the main outcrop by about a quarter of a mile.

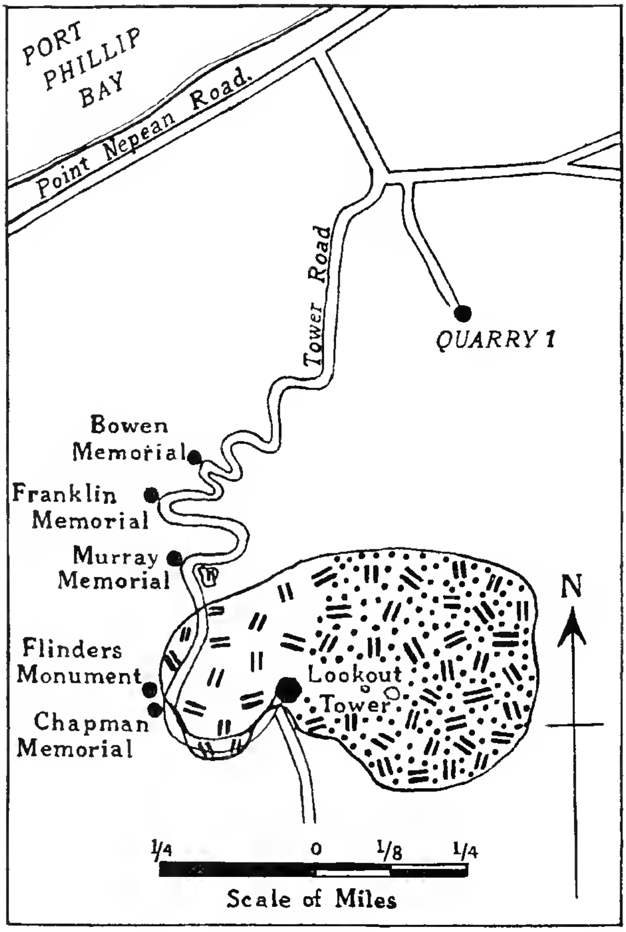

Fig. 2. Sketch map showing locations along Tower Road, and the outcrop of Dacite. Hornblende Dacite in the East (dotted), and Rhyodacite in the Western portions of the outcrop.

The rhyodacite outcrop thins out towards the higher levels of Arthur's Seat, so that present exposures present a pocket-like appearance, suggestive of the lower limits of a roof pendant. The rhyodacite has weathered in parts to a crumbly mass of clay, and is sometimes very much stained by secondary iron oxides. Closely-spaced joints in the upper portions of the rhyodacite exposed in road cuttings above Murray Memorial give rise to a pebbly structure on weathering.

No clearly marked metamorphic changes are visible in the dacites along contacts with the granite, although the grain size is sometimes a little coarser than usual in portions of the rhyodacite; no schistosity has been developed as at Selby (18) or Warburton (6). The dacites are older than the granite, however, since microscopic examination of contact specimens provides clear evidence of metamorphism. Furthermore, igneous veins derived from the granite have invaded the dacites, the lower limits of which show irregular embayed junctions with the granite, and small xenoliths of rhyodacite are included in the intrusive rock. The dacites are therefore pre-Granitic in age, and since they contain inclusions of sedimentary rocks which are likely to be portions of the Ordovician bedrock of the Mornington Peninsula, they are probably post-Ordovician. By analogy with occurrences of dacite in other parts of Victoria, they may be regarded as having been extruded in Upper Devonian times, while the granite is a later stage in the Palaeozoic igneous history, probably late Upper Devonian to early Carboniferous (10).

A dyke of felspar-hornblende porphyrite, 9 inches wide, cuts the granite at an angle of 45 degrees, for a distance of 50 feet on the seaward face of quarry 5, at The Rocks. About 100 yards north-east of quarry 5, a decomposed dyke; probably allied to the felspar-hornblende porphyrite, is 2 feet wide and winds in an irregular manner through the granite, as depicted diagrammatically in fig. 3. These dykes are probably genetically related to the dacites of the Dromana area, because similar dykes are allied to the dacites occurring at Selby (18) and at Warburton (6).

Granite.

Soil, vegetation and granitic detritus mask exposures of the granite at Arthur's Seat. No large tors are developed, and the study of the granite is confined to exposures made by quarrying and road cutting. Of the various quarries indicated by numbers on the map, No. 1 has been cut in aplite, Nos. 6 and 7 in granite porphyry, Nos. 5 and 9 in contaminated granite, and the remainder in normal granite.

An evenly spaced set of joints has been recorded at a quarry $2\frac{1}{2}$ miles east from Dromana jetty, and their strike is given as east-west and north-south (15, p. 136). This quarry is situated in the eastern portion of the granite exposure. On the northern sides of Arthur's Seat, the granite possesses numerous, very closely spaced joints, two sets striking W. 20° N. and W. 35° N., and two sets striking N. 15° E. and N. 25° W. The joints in the eastern part are sufficiently widely spaced to permit quarrying for building stone, but those in the northern portion of the area are seldom over 9 inches to 1 foot apart, making the granite useless for the extraction of blocks of a size requisite for building purposes.

Xenoliths are scarce in the main mass of the Dromana granite. A few are present near the rhyodacite contact between Murray Memorial and Chapman Memorial. A local concentration of xenoliths occurs between quarry 5 and quarry 9 at The Rocks, where the granite has become contaminated and the inclusions hybridised. Several large angular xenoliths of sedimentary origin have been exposed by quarrying, also relatively unaltered and granitised hornblende diorite which forms patches and schlieren in the contaminated granite at this locality (fig. 3).

The large undigested xenoliths of altered sediments associated with the schlieren may indicate the proximity of the Ordovician wall rock. If this is so, the hornblende diorite might represent the chilled edge of a stage in the differentiation of a dioritic magma which ultimately gave rise to the granite of this area. On the other hand, the schlieren may represent dykes of hornblende diorite which were originally injected into Ordovician sediments, and subsequently became partially absorbed by the granite magma.

Dykes associated with the late phases of the intrusion of the granite in the Dromana area consist of granite porphyry, granophyre, felspar porphyry, microgranite, graphic granite, aplite and quartz.

Granite porphyry occurs at quarries 6 and 7, where its relation to the granite is probably that of a dyke, though contacts are masked by products of weathering. A similar dyke about a foot wide cuts the granite at The Rocks. A dyke of granophyre, 4 feet wide, separates the granite from the rhyodacite in the road cutting above Murray Memorial. Between this dyke and the granite, a narrow, sheared and granulated zone has been produced, probably as a result of faulting. Narrower dykes of granophyre traverse the granite near Murray Memorial.

Felspar porphyry dykes, about 6 inches wide, intrude the granite at Chapman Memorial, and a similar, but slightly wider dyke cutting the granite just below Murray Memorial, contains veins of pink orthoclase.

Microgranite forms a dyke 30 feet wide at Flinders Monument, where it is cut by veins of aplite. Graphic granite is present in the road cutting between quarry 4 and quarry 5, and a narrow vein traverses the contaminated granite of quarry 5 (fig. 3). A prominent, closely jointed dyke of aplite, 50 feet wide, strikes north-north-west near Flinders Monument, and small offshoots from it sometimes have very dense, dark, fine-grained borders. Dykes and veins of aplite intrude the hornblende dacite about half a mile east of the Lookout Tower, whilst a larger intrusion occupies a considerable area around quarry 1. Two fine-grained dykes of aplite cut through the granite porphyry of quarry 6, and numerous veins and dykes are exposed along the Tower Road cuttings, especially near Bowen Memorial. They ramify through portions of the granite in a sinuous manner, but are straight and parallel where confined to joint planes.

Quartz veins have been injected into the granite and rhyodacite in the vicinity of Murray Memorial, and between Chapman Memorial and the summit of Arthur's Seat. They also occur at The Rocks in the north-west portion of the area.

Tertiary Rocks.

The south-eastern portion of the area on the accompanying map is covered by basalt as mapped by R. A. Keble. Outcrops of the fresh rock are scarce, and the basalt has weathered to a red-brown soil, cultivated for fruit growing. This area of basalt is probably connected with flows in the Cape Schanck-Flinders district, which are considered to belong to the Older Volcanic Series of Victoria.

River gravels, mapped by R. A. Keble, occur near the summit of Arthur's Seat, about half a mile south-east of the Lookout Tower. Exposures are to be observed in shallow road cuttings and attached to the roots of fallen trees. They locally form a thin veneer to the granite, and have not been observed associated with the dacite series. They contain rounded pebbles, ½ to 3 inches across, of white quartz, compact and laminated quartzite, hornfels, grit, sandstone, micaceous sandstone, aplite, granite, pegmatite, and rare basalt and jasper. Occasional boulders of quartzite up to 1 foot long are also present.

A bed of conglomerate, with occasional boulders of ferruginous grit, rests on a wave-cut platform in the granite at The Rocks. It is overlain by 30 to 40 feet of sands containing occasional pebbles (fig. 3).

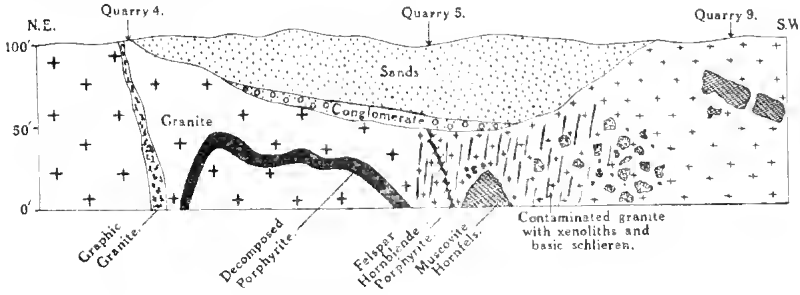

Fig. 3. Diagrammatic section at The Rocks, Dromana.

The conglomerate varies in thickness from a few inches to 3 feet. The average size of the pebbles is 4 inches, and they are set in a sandy to gritty base which has been partly cemented by iron oxide, producing local patches of hard ferruginous grit. The pebbles in this conglomerate consist of smooth, rounded, and sub-angular and pitted fragments of granite, aplite, hornfels, hybrid rock and hornblende diorite. Rare pebbles of an augite dacite are also present, and since all of the pebbles in the conglomerate were obviously derived from a former adjacent coastline, augite dacite must also have been present in this district, although no outcrops of it have been located in the neighbourhood.

No fossils were found in the conglomerate, but its age is probably late Tertiary or Pleistocene. It is 40 feet above sea level at the eastern end, and 15 to 20 feet above sea level 100 yards to the west. The dip is 7 degrees to the west, and may represent the original angle of rest on the surface of the granite, or tilting may have accompanied the elevation above sea level. The deposit extends from the face of the road cutting (i.e., into the cutting face) for a distance of 3 feet. Before the construction of the road, it was about 80 feet in this direction, and had a distinct tilt seawards.

Marine sands, which are probably Pleistocene in age, occupy the flatter portions of the area around Arthur's Seat, whilst Recent sands and gravels form a plaster to the older rocks. At quarry 6, angular fragments of granite have been recemented in a fine-grained matrix forming breccia.

Petrology of the Dacites.

The dacites include hornblende dacite and rhyodacite, and their mineral compositions are shown in the following table of micrometric analyses. The accessory minerals included in table 1 consist mainly of ilmenite.

Table 1.

	1.	2.	3.	4.	5.	6.	7.	8.	9.
Quartz	2·97	30·5	29·8	27·4	9·56	20·82	11·46	13·18	1·22
Plagioclase ..	21·66	38·5	33·6	23·4	15·30	21·32	27·04	28·92	24·13
Orthoclase ..	..	21·2	25·6	35·3					
Hornblende ..	8·30	0·3	5·2	8·1	..	..	..	..	..
Hypersthene ..	..	..	..	..	..	..	1·63	6·24	12·17
Biotite	3·86	6·8	4·0	1·6	3·82	10·22	13·95	4·28	10·96
Accessories ..	1·78	2·7	1·8	4·2	..	..	..	..	1·08
Groundmass ..	61·42	..	..	..	72·32	47·64	45·65	48·00	50·44

1. Hornblende Dacite, Dromana.
2. Biotite Rhyodacite, Dromana.
3. Hornblende-Biotite Rhyodacite, Dromana.
4. Hornblende Rhyodacite, Dromana.
5. Quartz Dacite, Healesville.
6. *a* Quartz-Biotite Dacite, Warburton.
7. *β* Quartz-Biotite Dacite, Warburton.
8. Quartz-Hypersthene-Biotite Dacite, Black Spur.
9. Hypersthene Dacite, Upwey.

The above table illustrates the absence of orthoclase in the hornblende dacite, and its relative abundance in the rhyodacite types. The table also indicates the amount of the microcrystalline groundmass in the hornblende dacite, whereas in the rhyodacite, all the groundmass constituents were sufficiently large to be identified and measured by the micrometric method.

Micrometric analyses of dacites from Warburton (6), Black Spur (5), and Upwey (18) are added to table 1 for purposes of comparison with the Dromana examples. From the table, it is seen that the Dromana hornblende dacite is generally less acidic than the dacites from these other Victorian localities. The percentage increase of hornblende in the rhyodacite types from Dromana indicates the amount of this mineral generated by thermal metamorphism.

The heavy mineral assemblages of the dacites consist of hornblende, biotite, apatite, zircon, magnetite and ilmenite. Rare garnet and epidote in contact types, and occasional pleochroic cores to apatite crystals, also occur. The index figures are as follows:—

	Index Number.	Specific Gravity.
Hornblende Dacite	5.6	2.68
Biotite Rhyodaeite	1.5	2.61

Rhyodacites.

Hand specimens of the rhyodacite resemble the Marysville rhyodacite (11), but thin section examinations show that the microcrystalline groundmass of the Marysville occurrence is not so well developed at Dromana, where a certain amount of recrystallisation has taken place as a result of thermal metamorphism. Phenocrysts of orthoclase-perthite and oligoclase sometimes possess lacineal borders and associated myrmekite (9), and separated patches of quartz are often in optical continuity. Large areas of ilmenite are surrounded by clusters of small biotite flakes (18), whilst the accessory minerals are apatite, zireon and rare crystals of sphene and pyrite. The hornblende is pale green in colour, possesses crenulate boundaries, sieve structure and abundant small inclusions of iron oxide, factors which indicate that the hornblende is a thermal metamorphie product in the rhyodacites.

Hornblende Dacite.

The hornblende dacite is a porphyritic rock with embayed phenocrysts of quartz, brownish-green primary hornblende, occasional brown biotite developed as a reaction product between the aeid groundmass and ilmenite, and corroded and zoned phenocrysts of oligoclase. Criss-cross fibres of pale green hornblende, which is probably secondary in origin, are partially altered to biotite. Specks of sulphide minerals are visible in the hand specimens of the hornblende dacite. The microcrystalline groundmass consists of quartz, oligoclase, ilmenite, biotite and pale green hornblende. Chlorite is occasionally associated with small crystals of sphene, and the accessory minerals are zircon and apatite. The felspar phenocrysts are sometimes zoned with inclusions of sphene and green chloritic material, and often possess pale greenish cores, due to the presence of hosts of dust-like inclusions and chloritic decomposition products. Where certain of the oligoclase phenocrysts possess blocky structure, this has been produced by intergrowth with small amounts of orthoclase introduced from the intrusive granite.

Felspar-Hornblende Porphyrite.

Dykes of felspar-hornblende porphyrite have a microporphyritic texture. The fine-grained groundmass constituents show flow structure, and consist of biotite, magnetite, apatite, laths of labradorite, small plates of hornblende, epidote and hematite. The micro-phenocrysts are labradorite and small elongated crystals of green uralitic hornblende containing numerous grains of iron ores. Occasional nests of secondary, pale green hornblende are invariably surrounded by rings of small biotite plates and granular epidote.

The decomposed dykes of felspar-hornblende porphyrite consist of abundant laths of rather altered labradorite, set in a clayey base, stained with limonite.

These dykes are finer-grained than those from Warburton (6) and Selby (18), which contain much larger crystals of hornblende, and usually do not show flow structures except at the edges. At Dromana and Selby, the felspar-hornblende porphyrite dykes are post-granitic intrusions, but at Warburton they are pre-granodiorite, so that in the first two localities these dykes, which are more basic than the rocks which they intrude, would represent a basic layer of magma situated below the consolidated granitic rock.

Xenoliths in the Dacite.

Xenoliths of sedimentary origin in the hornblende dacite at Dromana, are comparable with sedimentary xenoliths recently observed in the propylitised dacite of Hesket, in the Macedon district. In both of these localities, the xenoliths are sporadic in occurrence, small and rounded, and have been subjected to only slight alteration, with practically no reconstitution after engulfment in the dacites. There is very little indication of strewing about of the xenolithic material in the dacite lava, and almost no embayment or corrosion is shown along junctions.

In each locality, the xenoliths consist of very fine-grained mica hornfels, derived from the bedrock of Ordovician shales through which the dacitic lavas were extruded.

Alteration of the Dacites by the Granite.

Pools of quartz in optical continuity and a coarser texture along parts of the contact, indicate partial recrystallisation of the constituents of the rhyodacite by the granite. The ferromagnesian content of the rhyodacite changes in both nature and amount as parts of the contact are approached. The sequence outwards is hornblende rhyodacite, hornblende-biotite rhyodacite, to biotite rhyodacite. At the Murray Memorial area, hornblende is present practically to the complete exclusion of biotite, resulting in the production of hornblende rhyodacite. A little further from the contact, hornblende and biotite are almost equal in proportion, giving rise to a hornblende-biotite rhyodacite, but at a still greater distance, biotite is the chief ferromagnesian mineral in a biotite rhyodacite. These relationships are shown in columns 4, 3, and 2 of table 1. With increasing distances from the contact, there is also an increase in quartz, plagioclase and biotite, and a decrease in orthoclase and accessory minerals (table 1). Micrographic intergrowths replace lacineal borders in the hornblende rhyodacite, and the microcrystalline groundmass is absent. In the hornblende-biotite zone, remnants of the groundmass and abundant lacineal borders occur, and furthest from the contact, the biotite rhyodacite has a slightly increased proportion of groundmass, and shows little sign of contact metamorphism.

The development of hornblende at the expense of biotite as contacts are approached, has also been described from the Warburton district, where granodiorite is intrusive into a dacite series (7, p. 185). The production of secondary hornblende from a reddish-coloured form of biotite, has been indicated at Mt. Leinster in Eastern Victoria (3), where syenite has intruded granodiorite. A certain amount of a reddish biotite occurs in the thermally metamorphosed rhyodacite at Arthur's Seat, in addition to the ordinary greenish-brown variety, but the reaction has not continued as far as at Mt. Leinster, where hornblende inverts to augite at the contact. Parallel alterations at Arthur's Seat and Mt. Leinster are, the increase of the potash felspar content as the contact is approached, the absorption of quartz as the ferromagnesian minerals invert to higher termperature forms, and the presence of micrographic intergrowths between quartz and orthoclase in the thermally altered rocks.

Contact metamorphism is not well marked in the hornblende dacite at Arthur's Seat, mainly on account of lack of good contact exposures. At junctions with small irregular portions of the roof of the granite intrusion, and in boulders not *in situ,* the groundmass of the hornblende dacite shows partial recrystallization of quartz and felspar.

Petrology of the Granite.

The granite is a medium, even-grained rock with abundant greenish orthoclase. In thin section, it consists of quartz, orthoclase-perthite, oligoclase and biotite. The oligoclase is often blocky due to intergrowth with orthoclase, and sometimes possesses saussuritised cores. Muscovite is secondary after plagioclase, epidote occasional and myrmekite rare. Hornblende is generally confined to areas where assimilation of hornblende diorite has occurred, and so it is a contamination mineral in the granite. The accessory minerals consist of sphene, zircon, ilmenite, and apatite. The sphene is usually associated with the hornblende and may likewise be a contamination mineral. The felspars are often cloudy from abundant sericite, chloritic material and kaolin. Optically continuous patches of quartz fill the interspaces between some of the felspar crystals, and where such quartz patches occur, myrmekite and micrographic intergrowths are abundant.

Biotite and hornblende crystals which possess sieve structures and associated grains of ilmenite, may represent remnants of igneous xenoliths. Some of the larger oligoclase crystals indicate regrowth, by jacketting with later formed more acid oligoclase. Granulation and stringing out of the minerals in the granite has occurred along small shear planes.

Modified rapakivi structures (2, p. 219) occur in a very restricted manner at the contact between a small tongue of granite and hornblende dacite, east of the Lookout Tower. Rapakivi ("crumbly stones") are described by Sederholm as granites containing ovoids, four to ten centimetres across, consisting of orthoclase or microline surrounded by a rim of oligoclase (16, p. 75). The Dromana occurrences are not visible in the hand specimen; under the microscope, structures resembling rapakivi are five millimetres across, ovoid to sub-rectangular crystals of orthoclase-perthite being mantled by a continuous rim of oligoclase 0.3 to 0.5 mm. wide. In one example, almost in direct contact with the hornblende dacite, a wider rim of oligoclase is intergrown with orthoclase. Quartz and biotite occur in the orthoclase core, micropegmatitic intergrowths in the oligoclase mantles, and small pools of granitic material in both, similar to examples described by Sederholm (16). The rounded nature of the orthoclase ovoids is considered by Sederholm to result from defective development of crystal forms as a result of impurity (17, p. 92).

Wells and Woolridge consider that potash felspar with a surround of oligoclase such as described above, reflects the increasing basicity of the magma as contamination progresses (20, p. 198). Sederholm doubts whether rapakivi granites are differentiation products, and considers that many of them are syntectic rocks formed by assimilation of older rocks (17, p. 84). In agreement with Sederholm's view, the local development of "micro-rapakivi" structures in granite at Dromana, is considered to be due to assimilation, since the dacite has been partially engulfed by granite. The structures are not the result of basification by contamination, such as was found by Wells and Woolridge, because the Dromana granite has assimilated a relatively acidic rock, dacite, whereas Wells and Woolridge describe the development of these rapakivi structures in granite, as resulting from the assimilation of gabbro. At Dromana, the rapakivi structures in granite at its contact with the dacite, are considered to have arisen locally, from a slight marginal increase in the soda content of the magma, consequent upon the assimilation of dacite, producing a second generation of oligoclase.

The mineral composition of the Dromana granite is shown in table 2, in which the "accessory minerals" consist mainly of ilmenite and apatite. Micrometric analyses of the You Yangs granite (1), and of the granodiorites at Mt. Eliza (19), Macedon, Warburton (6), and Frankston, have been added for comparison. The trace of hornblende in the Warburton granodiorite was discovered during the heavy mineral analysis of this rock. The silica percentages given in the table, have been computed from the results obtained from the Rosiwal micrometric analyses.

TABLE 2.

	1.	2.	3.	4.	5.	6.
Quartz	34·8	28·7	29·37	26·3	28·1	35·88
Orthoclase	33·9	34·8	17·59	6·6	12·4	21·71
Plagioclase	24·9	25·5	39·87	38·1	34·5	28·57
Biotite	4·3	8·8	12·23	27·3	24·0	11·40
Hornblende	1·5	1·3	0·59	..	tr.	0·08
Accessories	0·6	0·9	0·30	1·7	1·0	2·36
Specific Gravity	2·63	2·65	2·70	2·72	2·72	2·64
Silica Percentage	75	71	69·5	64	65	72

1. Granite, Dromana.
2. Granite, You Yangs.
3. Granodiorite, Mount Eliza.
4. Granodiorite, Macedon.
5. Granodiorite, Warburton.
6. Granodiorite, Oliver's Hill, Frankston.

The above table shows that the Dromana granite contains more quartz and less biotite than the You Yangs granite, but the other constituents are more or less equivalent in amount. The granodiorites in table 2 have a lower quartz and orthoclase content, and a greater amount of plagioclase and biotite. Although the Dromana granitic rock was referred to by its trade name of "granite", it was stated that the proportion of orthoclase to plagioclase felspar was less than one to two, and so the rock was classified as a granodiorite (15, p. 136). The Rosiwal analysis in table 2, however, indicates an excess of orthoclase in the ratio of two to one and a half. The silica percentage is much higher than that of average granodiorite. In addition, the Dromana granite contains abundant microperthite which is a feature regarded by Johannsen as characteristic of granites and rare in granodiorites.

The granodiorite of Oliver's Hill (table 2, column 6), has a rather high silica percentage for a granodiorite, and it is regarded as representing a more acid offshoot from the Mt. Eliza granodiorite.

The heavy mineral indices and assemblages shown in table 3, elaborate the mineralogical comparison of the Dromana granite with the gray granodiorites outcropping in the Mornington Peninsula at Mt. Martha, Mt. Eliza, and Oliver's Hill, Frankston.

TABLE 3.—THE HEAVY MINERALS OF THE GRANITIC ROCKS OF THE MORNINGTON PENINSULA.

	1.	2.	3.	4.
Index Number	3·4	7·1	8·3	12·4
Specific Gravity	2·63	2·58	2·64	2·70
Anatase (blue)	V	..	..	..
Andalusite (pale green)	..	..	..	V
Apatite (colourless)	o	C	C	C
Apatite (with pleochroic cores)	r	V	V	V
Biotite (greenish-brown)	a	..	..	..
Biotite (brown)	o	A	A	A
Chlorite	o	V	o	o
Epidote	r	..	V	..
Garnet	..	V	..	o
Gold	V	..	..	..
Hornblende (greenish-brown)	C	o	r	a
Ilmenite	..	r	C	r
Magnetite	C	r	..	V
Orthite	..	..	..	V
Pyrite	o	r	..	o
Pyrrhotite	V	..	..	..
Rutile	..	V	..	..
Sphene	o	V	..	o
Tourmaline (blue)	..	..	..	V
Zircon (colourless)	C	C	C	C
Zircon (pale yellow)	..	V	..	..
Zoisite	V	..	..	..

A = very abundant; a = abundant; C = common; o = occasional; r = rare; V = very rare.

1. Granite, Dromana.
2. Granodiorite, Mount Martha.
3. Granodiorite, Oliver's Hill, Frankston.
4. Granodiorite, Mount Eliza.

The variation in the index numbers of these granitic rocks is due to the degree of differentiation, the amount of assimilation and the nature of the country rocks through which the magmas were injected.

In each example, inclusions in zircon crystals are relatively common, and the crystals are sometimes zoned at Dromana, Oliver's Hill, and Mt. Martha. Stout, stumpy crystals are very rare in the Mt. Eliza, Oliver's Hill, and Mt. Martha granodiorites, and very rare "torpedo" forms (1) occur in the Dromana granite. Andalusite, which occurs in the Mt. Eliza granodiorite, has also been recorded from the adjacent contact slates of the Mooroodue quarry. Rutile from the altered sediments, and hornblende, biotite, and apatite from the granodiorite were also recorded from the granodiorite from thin section examinations (19). One grain of anatase was observed in the Dromana granite, and none in the granodiorites outcropping to the north. Apatite is more abundant in types richer in biotite and hornblende, i.e., in the northern outcrops. Some of the apatite crystals are bluish at Dromana, pale yellowish-green at Mt. Martha and the majority are colourless. At Mt. Eliza and Oliver's Hill, all of the apatite crystals are colourless. One crystal of orthite in the Mt. Eliza granodiorite, has been observed in thin section.

Although the granite of Arthur's Seat was intruded into dacite and Ordovician rocks, its heavy mineral assemblage and index number indicate that few contamination minerals, either as xenocrysts or as the result of processes of contamination, were generated from the invaded rocks, or that if contamination products were added to the magma in the early stages of intrusion, such products have sunk from view. The Mt. Martha granodiorite was intruded into more extensively developed argillaceous rocks, from which a considerable amount of biotite was generated and added to the magma, and less sinking of newly formed basic minerals occurred. At Mt. Eliza, conditions were likewise favorable for the generation of biotite, but either in greater quantity than at Mt. Martha, or else with considerably less sinking of assimilation products. At Mt. Eliza, andalusite and garnet were also added to the magma as xenocrysts.

The differences existing between these granitic rocks exposed in neighbouring outcrops in the Mornington Peninsula (fig. 1), indicate that although they may have all been initially derived from a common magma chamber, differentiation and sinking of assimilation products continued further in the Dromana example, than in the granodiorites occurring to the north.

Xenoliths in the Granite.

The xenoliths in the Dromana granite have been derived from two sources, from sedimentary rocks, and from igneous rocks.

Argillaceous Ordovician rocks which became enclosed in the granitic magma, have been converted into muscovite hornfels consisting of an interlocking aggregate of quartz grains, laths of muscovite, and abundant scattered grains of iron ores. Brown tourmaline of pneumatolytic origin occasionally wraps around some of the quartz crystals, whilst prisms of foxy-red and yellow rutile have recrystallised from the original titaniferous minerals in the sedimentary inclusions. Small laths of biotite are occasionally developed, and well rounded crystals of zircon are present.

Coarser grained portions of these sedimentary inclusions are slightly schistose, and the borders of the larger inclusions are sometimes inshot with granitic material. Smaller xenoliths consist of a mosaic of quartz and pale green micaceous material. Biotite plates contain sagenitic webs of sphene, and minute pyritohedra of pyrite are included in the quartz grains.

The heavy mineral assemblage of these xenoliths is made up of abundant prisms of yellow-green to dark brown tourmaline, with ilmenite, rutile, apatite, rounded zircon, biotite, andalusite, muscovite, and rare staurolite.

The xenoliths of igneous origin have been derived either from hornblende diorite or from rhyodacite.

Xenoliths derived from the hornblende diorite consist of biotite and laths of oligoclase with numerous embedded grains of apatite. Occasional pools of quartz have been introduced from the granite magma, and the granite at contacts with some of these xenoliths contains poikilitic oligoclase bearing inclusions of epidote, biotite, ilmenite, and apatite derived from the xenoliths, whilst patchy intergrowths occur between orthoclase and oligoclase.

Xenoliths derived from the rhyodacite are finer in texture than the parent rock, and types from both the biotite and the hornblende-biotite rhyodacites have been recognised. Sieve structure is more marked in the ferromagnesian minerals of the xenoliths than in the contact rock, whilst ilmenite grains and apatite needles are more abundant.

Infiltration of granitic material has given rise to poikilitic oligoclase and orthoclase-perthite associated with quartz pools. The granite at junctions with these xenoliths contains abundant myrmekite, blocky felspars, and partially digested minerals, sometimes with lacineal borders, derived from the xenoliths.

Hybrid Rocks.

Much of the hornblende diorite, which usually occurs in well defined bands at The Rocks, has been hybridised by the granitic magma. Stages are represented in which hornblende, biotite, oligoclase, and orthoclase are present in variable amount.

Secondary quartz has been moulded on the felspars, and occasional crystals of sphene are associated with the hornblende. The accessory minerals are abundant apatite and iron ores with some zircon.

In less banded portions of the hornblende diorite schlieren at The Rocks, the hornblende is more prominently altered to biotite, and more granitic material has been introduced. These dark streaks and patches of hornblende diorite finally become distributed through the surrounding magma, forming a contaminated granite.

The specific gravity of sampled portions of the hybrid rock is 2.58, the low figure being due to alteration. The index number is 39.3, and most of it is composed of hornblende. Some of the apatite crystals in the heavy mineral assemblage contain dark coloured cores which are pleochroic and often sharply defined from the clear outer zone (8). The pleochroism is from dark blue and purple to light brown, and occasionally, darker lines of the colouring matter appear as dustlike inclusions along imperfect basal cleavage planes in the apatite. Similar occurrences are met with in the dacite and granite in the Dromana district.

Granitic Dykes.

In the granite porphyry, sericitisation of the felspars and regrowth around some of the phenocrysts, indicates that the rock has suffered late magmatic changes. Corroded phenocrysts of quartz, biotite, orthoclase-perthite, and oligoclase are set in a fine-grained groundmass of similar minerals, with accessory zircon, apatite, rare ilmenite, and magnetite. Oligoclase phenocrysts are often blocky where intergrown with orthoclase.

In the granophyre, the groundmass consists almost entirely of micrographic and cryptographic intergrowths of orthoclase and oligoclase with quartz. A few phenocrysts of quartz and orthoclase with occasional frameworks of micro-pegmatite are present. The specific gravity of the granophyre is 2.64, and the index number 2.7, the heavy minerals consisting of apatite, zircon, ilmenite, foxy-red rutile, biotite, hornblende, chlorite, and limonite.

The felspar porphyry consists of phenocrysts of orthoclase, oligoclase, occasional rounded and embayed quartz, and rare biotite, set in a fine-grained groundmass of similar minerals. Abundant ilmenite, apatite, rutile, and hematite, with occasional zircon and rare myrmekite are also present in the groundmass.

The microgranite consists of an interlocking aggregate of quartz and orthoclase-perthite, with idiomorphic oligoclase and biotite. The average grain size is 0.5 mm., as compared with a grain size of 4 mm. in the granite.

Intricate graphic intergrowths of quartz and orthoclase-perthite make up the bulk of the graphic granite, and the aplite of quarry 1 is a fine, even-grained rock with rare granophyric intergrowths of quartz and orthoclase.

Petrology of the Tertiary Rocks.

The basalt (Older Volcanic Series), consists of fresh and serpentinised olivine, colourless and pale violet augite crystals, set in a fine-grained matrix rendered dark-coloured by the prolific development of grains of iron ores. The violet augite crystals sometimes possess pale green pleochroic cores. A colourless glass forms part of the groundmass in which are set laths of labradorite, abundant rods of apatite and rare picotite. The phenocrysts are partly corroded by the groundmass, and the felspar laths often stream around them.

The matrix of the river gravels is composed of numerous quartz grains and fine clay particles, with small quantities of the following heavy minerals:—rounded and prismatic zircon, blue, brown, and violet tourmaline often parti-coloured, abundant limonite, rutile, andalusite, and epidote. Leucoxene, rare garnet, zoisite, cassiterite, staurolite, and hematite also occur.

The conglomerate band at The Rocks contains smooth, rounded pebbles set in a sandy to gritty matrix of angular rock fragments up to 5 mm. across, abundant quartz grains, kaolinised felspar and yellowish flakes of biotite. Clay particles are not nearly as common as in the river gravels from the summit of Arthur's Seat. The heavy minerals are similar to those contained in the rocks of the immediate neighbourhood, and from which the constituents of the conglomerate were obtained. The hornblende of the heavy mineral assemblage is quite fresh, and the biotite has only been partially bleached, indicating that the constituents of the conglomerate were not subjected to very much transportation.

The incoherent sandy deposits overlying the conglomerate at The Rocks contain 65 per cent. of grains over 0.5 mm., in size, 21.6 per cent. of grains between 0.5 mm. and 0.05 mm., and 13.4 per cent. of very fine clay particles. The bulk of the larger grains is composed of quartz, and the heavy minerals, which make up only 0.2 per cent. of the deposit, consist of brown and blue, rounded tourmaline grains, hornblende, rounded and prismatic zircons, occasional biotite, rutile, limonite, hematite, andalusite, leucoxene, and rare augite.

Conclusions.

At Arthur's Seat, the most southerly and smallest recorded dacite outcrop in Victoria, the associated igneous plutonic type is a granite, whereas in the dacite regions of Central Victoria, the intrusive rock associated with the dacitic lavas is granodiorite (7, 10, and 18). In the Dromana district, differentiation is therefore considered to have advanced to a greater degree than in the Palaeozoic petrographic provinces of Central Victoria. The Dromana dacites differ from those at Macedon, Warburton, Healesville, and Upwey in the presence of hornblende and the absence of hypersthene. The presence of the primary hornblende at Arthur's Seat is probably due to the fact that the volatile components of the magma were retained until the crystallisation of the hornblende dacite was practically complete, for Kennedy considers that any magma from which hornblende would crystallise under conditions tending towards the retention of the volatile components, would under effusive conditions (with the escape of volatiles), give rise to pyroxenes (14, p. 207).

Where the dacites are metamorphosed in the Macedon and Selby districts, biotite has been formed from hypersthene, while at Dromana, secondary hornblende is produced at the expense of biotite, indicating a higher temperature for the Dromana intrusive rock. At Mt. Leinster, the temperature of the intrusion must have been still higher, since the higher temperature mineral augite has been formed from biotite in the contact rocks.

Regarding the order of appearance of the Palaeozoic igneous rocks in the Dromana petrographic province, the oldest rock, the hornblende diorite is the most basic, and it most probably represents the chilled edges of a dioritic magma, which occupied the magma chamber early in the stages of the processes of magmatic differentiation which ultimately produced a granite. The hornblende dacite is the volcanic equivalent of hornblende diorite, so that by roof fissuring, portion of the hornblende diorite magma escaped to the surface as a lava flow. The vents through which this portion of the magma reached the surface would eventually become sealed, and differentiation processes continued in the magma chamber until the composition was analogous to that of granodiorite. At this stage, further roof fissuring occurred, and rhyodacite was poured out at the surface, the rhyodacite being the volcanic equivalent of granodiorite. After this second outpouring of magma, the vents were sealed up, and remained sealed whilst the magma, gradually becoming more granitic in composition, stoped its way upwards, and differentiation and sinking of assimilation products continued, until the magma finally crystallised as a potash granite. The remaining acidic liquors of the intrusion were then injected through the older rocks, probably in the order granite porphyry, granophyre, felspar porphyry, microgranite, graphic granite, aplite, and finally quartz veins, thus closing the magmatic activity of the Dromana province.

The absence of a floor of Ordovician rocks for the extruded dacites, may be attributed to assimilation and removal during the intrusion of the granite magma, rather than to wholesale roof foundering. The dacites are thus thought to have reached the surface through numerous small fissures, which did not give rise to any widespread or great thickness of lavas, as in Central Victoria, and which would, on account of their small size, be more readily sealed up after extrusive activity had occurred.

In regard to the association of diorite and granite, Daly quotes examples where these two rocks are syngenetic, and he states that the diorite appears to be an older chilled phase of the batholith in which the granite differentiated (4, p. 245). At Dromana, similar conditions might have obtained, but only on a small scale, since the granitic intrusion is a relatively small stock. The differentiated liquid produced in the manner suggested by Daly, would possess greater corrosive powers, and renewed eruptivity would occur after the formation of the chilled phase. The granitic magma would not be in equilibrium with the already chilled, solid diorite, and so would begin to absorb it, but solidification occurred before total engulfment of the chilled phase, leaving xenoliths and streaks of the diorite in the granite of the south-west portion of the stock at Dromana.

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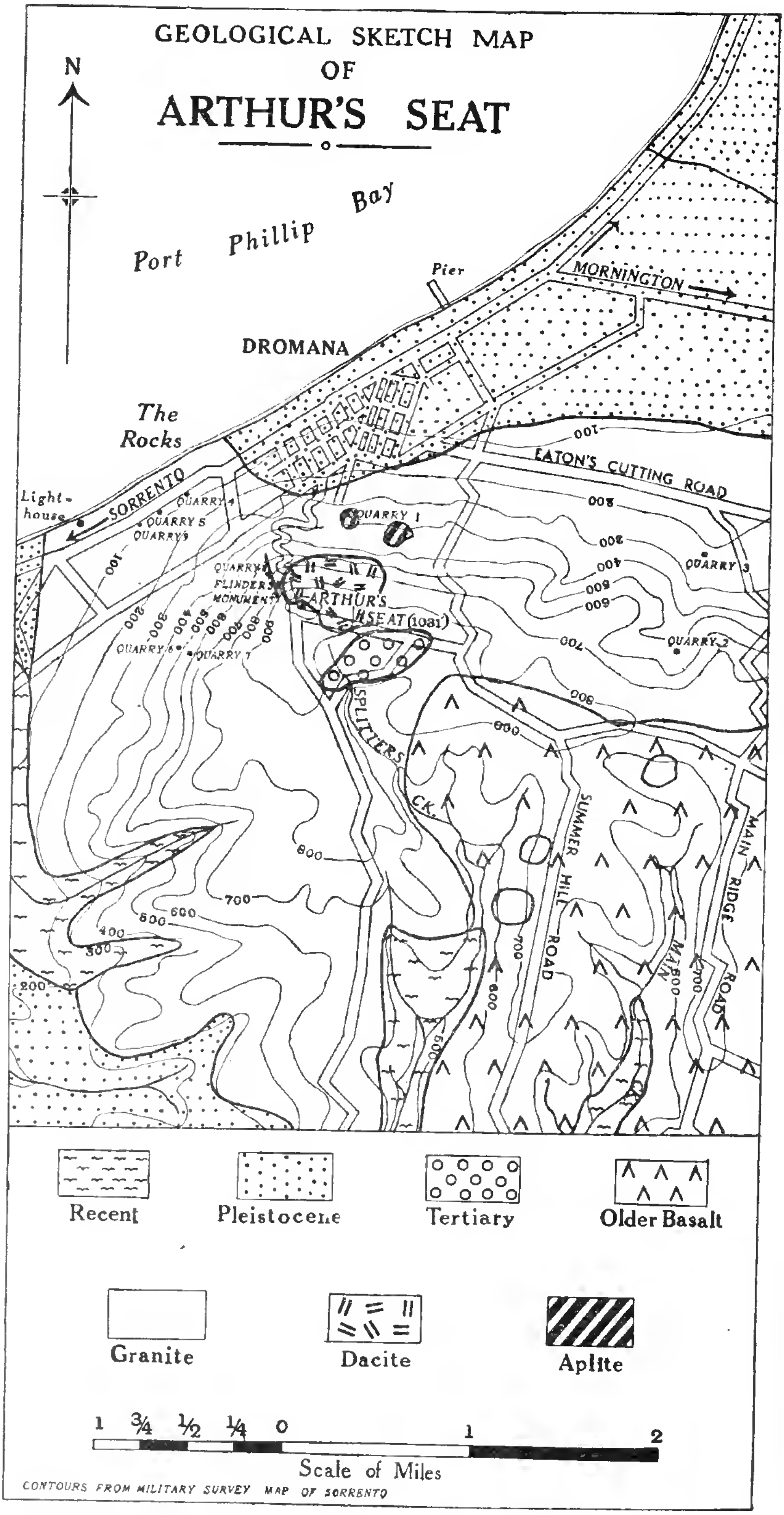
GEOLOGICAL SKETCH MAP
OF
ARTHUR'S SEAT
N
Port Phillip Bay
Pier
MORNINGTON
DROMANA
The Rocks
Light-house
SORRENTO
QUARRY 4
QUARRY 5
QUARRY 1
QUARRY 3
QUARRY 2
QUARRY 6
QUARRY 7
FLINDERS MONUMENT
ARTHUR'S SEAT (1081)
EATON'S CUTTING ROAD
SPLITTERS CK.
SUMMER HILL ROAD
MAIN RIDGE ROAD
MAIN
Recent
Pleistocene
Tertiary
Older Basalt
Granite
Dacite
Aplite
1 3/4 1/2 1/4 0 1 2
Scale of Miles
CONTOURS FROM MILITARY SURVEY MAP OF SORRENTO

[Proc. Roy. Soc. Victoria, **50** (N.S.), Pt. II., 1938.]

Art. XVI.—*Australian and New Zealand Species of the Foraminiferal Genera* Operculina *and* Operculinella.

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[Read 9th December, 1937; issued separately, 23rd May, 1938.]

Introduction.

The present paper is the outcome of a study undertaken for the purpose of arriving at a proper understanding of the species of *Operculina*, fossil and Recent, occurring in Australia and New Zealand. The genus *Operculinella* has been included in view of the very close relationship it bears to *Operculina*.

As far back as 1932 the present authors read a paper before the Australian and New Zealand Association for the Advancement of Science in Sydney, entitled "The Revision of the East Indian and Australian Species of Operculina", but which was then only published in abstract. The following paper is an enlargement of the subject, considerably extended and brought to date.

Consideration has been given to the following forms, which, so far as we have been able to ascertain, comprise those recorded from the Indo-Pacific region as *Operculina* or *Operculinella*, or appearing to belong to either genus. The reference given in each case is to the original author, whether the species or variety was or was not described from this area.

1781. *Nautilus ammonoides* Gronovius, p. 282, No. 1220, pl. xix. (Fasc. iii., Tab. 2), figs. 5, 6. Recent, Bay of Bengal.

1798. *Nautilus radiatus* Fichtel and Moll, p. 58, pl. viii., figs. *a-d*. Recent, Red Sea.

1798. *Nautilus venosus* Fichtel and Moll, p. 59, pl. viii., figs. *e-h*. Recent, Red Sea.

1822. *Lenticulites complanata* Defrance, Dict. Sci. Nat., vol. xxv., p. 453. Miocene, Dax, France.

1826. *Operculina madagascarensis* d'Orbigny, p. 281, No. 4. Recent, Madagascar.

1826. *O. gaimardi* d'Orbigny, p. 281, No. 5. Recent, Rawack.

1826. *Assilina discoidalis* d'Orbigny, p. 296, No. 1, Modèles, No. 88. Recent, Rawack.

1826. *A. nitida* d'Orbigny, p. 296, No. 4. Recent, Red Sea.

1839. *Planulina pyramidum* Ehrenberg, p. 133. Eocene, Egypt.

1846. *Operculina granulosa* Leymerie, p. 359, pl. xiii., fig. 12. Eocene, near Corbières, Southern France.

1850. *O. canalifera* d'Archiac, p. 245. Eocene, France.

1859. *Amphistegina cumingii* Carpenter, p. 32, pl. v., figs. 13-17. Recent, China Sea.

1896. *Operculina granulosa*, var. *niasi* Verbeek, p. 1158, pl. ix., figs. 128-131. Eocene, Island of Nias.

1896. *O. javana* Verbeek, p. 1159, pl. ix., figs. 132, 133. Upper Tertiary of Java.
1921. *O. bartschi* Cushman, p. 376, text-fig. 13. Recent, Philippines.
1921. *O. bartschi*, var. *plana* Cushman, p. 377, text-fig. 14. Recent, Philippines.
1921. *O. ornata* Cushman, p. 378, pl. lxxiv., figs. 2*a*, *b*. Recent, Philippines.
1921. *O. philippinensis* Cushman, p. 379, text-fig. 15. Recent, Philippines.
1921. *O. discoidalis*, var. *involuta* Cushman, p. 380, text-fig. 16. Recent, Philippines.
1921. *O. elegans* Cushman, p. 381, pl. xcvii., fig. 3. Recent, Philippines.
1925. *O. bartschi*, var. *punctata* Yabe and Hanzawa, p. 52, pl. vi., figs. 13-15; pl. vii., figs. 15-18. Late Tertiary and Post-Tertiary of Riukiu Islands.
1930. *O. complanata*, var. *multiseptata* Yabe and Hanzawa, p. 39, pl. ii., figs. 6, 7, 10; pl. xv.; pl. xvi., fig. 1. Middle Miocene. Taiwan (Formosa).
1932. *O. pacifica* Whipple, p. 83, pl. xx., figs. 1, 8. Eocene, Eua, Tonga.
1933. *O. heterosteginoides* Hofker, p. 148, pl. vi., figs. 1, 2; text-fig. 33. Recent, Kei Archipelago.

Because of the difficulty of distinguishing whether the differences between specimens of *Operculina* are specific or merely due to conditions of environment or to dimorphism or trimorphism, the genus is in a very unsatisfactory condition. Hofker, who has studied the Recent East Indian *Operculinae* from a biological standpoint, considers that all of the species recorded from this area (except *O. heterosteginoides*) should be placed under *O. complanata* (Defrance). He regards the differences as due to trimorphism and conditions of environment. In view of the importance placed by Hofker on the relation of the size of the proloculus to the external characters of the test, it will be of interest to summarise his views on this and to consider under each species how far they are supported by the material we have examined. He gives (Hofker, 1927, p. 61) the characteristics of the three forms thus:—

> "*Forma A1.*—Sutures never with well developed buds of secondary chalk (only the central part of the shell shows some heaps of clear chalk-material), and very little chalk buds on the chamber walls. Proloculum about 35 microns; marginal cord not very distinguishable in the more involute speciments. Chambers very numerous, especially in flat individuals.
>
> *Forma B.*—Always very large specimens (up to 9 mm. diameter) with smooths walls, ornamented with very small chalk buds. Only the centre of the shell with chalk masses on the sutures. Chambers very numerous. Proloculum 27 microns.

Forma A2.—Sutures with very well developed buds of secondary chalk and with very large masses of chalk material on the walls. Most individuals are very strongly built, with somewhat rounded chambers, the number of which is mostly a little smaller. Proloculum about 60 microns."

Before proceeding further, it is proposed to give an account of *Operculina complanata*, as it occurs in the vicinity of Bordeaux, France, from whence it was described, after which a list of the species we have recognised, followed by notes on each, will be given.

Operculina complanata (Defrance).

(Plate XVI., figs. 1, 2, text fig. 1.)

Lenticulites complanata Defrance, 1822, Dict. Sci. Nat., vol. xxv., p. 453.

Operculina complanata (Defr.): d'Orbigny, 1826, p. 281, pl. xiv., figs. 7-10; Modèles, No. 80.

This species was described from the Lower Miocene (Aquitanian) of Dax, near Bordeaux, France. We have examined suites of specimens from this locality and from beds of similar age in the same area, viz., from Saucat and Lagus. From these the following description of *O. complanata* is given:—

Test ear-shaped, with a rounded peripheral keel (the "marginal cord"), strongly compressed and with both faces slightly concave, not thickened in the centre; chambers numerous, in up to 3½ whorls in the megalospheric form, increasing gradually in size as added, but always very narrow, numbering 25 or more in the last-formed whorl; sutures thin and evenly recurved, not limbate or raised, barely visible from the exterior. Major diameter of test, 8 mm., minor diameter, 6 mm.

In exterior view, the surface of all of our specimens is smooth, except those from Lagus, which, particularly when moistened, show a faint irregular beading on the interseptal areas. In thin section, however, the Dax examples show traces of beading on the chamber surface. The Lagus specimens are thinner shelled and appear to have come from a less-calcareous deposit than those from Dax and Saucat. The specimens are all megalospheric, the proloculus averaging 0.18 mm. in diameter (external measurement).

The most striking feature of *O. complanata* is one to which reference does not appear previously to have been made. This is the remarkable development of the interseptal canal system on the anterior side of each chamber. The interseptal canals form at regular intervals short branches which extend forward and outward under the chamber wall, where they appear to terminate blindly. The shell material enclosing these branches, when seen in a thin section of the test, gives the effect of a series of brackets on the septum, supporting the outside chamber wall. This structure is illustrated in Figs. 1 and 2 on Plate XVI., and has also been figured by Silvestri (1907, pl. ii., fig. 4), who, however, apparently was not aware that it was characteristic of *O. complanata* and accordingly recorded his specimens under the name of *O. complanata*, var. *heterostegina*, var. n. His material was from Northern Italy, from beds of the same age as those from which *O. complanata* was described.

This structure was not recorded or figured by Hofker in connection with the Siboga material referred by him to *O. complanata* and we are therefore unable to agree with his identification of the East Indian Operculines with Defrance's species. It may be noted that Hofker has since recognised a similar structure in material collected by Dr. Th. Mortensen's Pacific Expedition 1914-16 and has, on it, based a new species *O. heterosteginoides* (Hofker, 1933, p. 148, pl. vi., figs. 1, 2; text-fig. 33). He mentions that this species has been described in some records as only a variety of *O. bartschi* Cushman and also that it did not occur in the Siboga material.

The only other species showing the same structure as *O. complanata*, which has been described from the Indo-Pacific region, is *O. pacifica* (Whipple, 1932, p. 83, pl. xx., figs. 1, 8) from the Eocene, of Eua, Tonga.

O. complanata accordingly shows a more advanced development than most of the Indo-Pacific species of *Operculina* and therefore connects the simpler forms of the genus with *Heterostegina*. It may be mentioned that the senior author, in 1900 (Chapman, 1900, p. 18, pl. iii., fig. 6), showed that, in the microspheric form of *Heterostegina depressa* d'Orb., the first few chambers are undivided and are immediately followed by several chambers with rudimentary septation, as in *Operculina complanata*. The next stage in the division of the chambers is the presence of incomplete cross septa which do not extend more than two-thirds across the chamber cavity, after which the characteristic secondary septation of *Heterostegina* is taken on.

List of Species Recognized.

Eocene:

Operculina pyramidum (Ehrenberg)
O. canalifera d'Archiac.

Miocene:

O. victoriensis, sp. nov.
O. kawakawaensis, sp. nov.
O. matapauensis, sp. nov.

Recent:

O. ammonoides (Gronovius).
O. bartschi Cushman.
Operculinella venosa (Fichtel and Moll).

Acknowledgments.

We are indebted to Mr. Arthur Earland, F.R.M.S., and to Dr. J. A. Cushman for information concerning *Operculina ammonoides* from the rare work of Gronovius. Mr. Earland has also kindly supplied us with a number of examples of *Operculinae* from the Indian Ocean. We wish also to extend our best thanks to Professor J. H. F. Umbgrove, of Delft University, for homoetypes of *O. javana* Verbeek.

Description of the Species.

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

Eocene Species.

OPERCULINA PYRAMIDUM (Ehrenberg).

Planulina pyramidum Ehrenberg, 1839, p. 133.
Operculina pyramidum (Ehr.): Schwager, 1883, p. 143, pl. xxix., figs. 4*a-c*. Chapman and Crespin, 1935, p. 59.

This species was recorded by Chapman and Crespin (*loc. cit.*) as occurring in sections of limestone from near Bullara, North-west Division, Western Australia, in association with *Discocyclina*. The sections have not been available for re-examination and figuring.

OPERCULINA CANALIFERA d'Archiac.

Operculina canalifera d'Archiac, 1850, p. 245. Chapman and Crespin, 1935, p. 59.

The comments made in relation to the preceding species apply also to this.

Miocene Species.

Operculina victoriensis, sp. nov.

(Plate XVI., figs. 3-8, text-fig. 2.)

Operculina complanata Chapman (*non Lenticulites complanata* Defrance), 1910, p. 294.
O. complanata, var. *granulosa* Chapman (*non O. granulosa* Leymerie), 1910, p. 294.
O. bartschi Crespin (*non* Cushman), 1936, pl. i., fig. 12.

Test ovate, compressed, complanate, sometimes with the faces slightly concave. with a narrow peripheral keel; chambers numerous, in up to $3\frac{1}{4}$ whorls in the megalospheric form, number in last-formed whorl averaging 16-18; sutures usually limbate and raised, radial at inner end and with outer end sharply reflexed, sometimes evenly reflexed throughout. Larger diameter of megalospheric specimens up to 4 mm.; microspheric specimens up to 6 mm.

Holotype (Chapman Coll.) from Lower Miocene, Red Bluff, Shelford, Vic.

This species is of common occurrence in Miocene deposits in Victoria, being found in limestones and marls. To show what relationship, if any, exists between the external characters of the shell and the size of the proloculus, the following notes on the specimens occurring in a typical series of samples are given:—

Mines Department Bore, Parish of Nuntin, at 190 feet. Lower Miocene—B 2 Zone.

Apparently a moderately deep water deposit. *Cycloclypeus communis* Martin is common and the specimens thin-shelled and almost transparent.

28 specimens of *Operculina* were examined. These fall into two groups—

(1) Sutures limbate, raised and more or less beaded. Chamber walls ornamented with beads, which vary from a single row of comparatively large sized beads along the centre of the chamber to smaller beads closely covering the surface of the chamber. Most specimens show chamber beading of an intermediate type.—25 specimens.

(2) Practically smooth specimens, with a few beads on the early sutures.—3 specimens.

Specimens of both forms attain a diameter of 3 mm. The number of whorls in each does not exceed $3\frac{1}{2}$, with 15 to 17 chambers in the outside whorl. The average height of the chambers in the last quarter whorl is 0.3 mm. The proloculus in both forms measures between 0.04 and 0.05 mm. in diameter.

Geological Survey Bore, Hamilton, 80-85 feet. Lower Miocene—B 2 Zone.

Material a richly foraminiferal marl, with abundant *Lepidocyclinae* and *Amphisteginae*. It is apparently a shallower water deposit than the preceding.

23 specimens were examined. These fall into the following groups—

(1) Sutures limbate and raised, with beading usually best developed on sutures of earlier chambers. Few large beads on centre of shell. Chamber walls ornamented—(*a*) along centre with few comparatively large beads; (*b*) whole surface closely beaded; and (*c*) intermediate beading.—18 specimens.

(2) Sutures limbate, sometimes much raised. Chamber wall smooth.—5 specimens.

Particulars of specimens sectioned are as follows:—

Specimen Number—	1.	2.	3.	4.	5.
Larger diameter ..	2·6 mm. (estimated)	3 mm. (estimated)	2·9 mm.	3 mm.	2·8 mm.
Diameter of proloculus (external and internal)	0·112; 0·079 mm.	0·102; 0·060 mm.	0·115; 0·086 mm.	0·109; 0·068 mm.	0·05; 0·029 mm.
Number of whorls ..	3	3½	3½	3	4
Number of chambers in outside whorl	17	16	13	17	17
Aver. width of chambers in last ¼ whorl	0·29 mm.	0·3 mm.	0·23 mm.	0·36 mm.	0·2 mm.
Sutures	Limbate and raised	Limbate and beaded	Limbate, much raised	Limbate, little raised	Limbate, slightly raised
Ornament on chamber walls	Few, fairly strong beads in centre of chamber	Covered with medium sized beads	Wall smooth	Wall smooth	Wall smooth

These specimens show that, in the Hamilton Bore at least, the smooth-shelled form is not necessarily the microspheric and that the A form may be either smooth-shelled or beaded on both sutures and chamber walls.

Red Bluff, Shelford.

Lower Miocene.—Stratigraphic position unsettled, but younger than the two preceding—probably of the same age as Balcombe Bay beds.

Material a yellow marl, apparently formed in fairly deep water, and rich in foraminifera. *Operculina* very common and the only large foraminifer present. 110 specimens were examined. These fall into three groups—

(1) Very finely beaded all over.—2 specimens.

(2) Very slightly beaded in early portion of shell.—75 specimens.

(3) Wholly smooth.—33 specimens.

The sutures are limbate and very slightly raised in all cases.

Particulars of the specimens sectioned are as follows:—

No.	Larger Diameter of Shell.	Diameter of Proloculus (External and Internal).	No. of Whorls.	Chambers in Last Whorl.	Average Width last ¼ Whorl.	Sutures.	Ornament on Chamber Walls.
1	3·2 mm.	0·137; 0·078 mm.	3½	16	0·34 mm.	Limbate, raised	Covered with small beads
2	2·8 mm.	0·114; 0·078 mm.	3	15	0·3 mm.	,,	Few small beads on early chambers
3	3·4 mm.	0·115; 0·070 mm.	3½	20	0·3 mm.	Thick limbate, raised	,, ,,
4	2·9 mm.	0·124; 0·072 mm.	3½	16	0·2 mm.	Limbate raised and very sharply reflexed	Nil
5	3·1 mm.	0·116; 0·080 mm.	3	17	0·2 mm.	Limbate raised	Few large beads on centre of each side of test
6	3 mm.	0·112; 0·081 mm.	3½	19	0·2 mm.	,, ,,	,, ,,
7	3·4 mm.	0·054; 0·030 mm.	4	20	0·3 mm.	Limbate barely raised	Nil
8	3·6 mm.	0·160; 0·105 mm.	3¼	19	0·3 mm.	,, ,,	Nil

Trimorphism therefore appears to be present in the Red Bluff specimens, Nos. 1, 2, 3, 4, 5, and 6 representing the A1 form, No. 8 the A2, and No. 7 the B. The external characters of the test are not, however, consistent with the size of the proloculus

Flinders.

Lower Miocene—B 2 Zone.

Polyzoal limestone, with *Lepidocyclina*, *Amphistegina*, *Hofkerina*, *Operculina*, etc. The calcareous foraminifera are all thick-shelled.

27 specimens of *Operculina* were examined. These fall into the same two groups as the Nuntin Bore specimens—

Group 1. 23 specimens.

Group 2. 4 specimens.

Details of three specimens examined in section are as follows:—

Specimen Number—	1.	2.	3.
Larger diameter ..	2·4 mm.	2·1 mm.	2·3 mm.
Diameter of proloculus (external and internal)	0·090; 0·053 mm.	0·118; 0·068 mm.	0·160; 0·083 mm.
Number of whorls ..	3	2¾	2¾
Number of chambers in last whorl	14	20	15
Average width of chambers in last ¼ whorl	0·24 mm.	0·2 mm.	0·2 mm.
Sutures	Raised and beaded	Limbate and much raised	Slightly raised and beaded
Ornament on chamber walls	Surface closely covered with medium sized beads	Nil	Rows of medium sized beads along depressed chamber surface

These are all of Form A, although three types of ornament are represented and Specimen No. 2 has a considerably larger number of chambers to the outside whorl than the other specimens.

The genus *Operculina* is very common in the Lower Miocene of the old Altona Bay Coal Shaft. Except as regards size, the specimens exhibit the same lack of relationship beween the size of the proloculus and the external characters of the shell. Sections of two specimens of the A form show the proloculus to have the following dimensions:—

External diameter—(1) 0.115 mm.; (2) 0.113 mm.

Internal diameter—(1) 0.082 mm.; (2) 0.069 mm.

Similar details in regard to a microspheric specimen 5 mm. in diameter are—0.036 (external) and 0.026 (internal). This has five whorls, with 20 chambers in the outside whorl. The A form has up to $3\frac{1}{2}$ whorls, with a maximum of 20 chambers in the last-formed whorl.

The species showing the closest affinity with *O. victoriensis* is probably the Recent *O. bartschi* Cushman, described from the Philippines. The latter species is considerably larger, attaining a diameter of 8 mm. and it has 20 to 25 chambers to the whorl, as compared with a maximum of 20 in *O. victoriensis.* The central portion of the shell is often much thickened and strongly biconvex, while this is never seen in *O. victoriensis.*

Distribution:—Victoria—Railway Cutting, Neumerella; Skinner's, Mitchell River, Bairnsdale; Shell lime pit, E. of Longford; Robinson's Quarry (Dutson's), Longford; Flinders; Balcombe Bay, Mornington; Altona Bay Coal Shaft; Green Gully, Keilor; marl beds in polyzoal limestone, north end of Bathing Beach, Torquay; Filter and Upper Quarries, Batesford; Campbell's Point, Lake Connewarre; Red Bluff, Shelford: Muddy Creek, Hamilton; Portland.

South Australia—Cliffs on Murray River, near Morgan.

The above records are all from surface exposures. The species is also common in borings in Gippsland, Western Victoria, and the Mallee. The range of *O. victoriensis* appears to extend from the upper part of the Lower Miocene to the Middle Miocene.

Operculina kawakawaensis, sp. nov.

(Plate XVI., fig. 9; text-fig. 3.)

Operculina complanata Chapman (*non Lenticulites complanata* Defrance), 1926, p. 91, pl. xviii., fig. 1; pl. xix., fig. 3.

Test ovate, compressed, with a strong peripheral keel which forms a raised margin to both faces of the test; central portion of each face flat, the outside whorl with the lateral surfaces slightly concave; whorls numbering up to $2\frac{3}{4}$; chambers numerous, 22-23 in the adult whorl, each about six times as long as wide; sutures broad, limbate, much raised in the outside whorl, and evenly recurved. Larger diameter of the test up to 4 mm.: lesser diameter up to $3\frac{1}{2}$ mm.

Holotype in Auckland University Museum Coll.

This species occurs in great numbers in a rock-specimen kindly loaned to us by Professor J. A. Bartrum from the Auckland University Collection. The material is a firmly-consolidated greensand from the dumps of one of the old coal mines at Kawakawa, Bay of Islands, New Zealand. For full details of the occurrence of this rock, reference should be made to the senior author's notes in the paper quoted above.

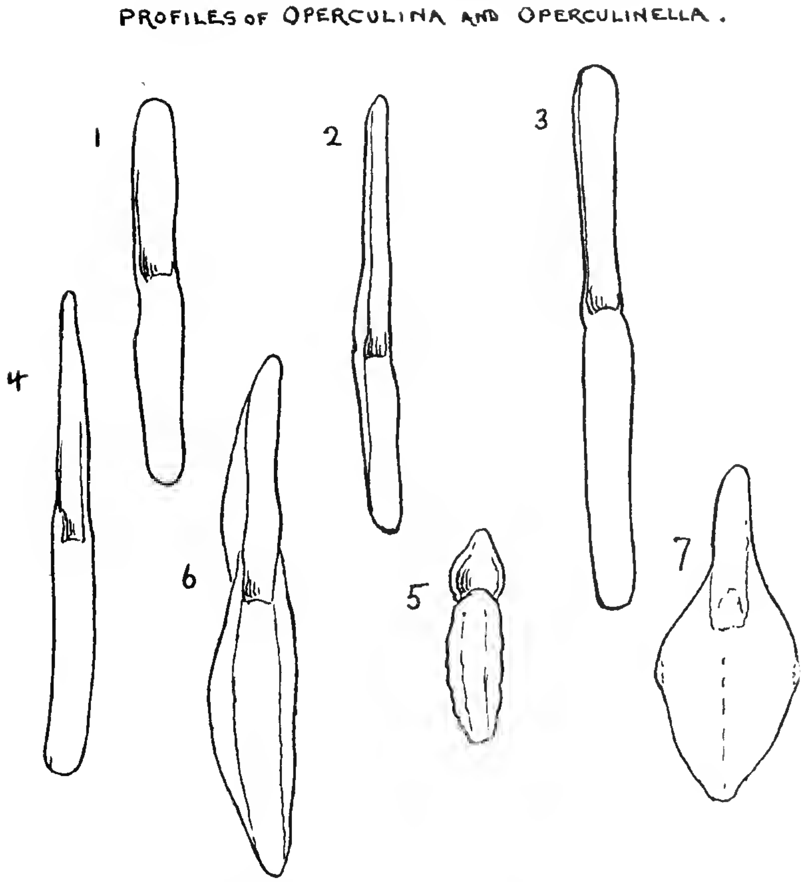
O. kawakawaensis bears a good deal of resemblance to *O. complanata*, particularly in the shape of the chambers and the number of chambers to a whorl. Sections made show, however, that the septal processes found in *O. complanata* are not present in the New Zealand species, which may also be distinguished by the very strong, flat-topped, protuberant sutures.

The only specimens are from the Lower Miocene of Kawakawa where it is found associated with an undescribed species of *Halkyardia*.

Operculina matapauensis, sp. nov.

(Plate XVII., figs. 10, 11; text-fig. 4.)

Test almost circular to ovate, compressed, complanate, with a very broad peripheral keel, which forms a raised rim to both faces of the test and frequently to the earlier whorls; whorls as many as $4\frac{1}{4}$ in the A form; chambers numerous, 4 to 5 times as long as wide in the last quarter whorl, up to 22 in the last whorl; sutures strongly recurved, usually limbate and raised; surface of chambers slightly depressed, sometimes with a few, fairly large beads irregularly placed on the surface of the earlier chambers. Diameter up to 3.3 mm.



TEXT-FIG. 1.—1. *Operculina complanata* (Defr.). Plesiotype. L. Miocene (Aquit.), Dax, France. × 12. 2. *O. victoriensis*, sp. nov. Holotype. L. Miocene, Shelford, Vic. × 14. 3. *O. kawakawaensis*, sp. nov. L. Miocene, Kawakawa, Bay of Islands, N.Z. From section of specimen on rock surface. × 16. 4. *O. matapauensis*, sp. nov. Holotype. Miocene, Matapau, New Guinea. × 16. 5. *O. ammonoides* (Gron.). Plesiotype. Great Barrier Reef, near Townsville, Queensland. × 12. 6. *O. bartschi* Cushman. Form A. Plesiotype. Off Masthead Island, Queensland, 20 fms. × 12. 7. *Operculinella venosa* (F. and M.). Plesiotype. Shark Bay, W.A. × 12.

Holotype (Chapman Coll.) from Miocene of Matapau, New Guinea.

This species is common at Matapau, where it occurs in association with *Calcarina defrancii, Baculogypsina sphaerulata, Elphidium craticulatum, Ammomassilina alveoliniformis,* and other forms of a Recent, tropical, shallow-water aspect. It is not likely to be mistaken for any previously-described form.

What appear to be the A and B forms were found. A section of the former shows a thick marginal cord following the spiral suture, $4\frac{1}{2}$ whorls, with 22 chambers in the outside whorl, and a proloculus measuring 0.058 mm. in internal diameter (external, 0.073 mm.). The marginal cord is mueh narrower in the section of the other form. This specimen has four whorls, with 16 chambers in the outside whorl. The proloculus is 0.026 mm. in internal diameter (external, 0.055 mm.). The shell wall of both specimens is smooth and the sutures are limbate and raised.

The only specimens of *O. matapauensis* are from the type locality, where it is common.

Recent Species.

Operculina ammonoides (Gronovius).

(Plate XVII., figs. 12-16, text-fig. 5.)

Nautilus ammonoides Gronovius, 1781, p. 282, pl. xix., figs. 5, 6.
Assilina discoidalis d'Orbigny, 1826, p. 296, No. 1, Modèles, No. 88.
Operculina gaimardi d'Orb., 1826, p. 281, No. 5.
Assilina nitida d'Orb., 1826, p. 296, No. 4.
Operculina gaimardi d'Orb.: Fornasini, 1903, p. 396, pl. xiv., fig. 4.
Assilina discoidalis d'Orb. var.: Fornasini, 1903, p. 396. pl. xiv., fig. 8.
A. nitida d'Orb.; Fornasini, 1903, p. 397, pl. xiv., fig. 11.
Operculina discoidalis (d'Orb.): Cushman, 1921, p. 379.
O. discoidalis, var. *involuta* Cushman, 1921, p. 380, text-fig. 16.
O. elegans Cushman, 1921, p. 381, pl. xcvii., fig. 3.
O. ammonoides (Gron.): Cushman, 1921, p. 382.
O. gaimardi d'Orb.: Cushman, 1924, p. 50, pl. xvii., fig. 4.
O. (*Operculinella*) *venosa* Yabe and Hanzawa (*non Nautilus venosus* Fichtel and Moll), 1925, p. 49, pl. v.; pl. vi., figs. 1-5; pl. viii., figs. 1-10.
O. complanata Hofker (*non Lenticulites complanata* Defrance), 1927 (pars), p. 61.

This is a very variable species, within well-defined limits. The test is, as a rule, rounded in outline and biconvex, with a peripheral keel. The thiekness of the test varies eonsiderably, the extremes being represented by d'Orbigny's Modèle of *Assilina discoidalis* and his figure, as reprodueed from his Planehe Inédite by Fornasini, of *A. nitida*. The chambers are numerous, increasing fairly slowly in size as added. They may number as many as 24 in the adult whorl. The surfaee of the chambers may be smooth, but is frequently covered with numerous small papillae and occasionally with large clear beads.

The sutures are generally slightly reeurved, the amount of curvature being greatest at the outer end. In some specimens they may be depressed, but, as a rule, they are limbate and raised, most usually strongly beaded. The limbation is oeeasionally very heavy and the sutural beads very large, three or four beads making up the length of the suture of the ehamber. The position of the proloculus is generally indieated by a large bead of elear shell substance in the centre of eaeh face.

The most striking variation is in the extent to which each whorl overlaps the preceding whorls. This has been excellently illustrated by Yabe and Hanzawa (*loc. cit.*) in series of Recent specimens from Samoa and younger Tertiary examples from the Riukiu Islands. In shape, the involute specimens resemble *Operculinella venosa,* with which they have been identified, but *O. venosa* always has the early whorls involute, and the suture lines are sinuous and not beaded, the surface of the test being plane and smooth. Reference to Fichtel and Moll's figures of *O. venosa* and to the later descriptions and figures given by Carpenter, Brady, and Hofker (vide *Operculinella venosa,* postea) will show how different the two species are.

In any large series of examples of *O. ammonoides,* specimens will be found in which the whorls widen more rapidly than in the typical form of the species, resulting in an ear-shaped, comparatively thin, test. This, in our opinion, represents d'Orbigny's *O. gaimardi,* which was first recorded from Rawack, the type locality of *O. discoidalis* d'Orb., which is undoubtedly identical with *O. ammonoides.*

O. discoidalis, var. *involuta,* and *O. elegans,* described by Cushman (*loc. cit.*) from the Philippines are also considered to come within the limits of variation of *O. ammonoides.*

Sections made of *O. ammonoides* show the following:—

Specimen Number—	1.	2.	3. (*O. gaimardi* form.)	4.
Larger diameter	2·1 mm.	1·6 mm.	2·1 mm.	1·9 mm.
Diameter of proloculus (external and internal)	0·073; 0·038 mm.	0·054; 0·031 mm.	0·037; 0·017 mm.	0·079; 0·048 mm.
Number of whorls ..	4	4	4	3
Chambers in outside whorl ..	18	16	16	13
Average width chambers last ¼ whorl	0·2 mm.	0·15 mm.	0·15 mm.	0·15 mm.
Sutures	Beaded	Early beaded, then limbate	Beaded, outer end recurved	Few, very large beads
Ornament on chamber walls	Nil	Finely papillate	Nil	Nil

Specimens Nos. 1, 2, and 3 are from the Great Barrier Reef, near Townsville. No. 4 is from North-East Bay, Great Palm Island.

The types of *O. ammonoides* were from the Bay of Bengal. The species is widely distributed in shallow water in the tropical Indo-Pacific region. On the Barrier Reef, it appears to be found in shallower water than *O. bartschi.* In view of the rarity of the work of Gronovius, in which *O. ammonoides* was described, we reproduce, by the kindness of Dr. J. A. Cushman, a photograph of the type figure.

Distribution.—Recent: Numerous localities on the Great Barrier Reef, Queensland.

Post-tertiary: Bore on Michaelmas Reef, 22 miles N.E. of Cairns, Queensland, between 441 and 600 feet.

Late Tertiary: Yule Island, Papua.

Operculina bartschi Cushman.

(Plate XVII., figs. 17-20, text-fig. 6.)

Operculina bartschi Cushman, 1921, p. 376, text-fig. 13.
O. bartschi, var. *plana* Cushman, 1921, p. 377, text-fig. 14.
O. bartschi, var. ornata Cushman, 1921, p. 378, pl. lxxiv., figs. *2a, b.*
O. philippinensis Cushman, 1921, p. 379, text-fig. 15.
O. complanata Hofker (*non Lenticulites complanata* Defrance), 1927 (pars), p. 61.

Cushman's description of *O. bartschi* is as follows:—

"Test comparatively large, compressed except in the central region, coils widening rapidly; central portion thickened, biconvex, composed of several coiled chambers, and ornamented on the surface with numerous comparatively large bosses; chambers numerous, 20 to 25 in the last-formed coil; curved sutures distinct, not ornamented, but the chambers between with numerous comparatively large granulations, usually in somewhat definite lines across the test. Diameter up to 8 mm."

The types were from the Philippines, in 25 fathoms.

The variety *plana* was described as having the surface of the later chambers smooth, very thin and translucent. In the variety *ornata,* the sutures are beaded and the surface of the later chambers is smooth. Cushman states that all three forms occur together. *O. philippinensis* seems to us to be another variant on *O. bartschi,* with which it is frequently associated around the Philippines.

The only examples of *O. bartschi* we have are from off Masthead Island, in the Capricorn Group, from 20 fathoms, where it is common. Three forms are present. The first attains a diameter of 6 mm. and is very strongly built. The central portion of the test is much thickened and with masses of clear shell material which obscure the early whorls. It has three whorls in the adult, with up to 22 chambers to the whorl. There is a strong marginal keel. The early sutures are beaded, those in the later part of the test being limbate and sometimes slightly raised. Occasionally all of the sutures are beaded. The surface of the chambers may be smooth, ornamented with a few large beads, or they may be covered with very small tubercles, amongst which may be irregular rows of larger beads.

The second form is smaller, with a maximum diameter of 3 mm. It has up to $4\frac{1}{2}$ whorls, with not more than 18 chambers to a whorl, but usually less. The central portion of the test is only slightly thickened. Any beading is confined to the early sutures. The wall is thin and comparatively translucent. This is Cushman's *O. bartschi*, var. *plana*.

The third form is very similar to No. 2, but has all of the sutures beaded, the beads becoming smaller in successive chambers. The surface of the chambers, except in the second half of the last whorl, is covered with granules. It is therefore identical with *O. bartschi*, var. *ornata* Cushman.

All of the examples of *Operculina* present in a quantity of the material were picked out. There were 44 specimens, of which 13 were of the first form, 30 of the second, and 1 of the third. Sections made show that the first is the megalospheric and the second the microspheric. The third was not sectioned, as it was represented by only one specimen, but it is megalospheric. It should be noted that the microspheric form is always smaller than the megalospheric and is more than twice as common.

The proloculus of the first form attains an internal diameter of 0.231 mm., which is much larger than the maximum diameter given by Hofker, viz., 0.060 mm. The diameter of the proloculus of two sections of the microspheric form is respectively 0.061 (external) and 0.039 (internal) and 0.056 (external) and 0.035 (internal). Hofker gives the diameter of the proloculus of the microspheric form as 0.027 mm.

Genus **Operculinella** Yabe, 1918.

Operculinella venosa (Fichtel and Moll).

(Plate XVII., figs. 21, 22, text-fig. 7.)

Nautilus venosus Fichtel and Moll, 1798, p. 59, pl. viii., figs. *e-h*.
Amphistegina cumingii Carpenter, 1859, p. 32, pl. v., figs. 13-17.
Nummulina radiata Carpenter (*non Nautilus radiatus* Fichtel and Moll), 1862, p. 275.
Nummulites cumingii (Carp.): Brady, 1884, p. 749 pl. cxii., figs. 11-13; text-fig. 22.
Operculinella cumingii (Carp.): Yabe, 1918, p. 122, pl. xvii., figs. 8-12.
Operculina venosa (F. & M.); Hofker, 1933, p. 143, pl. v., figs. 13-16; text-fig. *32a-c*.

The structure of this species has been fully described by Carpenter and by Hofker. The latter has found it to be trimorphic, the outspread type of shell being the microspheric form.

In the material we have examined, *O. venosa* is very rare, the only records being from:—

Recent—Thursday Island; Shark Bay, Western Australia, 8 fms.

Late Tertiary—Yule Island, Papua.

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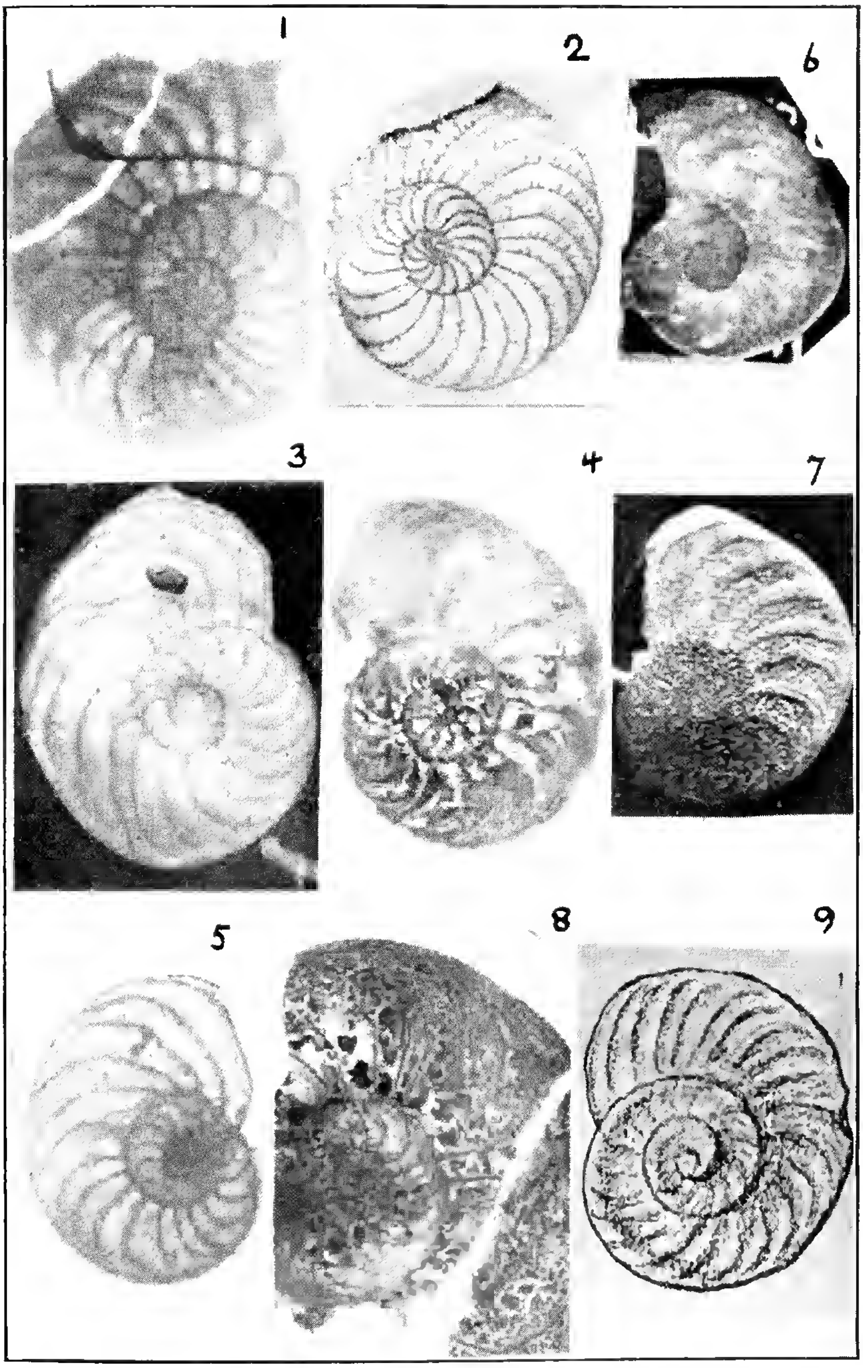
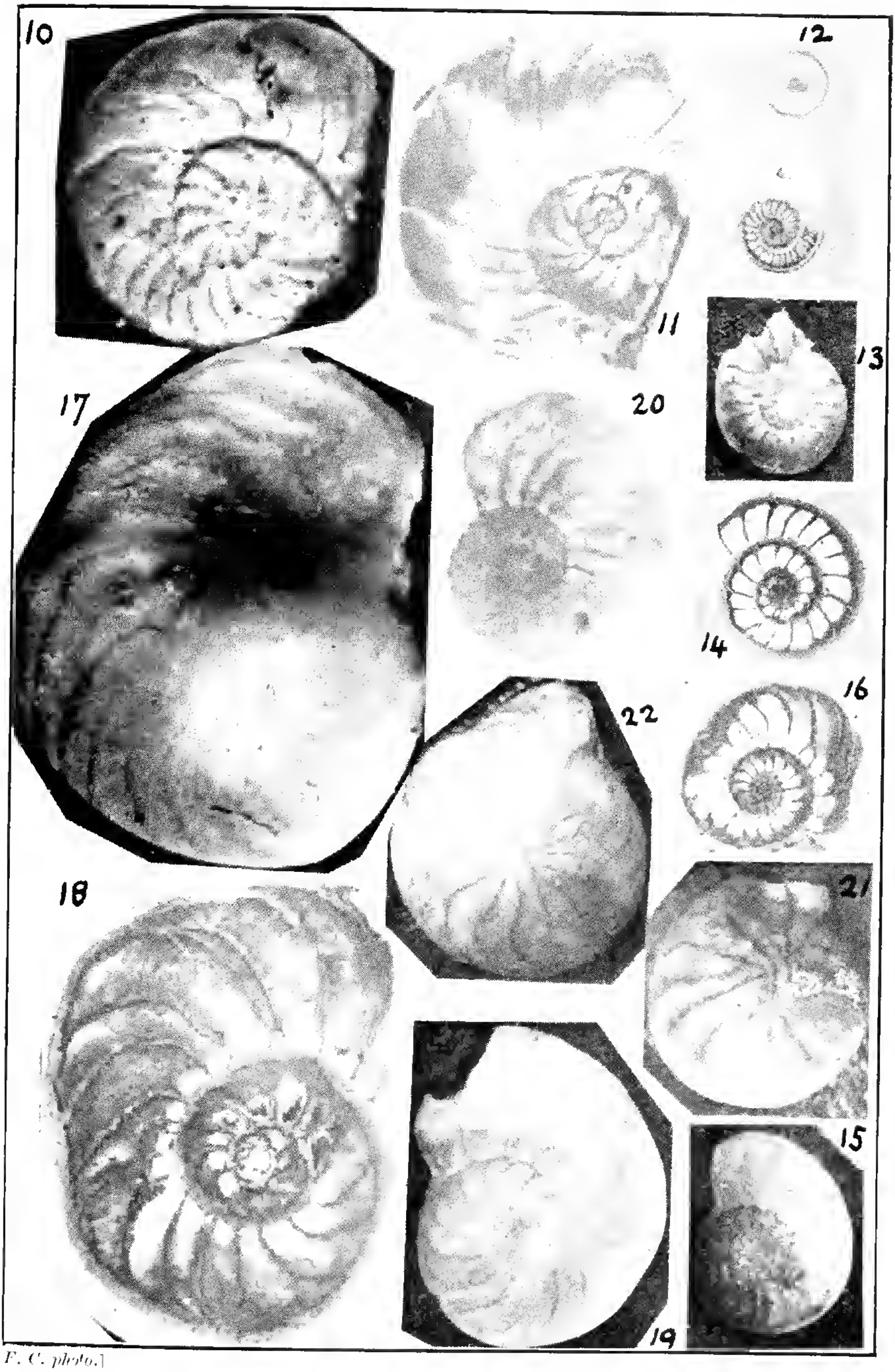


F. C. photo].

Operculina complanata, O. victoriensis, O. kawakawaensis.



F. C. photo.]

Operculina matapauensis, O. ammonoides, O. bartschi and Operculinella venosa.

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Explanation of Plates.

PLATE XVI.

FIG. 1.—*Operculina complanata* (Defrance). Lower Miocene (Aquitanian). Dax, near Bordeaux, S. of France. × 14.

FIG. 2.—*O. complanata*. Horizontal section. Lower Miocene. Lagus, S. of France. × 7.

FIG. 3.—*Operculina victoriensis*, sp. nov. Holotype. Form A. Lower Miocene. Red Bluff, Shelford, Victoria. × 14.

FIG. 4.—*O. victoriensis*, sp. nov. Form A2. Horizontal section. Lower Miocene. Red Bluff, Shelford. × 14.

FIG. 5.—*O. victoriensis*, sp. nov. Form A1. Horizontal section. Lower Miocene. Red Bluff, Shelford. × 14.

FIG. 6.—*O. victoriensis*, sp. nov. Paratype. Form B. Lower Miocene. Altona Bay Coal Shaft, Port Phillip. × 7.

FIG. 7.—*O. victoriensis*, sp. nov. Paratype. Form B. Lower Miocene. Hamilton Bore, 80-88 feet, Western Victoria. × 14.

FIG. 8.—*O. victoriensis*, sp. nov. Form B (smooth shelled). Horizontal section. Lower Miocene. Altona Bay Coal Shaft. × 14.

FIG. 9.—*Operculina kawakawaensis*, sp. nov. Copied from original drawing. Lower Miocene. Kawakawa, Bay of Islands, N. Zealand.

PLATE XVII.

FIG. 10.—*Operculina matapauensis*, sp. nov. Holotype. Lower Mid-Miocene (stage f.). Matapau, New Guinea. × 14.

FIG. 11.—*O. matapauensis*, sp. nov. Horizontal section. Lower Mid-Miocene. Matapau, New Guinea. × 14.

FIG. 12.—*Operculina ammonoides* (Gronovius). Original figure of "Nautilus ammonoides", Gronovius, 1781.

FIG. 13.—*O. ammonoides* (Gronovius). Plesiotype. Recent. Great Barrier Reef, near Townsville, Queensland. × 14.

FIG. 14.—*O. ammonoides* (Gron.). Form B. Horizontal section. Great Barrier Reef, near Townsville, Queensland. × 14.

FIG. 15.—*O. ammonoides* (Gron.). Plesiotype, forma *O. gaimardi* d'Orb. Same locality. × 14.

FIG. 16.—*O. ammonoides* (Gron.). Form B (forma *O. gaimardi* d'Orb.). Horizontal section. Same locality. × 14.

FIG. 17.—*Operculina bartschi* Cushman. Form A. Recent. Off Masthead Island, Queensland, 20 fathoms. × 14.

FIG. 18.—*O. bartschi* Cushman. Form A. Horizontal section. Same locality. × 14.

FIG. 19.—*O. bartschi* Cushm. Form B. Same locality. × 14.

FIG. 20.—*O. bartschi* Cushm. Form B (= *O. bartschi*, var. *plana* Cushman). Horizontal section. Same locality. × 14.

FIG. 21.—*Operculinella venosa* (Fichtel and Moll). Form A. Shark Bay, W. Australia, 8 fathoms. × 14.

FIG. 22.—*O. venosa* (F. and M.). Form B. Same locality. × 14.

THE SIR JOSEPH BANKS ISLANDS.

REPORTS OF THE EXPEDITION OF THE McCOY SOCIETY FOR FIELD INVESTIGATION AND RESEARCH.

PART ONE.

Contents

1. *General Introduction.*

By D. J. MAHONY, M.Sc.

The Sir Joseph Banks Group consists of about 20 islands, islets and reefs lying eastward of Louth Bay in Spencer Gulf, South Australia.

Matthew Flinders discovered the group in 1802 during his survey of the southern coast of Australia in the sloop *Investigator,* 334 tons. Under the date Feb. 26, 1802, he records that " Three small isles had been seen from Thistle's Isle and their bearings set; and the discovery of them now augmented by several others, forming a cluster to the eastward of Point Bolingbroke. This was called the Sir Joseph Banks group, in compliment to the Right Honourable president of the Royal Society, to whose exertion and favour the voyage was so indebted "(1). The view to which Flinders refers was obtained from Stamford Hill, Port Lincoln, which he had named in honour of his native county. He named the various islands after Lincolnshire villages, near one of which Sir Joseph Banks lived in Reevesby Abbey.

On Saturday, March 6, Flinders landed on Kirkby Island to take bearings of the other members of the group, but they proved so numerous that his observations were not completed before dark. Next morning he landed with 'the botanical gentlemen', one of whom was the famous Robert Brown. He noted that granite forms the basis of Kirkby Island and that it is covered with a stratum of calcareous rock. " The island was destitute of wood, and almost of shrubs; and although there were marks of its having been frequented by geese, none of the birds were seen, nor any other species of animal except a few hair seals upon the shore. This description, unfavourable as it is, seemed applicable to all the group, with the exception of Reevesby and Spilsby Islands, which are higher and of greater extent, and probably somewhat more productive "(2).

For a number of years the islands have been leased for grazing sheep, but the carrying capacity is low and the effects of human occupation are not very marked.

The McCoy Society visited the islands in December, 1936, and spent about two months in investigating the geology, botany, and zoology of the group. The following papers are the first part of a series describing the results. The remainder will appear in vol. 51 (1) of the Proceedings of the Royal Society of Victoria.

1. Flinders, Matthew. A voyage to Terra Australia. Vol. 1, p. 142.
2. *Ibid.*, p. 153.

Most of the islands rise less than 100 ft. above sea level, the highest land being near the northern end of Spilsby Island which is marked 162 ft. on the Admiralty chart. The northern part of the group, except Dalby and Kirkby Islands, all rise from a sheal about nine miles long, as defined by the 5-fathom line; the more southern islands are separated by deeper water. All consist of a complex of ancient igneous and sedimentary rocks overlain in part by consolidated dune limestone, probably of post-tertiary age, and recent unconsolidated sand dunes.

The annual rainfall is about 15 inches, and summer daytime temperatures are high, but during our visit the nights were cool and there was a considerable precipitation of dew. There is no permanent surface water, but two wells on Reevesby Island sunk in the superficial deposits yield a supply of rather brackish hard water.

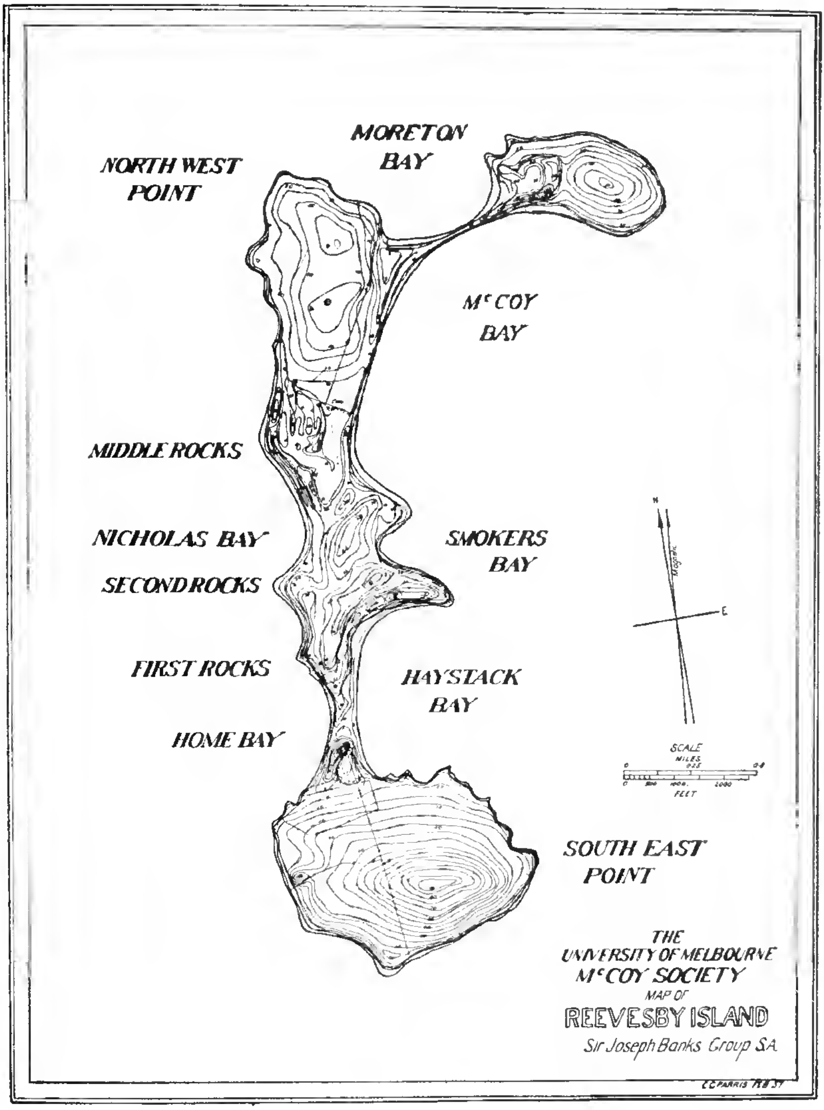
The larger islands are covered for the most part with a fairly thick growth of Boobyalla bushes and there are a very small number of Eucalypts and Casuarinas. The more open parts of the islands support a thin covering of grass, and *Mesembryanthemum* flourishes on the sand hills.

The only surviving mammals are seals on some of the smaller islets, but bones of *Arctocephalus cinereus* and *A. doriferus* are abundant in places on Reevesby Island. Wallabies of the *eugenii* type must once have been plentiful if one may judge by the bones among the sand hills, but none survive. A mandible of the peculiar Australian Rat, *Conilurus*, was found, but no living specimens were seen.

Birds of especial interest are the Rock Parrot, *Neophema petrophila*, and the White-faced Storm Petrel, *Pelagodroma marina*, which breeds in large numbers on Reevesby Island. Several other sea birds nest on various islands, including large colonies of Crested Terns, *Sterna bergii*, and two species of Cormorants, *Phalacrocorax fuscescens* and *P. varius*. Few species of Passerine birds were noted, the most common being the Silvereye, *Zosterops lateralis*.

Tiger snakes, usually almost black, are very plentiful and acording to reliable accounts Death Adders were formerly only too common, but none was seen during our visit. The commonest lizards are the Stumpy-tail, *Trachysurus rugosus*, and small skinks; there are also a few Lace Lizards (*Varanus sp.*).

Insects are fairly abundant and diversified. The most interesting are the Ants which are represented by great numbers of individuals; 33 species were collected, of which 14 are new.


MORETON BAY
NORTH WEST POINT
Mc COY BAY
MIDDLE ROCKS
NICHOLAS BAY
SMOKERS BAY
SECOND ROCKS
FIRST ROCKS
HAYSTACK BAY
HOME BAY
SCALE
MILES
FEET
SOUTH EAST POINT
THE
UNIVERSITY OF MELBOURNE
Mc COY SOCIETY
MAP OF
REEVESBY ISLAND
Sir Joseph Banks Group SA

2. *List of Vascular Plants.*

By STELLA G. M. FAWCETT, M.Sc., and C. ELIZABETH VANCE, M.Sc.

The first list of plants of the Sir Joseph Banks Group of Islands was made by J. H. Maiden in 1908. He visited Reevesby Island in 1907 and remained for one day. His records are necessarily incomplete, as he visited the island in the dry season. He gives a list of sixteen species. The following list also gives an incomplete picture of the vegetation of the group, as our collections were made in the driest months of the year, when annuals are lacking. Many of these have been identified by their fruits and seeds, but it was found impossible to name others as only their fragmentary remains were present.

References.

Maiden, J. H., 1908.—*Trans. Roy. Soc. South Aust.*, xxxii., pp. 252-286.
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Family.	Species.	Reevsby.	Winceby.	Lusby.	Dalby.	Marum.	Kirkby.	Langton.	Sibsey.	L. English.	Roxby.	Hareby.	Blyth.	Spilsby.	L. Spilsby.	Partney.	Habitat.	Habit.
Potamogetonaceae ..	*Zostera tasmanica* G. V. Martens	+	..	+	+	+	+	+	..	..	+	..	..	..	+	..	Above and just below low tide mark	
	Cymodocea antarctica (Labill,) Endl.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Submerged	
	**Posidonia australis* Hook. f. ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Submerged	
Hydrocharitaceae ..	*Halophila ovalis* (R. Br.), Hook. f.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Submerged	
Gramineae ..	**Spinifex hirsutus* (R. Br.), Benth.	+	..	+	+	..	+	+	+	..	+	..	+	+	+	+	Outer edges of sand-dunes	Stout creeping grass
	Stipa elegantissima Labill. ..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	+	Travertine	Tufted grass
	S. eremophila Reader	+	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Travertine and sandy soil	Small tussocky grass
	S. teretifolia Steud.	..	..	..	..	..	+	..	..	..	..	..	..	+	+	..	Dunes and travertine cliffs	Tussocks ·6 m.
	S. horrifolia J. M. Black ..	+	..	..	..	..	+	..	..	..	..	..	..	..	..	..	Travertine	Minute tussocks, leaves 3 cm. long
	S. scabra Lindl.	+	..	+	+	+	+	+	+	..	+	..	..	..	+	..	Sandy soil	Tussocks
	Sporobolus virginicus (L.), Kunth.	+	..	..	..	..	..	..	..	..	..	..	..	+	..	..	Outer sides of dunes ..	Dwarf creeping grass
	Calamagrostis filiformis (Forst.), Pilger	+	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Sandy soil	Small grass to 5 cm. high
	†*Ammophila arenaria* (L.), Link.	+	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Dunes	Tufted grass to ·6 m. high
	Danthonia semiannularis (Labill.), R. Br.	+	+	+	+	+	..	+	+	+	..	..	..	+	+	+	Travertine	Minute tussocks 2–4 cm. high
	†*Koeleria phleoides* Pers. ..	+	+	..	..	+	..	..	+	..	..	..	..	..	..	+	Travertine and sandy soil	Erect annual 10 cm.
	**Distichlis spicata* (L.) Greene ..	+	..	..	..	..	..	..	..	..	..	..	..	+	..	..	Dunes	Creeping grass 5 cm.
	Poa caespitosa Forst.	+	..	..	..	..	+	..	..	..	..	..	..	+	..	..	Dunes, travertine and granite slopes as on Kirkby	Tussocks 30 cm.
	†*Festuca bromides* L.	+	+	..	+	+	+	+	+	..	+	..	..	..	..	+	Travertine and sandy soil	Small annual 10 cm.
	†*Bromus madritensis* L. ..	+	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Sandy soil	Annual to 15 cm.
	B. arenarius Labill.	+	..	..	..	..	..	+	..	..	..	..	..	+	+	..	Travertine and sandy soil	Erect annual to 12 cm.
	†*B. unioloides* H. B. et K. ..	+	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Sandy soil	Minute annual 5 cm.
	†*B. mollis* L.	+	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Sandy soil	Erect annual 20 cm.
	B. sterilis L.	+	..	..	..	..	+	..	..	..	..	..	..	+	+	..	Sandy soil	Erect annual 10 cm.
	Cynodon dactylon Rich. ..	..	..	..	..	..	..	..	..	..	..	..	..	..	+	..	Travertine	Prostrate perennial grass 6 cm.
	†*Lolium temulentum* L. ..	+	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Sandy soil	Erect grass 12 cm.

* = Recorded by Maiden. † = Introduced.

Family.	Species.	Reevsby.	Winceby.	Lusby.	Dalby.	Marum.	Kirkby.	Langton.	Sibsey.	L. English.	Roxby.	Hareby.	Blyth.	Spilsby.	L. Spilsby.	Partney.	Habitat.	Habit.
Gramineae—*continued*	†*L. perenne* L.	+	..	..	..	..	..	..	..	..	..	..	..	..	+	..	Sandy soil	Prostrate tufted grass
	†*L. rigidum* Gaudin	+	..	..	..	..	..	..	+	..	..	..	..	..	+	..	Dunes	Small annual grass, rigid, 10 cm.
	Lepturus incurvatus Trin. ..	+	..	..	..	..	..	..	..	..	..	..	..	+	..	..	Sandy soil	Prostrate tufted grass
	L. cylindricus Trin.	+	..	..	..	..	..	..	..	..	..	..	..	+	..	..	Dunes	Rigid, erect grass 8 cm.
	*†*Hordeum murinum* L. ..	+	+	..	+	+	+	+	+	+	..	..	..	+	..	+	Sandy soil	Small herb 8 cm.
	†*H. maritimum* With.	+	..	..	..	..	..	..	..	..	..	..	..	+	..	..	Dunes	Small herb 5 cm.
Cyperaceae ..	**Scirpus nodosus* Rottb. ..	+	..	..	..	..	..	..	..	..	..	..	..	+	..	..	Dunes	Tussocks
Juncaceae ..	*Juncus bufonius* L.	+	+	..	+	+	+	+	+	..	+	..	..	..	+	+	Travertine and sand ..	Small herb, 15 cm.
Liliaceae	*Dianella revoluta* R. Br. ..	..	..	..	..	..	..	..	..	..	..	..	..	+	..	..	Dunes	Tussocks 10–70 cm.
	Bulbine semibarbata (R. Br.), Haw.	+	..	..	..	..	+	..	..	..	..	..	..	..	..	..	Travertine	Dwarf herb
Casuarinaceae ..	**Casuarina stricta* Ait. (1789) ..	+	..	..	..	..	..	..	..	..	..	..	..	+	..	..	Granite and deep sandy soil	Tree 7 m.
Urticaceae ..	†*Urtica urens* L.	+	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Travertine	Erect annual, 10 cm.
Santalaceae ..	*Exocarpus aphylla* R. Br. ..	..	..	..	+	..	..	..	..	..	..	..	+	..	..	..	Dunes	Stiff leafless shrub, 70 cm.
Polygonaceae ..	**Muehlenbeckia adpressa* (Labill.), Meisn.	+	+	+	..	+	..	+	..	..	+	..	..	..	..	..	Sandy soil	Perennial climber, sometimes trailing
Chenopodiaceae ..	*Rhagodia baccata* (Labill.), Moq.	+	+	..	..	..	..	..	+	..	..	..	..	..	..	..	Travertine and sandy soil	Erect or scrambling shrub, ·5 m.
	R. parabolica R. Br.	+	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Sandy soil	Erect shrub, ·7 m.
	R. crassifolia R. Br.	+	+	+	..	+	+	+	+	..	+	..	..	+	+	+	Sandy soil, travertine ..	Erect or straggling shrub, 1 m.
	R. nutans R. Br.	+	..	..	..	..	+	+	+	..	+	..	..	+	..	+	Sandy soil, travertine ..	Weak trailing herb
	Chenopodium carinatum R. Br. ..	+	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Sandy soil	Minute herb
	†*C. murale* L.	+	..	..	..	..	..	..	..	..	..	..	..	+	..	..	Sandy soil	Stout annual, ·3 m.
	**Atriplex paludosum* R. Br. ..	+	+	+	+	+	+	+	+	..	+	+	+	+	+	+	Travertine, sandy soil, salt pans	Erect or straggling shrub to ·5 m., often forming circular patches, 4 m. diameter

* = Recorded by Maiden. † = Introduced.

Family.	Species.	Reevsby.	Winceby.	Lusby.	Dalby.	Marum.	Kirkby.	Langton.	Sibsey.	L. English.	Roxby.	Hareby.	Blyth.	Spilsby.	L. Spilsby.	Partney.	Habitat.	Habit.
Chenopodiaceae—*continued*	**Atriplex cinereum* Poir. ..	+	+	+	+	+	+	+	+	..	..	..	+	+	+	..	Extreme outer edge of dunes	Erect shrub, 1·7 m.
	A. Muelleri Benth.	..	+	..	..	..	+	+	+	..	..	..	..	..	+	..	Edge of travertine plateaux	Small shrub, 100 cm.
	Bassia ventricosa J. M. Black ..	..	+	+	+	+	+	+	+	..	+	..	..	..	+	+	Travertine	Diffuse, weak shrub, ·5 m.
	B. biflora (R. Br.), F. v. M. ..	..	+	..	+	..	+	+	..	..	+	..	..	..	..	..	Travertine	Diffuse, weak shrub, ·5 m.
	Kochia oppositifolia F. v. M. ..	+	..	+	..	..	+	..	..	+	+	..	..	+	..	..	Salt pans, travertine ..	Erect succulent shrub, ·5 m.
	Salsola Kali, L.	..	+	+	..	+	+	+	+	..	+	..	..	+	+	+	Travertine, sandy soil ..	Bushy or straggling herb, 50 cm.
	Suaeda australis (R. Br.), Moq.	+	+	+	+	+	+	+	+	..	+	..	..	+	..	+	Near sea at foot of cliffs	Succulent herb, 20 cm.
	**Enchylaena tomentosa* R. Br. ..	+	+	+	+	+	+	+	+	..	+	..	+	+	+	+	Sandy soil, travertine ..	Semi-prostrate or scrambling shrub, leaves succulent
	Threlkeldia diffusa R. Br. ..	+	+	+	+	+	+	..	+	..	+	..	..	+	+	+	Sandy soil, travertine ..	Semi-prostrate or scrambling shrub, leaves succulent
	Arthrocnemum halocnemoides. Nees. var *pergranulatum* J. M. Black	+	..	+	..	+	..	..	..	..	..	..	..	+	..	..	Salt pans	Erect. or spreading succulent shrub, ·5 m.
	Salicornia australis Banks et Sol.	+	..	..	..	..	..	..	..	..	..	..	..	+	..	..	Salt pans	Prostrate, half shrub, ·3 m.
Aizoaceae ..	*†*Mesembryanthemum crystallinum* L.	+	+	+	..	+	..	..	+	+	..	..	..	+	..	+	Travertine, sandy soil ..	Succulent, creeping herb 15 cm.
	M. aequilaterale Haw. ..	+	..	..	+	..	+	+	..	..	+	..	..	+	+	+	Travertine dunes, sandy soil	Succulent, mat plant
	M. australe, Soland	+	+	+	+	+	+	+	+	..	+	..	..	+	..	+	Travertine, dunes ..	Succulent mat plant, often scrambling
	Tetragonia implexicoma (Miq.), Hook. f.	+	+	+	+	+	+	+	+	..	+	..	..	+	+	..	Travertine, cliffs, sandy soil	Scrambling weak half shrub
Caryophyllaceae ..	*Spergularia rubra*	+	..	..	..	+	+	..	+	..	..	..	..	+	..	..	Travertine	Small herb, 5 cm.
	†*Silene gallica* L.	+	..	..	..	..	..	..	..	..	..	..	..	+	..	..	Travertine	Small herb, 10 cm.
	Scleranthus pungens R. Br. ..	..	..	..	..	..	..	..	..	..	..	..	..	+	..	..	Travertine plateau near sea	Cushion bush, 30 cm.
	Polycarpon tetraphyllum Loefl. ..	+	+	+	+	+	+	+	+	+	+	+	..	..	+	+	General ex. on dunes ..	Prostrate annual
Ranunculaceae ..	*Clematis microphylla* D. C. ..	..	..	..	..	..	..	..	..	..	..	..	..	+	..	..	Dunes	Half woody climber

* = Recorded by Maiden. † = Introduced.

Family.	Species.	Reevsby.	Winceby.	Lusby.	Dalby.	Marum.	Kirkby.	Langton.	Sibsey.	L. English.	Roxby.	Hareby.	Blyth.	Spilsby.	L. Spilsby.	Partney.	Habitat.	Habit.
Papaveraceae ..	*Papaver aculeatum* Thunb., 1813	+	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Sandy soil	Small herb, 10 cm.
Cruciferae ..	†*Sisymbrium orientale* L., 1759 ..	+	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Sandy soil	Robust herb, 100 cm., annual
	Lepidium foliosum Desv. ..	..	+	..	+	..	+	..	+	+	..	..	..	+	+	..	Among rocks, at bases of cliffs	Erect herb, 100 cm.
	†*Coronopus didymus* (L.), Sm. ..	+	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Sandy soil	Small, straggling herb, 5 cm.
	†*Cakile maritima* Scop. ..	+	..	..	..	..	..	..	..	..	..	..	..	+	..	..	Dunes	Procumbent herb, 10 cm.
Crassulaceae ..	*Crassula Sieberiana* (Schultes), Ostenf.	+	+	..	..	+	+	+	+	..	+	..	..	+	+	+	Travertine	Minute annual
Pittosporaceae ..	*Bursaria spinosa* Cav. ..	..	..	..	..	..	..	..	..	..	..	..	..	+	..	..	Travertine slopes ..	Erect bushy shrub, 2 m.
Leguminosae ..	*Acacia calamifolia* Sweet. ..	..	..	..	..	..	..	..	..	..	..	..	..	+	..	..	Travertine slopes ..	Erect shrub, 2 m.
	A. rupicola F. v. M.	+	..	..	..	..	..	..	..	..	+	..	..	..	..	..	Deep sandy soil ..	Dense rounded shrub, 1·5 m.
	A. Oswaldii F. v. M.	+	..	..	..	..	..	..	..	..	..	..	..	+	..	..	Deep sandy soil ..	Shrub or small tree, 5 m.
	Pultenaea daphnoides Wendl. ..	..	..	..	..	..	..	..	..	..	+	..	..	+	..	..	Travertine	Shrub, 1 m.
	†*Medicago denticulata* Willd. ..	+	..	..	..	+	..	..	+	..	..	..	..	+	..	..	Sandy soil	Small, straggling herb, 6 cm.
Geraniaceae ..	*†*Erodium cicutarium* (L.), L'Her.	+	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Edges of travertine plateaux	Minute annual, 2 cm.
	Pelargonium australe Willd. ..	..	..	..	..	..	+	..	..	..	..	..	..	..	+	..	Edges of travertine plateaux	Dense herb, to 100 cm.
Oxalidaceae ..	*Oxalis corniculata* L.	+	..	..	..	..	..	..	..	..	..	..	..	+	..	..	Travertine, sandy soil ..	Minute herb, 4 cm.
Zygophyllaceae ..	**Nitraria Schoberi* L.	+	+	+	..	+	+	+	+	+	+	..	..	+	..	+	Travertine cliffs ..	Fleshy-leaved shrub, 3 m.
Sapindaceae ..	*Dodonaea viscosa* L.	..	..	..	..	..	..	..	..	..	+	..	..	+	..	..	Deep travertine soil ..	Erect shrub, 1 m.
	D. attenuata A. Cunn. ..	..	..	..	..	..	..	..	..	..	+	..	..	+	..	..	Deep travertine soil ..	Erect shrub, 1 m.
Malvaceae ..	**Lavatera plebeja* Sims. ..	+	+	+	+	+	+	..	+	..	+	..	..	+	+	+	Edges of travertine plateaux	Herb, or half-shrub, erect, to 1·5 m.
	†*Malva parviflora* L.	+	..	..	..	..	..	..	..	..	..	..	..	+	..	..	Travertine	Erect spreading annual
Frankeniaceae ..	**Frankenia pauciflora* D. C. ..	+	+	+	+	+	+	+	+	..	+	+	..	+	+	+	Travertine	Semi-prostrate dwarf-shrub
Thymelaeaceae ..	*Pimelea serpyllifolia* R. Br. ..	..	..	..	..	..	..	..	..	..	..	..	..	+	..	..	Dunes	Shrub, 1 m. high
Myrtaceae ..	*Melaleuca halmaturorum* F. v. M.	..	..	..	..	..	..	..	..	..	..	..	..	+	..	..	Salt pans	Tree to 4 m., dense canopy
	Eucalyptus angulosa Schau. ..	+	..	..	..	..	..	..	..	..	..	..	..	+	..	..	Deep sandy soil ..	Tree, 5 m., mallee
Umbelliferae ..	*Daucus glochidiatus* (Labill.). Fisch., Mey. et Ave-Lall.	+	..	..	..	..	+	..	..	..	..	..	..	+	..	..	Among rocks at bases of cliffs	Herb, erect, ·15 cm.
	Apium australe Pet-Thou. ..	+	..	+	..	..	..	..	..	..	..	..	..	+	..	..	Among rocks near sea ..	Herb, 15 cm.

* = Recorded by Maiden. † = Introduced.

Family.	Species.	Reevsby.	Winceby.	Lusby.	Dalby.	Marum	Kirkby.	Langton.	Sibsey.	L. English.	Roxby.	Hareby.	Blyth.	Spilsby.	L. Spilsby.	Partney.	Habitat.	Habit.
Gentiancaceae ..	*Erythraea spicata* Pers. ..	..	..	..	..	..	+	..	..	..	..	..	..	..	..	..	Travertine	Erect herb, 10 cm.
Convolvulaceae ..	*Convolvulus erubescens* Sims. ..	..	..	..	..	..	+	..	..	..	+	..	..	+	..	..	Travertine	Slender twining herb
	Dichondra repens Forst. et f. ..	+	..	..	..	..	..	..	..	..	..	..	..	+	..	..	Damp places, sandy soil	Herb, creeping, 5 cm. high
Solanaceae ..	*Solanum nigrum* L.	+	..	..	..	..	+	..	..	..	..	..	..	+	..	..	Sandy soil and travertine	Diffuse half-shrub
	Lycium australe F. v. M. ..	+	+	..	+	..	+	+	..	..	..	..	..	..	..	..	Travertine, some on sandy soil	Shrub, intricate branches, 60 cm.
	†*L. ferocissimum* Miers	+	+	+	..	..	..	..	..	..	..	..	..	+	..	+	Sandy soil, edges of travertine plateaux	Spiny shrub, 1·6 cm.
	†*Datura stramonium* L. ..	+	..	..	..	..	..	..	..	..	..	..	..	+	..	..	Sandy soil	Stout herb, 15 cm.
	Nicotiana suaveolens Lehm. ..	+	+	+	+	+	+	..	..	..	+	..	..	+	+	+	Dunes and sandy soil ..	Rosette plant, 30 cm.
Myoporaceae ..	**Myoporum insulare* R. Br. ..	+	+	+	+	+	+	..	..	..	+	..	..	+	+	..	Sandy soil and deep travertine soil	Spreading shrub, to 6 m.
Campanulaceae ..	*Wahlenbergia gracilis* (Forst. f.), A. DC.	..	..	..	..	..	..	..	..	..	..	..	..	+	..	..	Dunes	Slender herb, to 20 cm.
Compositae ..	*Brachycome pachyptera* Turcz. ..	+	..	..	..	+	..	..	..	..	..	..	..	..	..	+	Travertine	Small herb, 10 cm.
	B. exilis Sond.	+	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Travertine	Slender herb, 9 cm.
	Cotula coronopifolia L. ..	+	..	..	..	..	..	..	+	..	..	..	..	+	..	..	Swampy depressions ..	Small erect herb, 15 cm.
	**Senecio lautus* Sol.	+	..	..	+	..	+	+	..	..	+	..	..	+	..	+	Sandy soil, travertine ..	Free branching herb
	†*Cryptostemma calendulaceum* (L.), R. Br.	+	..	..	..	..	..	..	+	..	+	..	..	+	..	..	Sandy soil	Straggling herb, 7 cm.
	Cassinia spectabilis (Labill.), R. Br.	..	..	..	..	..	..	+	..	..	..	..	+	..	..	..	Sandy soil, travertine ..	Half-shrub, to 1 m., leaves sticky, woolly beneath
	P...sperma angustifolium Labill.	+	..	..	..	..	..	..	..	..	..	..	..	+	..	..	Travertine	Herb, erect, 10 cm.
	†*Inula graveolens* (L.), Desf. ..	+	..	..	..	..	+	..	..	..	..	..	..	+	..	..	All habitats ex. dunes ..	Robust herb, to 75 cm.
	**Calocephalus Brownii* (Cass.), F. v. M.	+	..	..	..	..	..	+	..	..	+	+	+	+	..	..	Dunes	Divaricate shrub, white tomentum, forming dense mounds to 2 m. diameter
	†*Centaurea melitensis* L. ..	+	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Sandy soil, travertine ..	Erect herb, to 15 cm.
	†*Sonchus oleraceus* L.	+	..	..	..	+	..	..	..	..	+	..	..	+	..	+	All habitats ex. dunes ..	Erect herb, to 20 cm.
	S. asper Hill.	+	+	..	..	..	..	..	..	..	..	..	..	..	..	..	Among rocks near sea ..	Erect herb, to 10 cm.
	Helichrysum leucopsidium D. C.	..	..	..	..	..	+	..	..	..	+	..	..	..	..	..	Travertine	Erect herb, 15 cm.
	Gnaphalium luteo album L. ..	+	..	..	..	..	+	..	..	..	+	..	..	+	..	..	Travertine	Erect herb 25 cm.
	Olearia axillaris (DC.), F. v. M.	+	..	+	..	+	..	..	..	..	+	..	..	+	..	..	Dunes, sandy soil ..	Erect bushy shrub, 1–3 m.
	O. ramulosa (Labill.), Benth. ..	+	..	..	..	..	..	..	..	..	..	..	..	+	..	..	Deep sandy soil .	Dense shrub, 1·5 m.

* = Recorded by Maiden. † = Introduced.

3. *Hydrozoa.*

By MAURICE BLACKBURN, M.Sc.

In the following report, 35 species of Hydrozoa are listed, representing specimens collected during the months of December 1936 and January 1937. Of these species, all of which belong to the order Calyptoblastea (Leptomedusae), 34 are polyp-types and 1 a medusa-type. Apart from descriptions of new species, the only details given are those relating to locality, presence or absence of gonosomes, additions or corrections to previous descriptions and important varietal differences. Only the most significant references to synonymy are given.

Types of new species are located in the National Museum Collection, Melbourne.

It should be stated that family and generic divisions have been used here in the senses in which they have generally been understood by Australian workers in this field. There are however two notable amendments: the genus *Parascyphus* Ritchie, 1911, regarded by many authors as synonymous with *Thyroscyphus* Allman, 1877, is regarded following Stechow (Zool. Jahrb., Syst., xlvii., 1923*a*, p. 170) and Splettstösser (*ibid.*, lviii., 1929, pp. 100-104 *et seq.*) once more as a separate genus; and the genus *Dynamena* Lamouroux, 1812 is also recognised as defined by Billard (Rep. Sci. Siboga-Exped., Mono. vii*b*., 1925, p. 21), whose divisions of the Sertulariidae appear to the author to be founded on the most comprehensive range of significant characters. Regarding family divisions, the correct systematic positions of the genera *Parascyphus* and *Stereotheca* are notably still somewhat dubious: the author has therefore judged it best to include them in the families to which Australian scientific opinion has most recently referred them, i.e., the Campanulinidae and Syntheciidae respectively.

Two other debatable points come within the scope of this report, in connexion with the genera *Paracalix* Stechow, 1923 (Campanulariidae) and *Phylactotheca* Stechow, 1913 (Haleciidae). The first of these was proposed by Stechow (Zool. Anz., lvi., 1923*b*, p. 3, and *loc. cit.*, 1923*a*, p. 106) for the reception of two species of *Campanularia* (*C. ambiplica* Mulder and Trebilcock and *C. pulcratheca* M. and T.), the basis for this separation being given as the bilateral symmetry of the hydrothecae and the inflection of the hydrotheca-walls to form one or two more or less prominent intrathecal ridges. Regarding the first point it should be noticed that at least one species specifically retained by Stechow himself in the genus *Campanularia* (*C. australis* Stechow) exhibits the same character in cross-section, and there are possibly others also with the same type of symmetry: regarding the second, it appears to the author that the development of the intrathecal ridge in these two species is to be regarded as closely parallel with that occurring in certain species of the Plumulariid genus *Kirchenpaueria* (*K. mirabilis* Allman, *K. producta* Bale, *K. allmani* Torrey, and *K. biseptata* sp. nov.) but not in other members of the same genus (*K. pinnata* Linnaeus, *K. similis* Hincks and *K. hians* Marktanner-Turneretscher). Stechow, it is true, does propose (Zool. Jahrb., Syst., xlii., 1919, p. 110) for these former species the separate genus *Pycnotheca* (*Diplocheilus* Allman, 1888 praeocc.) but he bases the distinction on other characters in addition to the intrathecal ridge; while Bale (Commonwealth Fisheries, Zoo. Res., ii., i., 1914, p. 61, and *ibid.*, iii., v., 1915, p. 302) in defending the retention of the same forms in the genus *Kirchenpaueria*, points out that the presence of such a ridge in the Plumulariidae or Sertulariidae has never been regarded of generic importance. It therefore seems to the author desirable that the genus *Paracalix* be suppressed and that the species referred to it be replaced in the genus *Campanularia* until such time as the possible discovery of a wholly distinct type of gonosome shall preclude this proceeding.

The second genus *Phylactotheca*, comprising two recorded species *P. pacifica* Stechow from Tonga and *P. armata* Stechow from Australia, commands a somewhat better case for recognition. Stechow (*loc. cit.*, 1923*a*, pp. 86-87) recognises four genera of nematophore-bearing Haleciidae, three of which he places in the subfamily Haleciinae ("Theken napfförmig, mit einer Punktreihe am Rande") and one in the subfamily Phylactothecinae ("Theken tief-glockenförmig, vollig frei"). The first three are separated by him on the basis of supposed differences in the nematophores, viz., *Hydrodendron* Hincks, 1874 ("Nematophoren klein, ohne Nematotheken"), *Diplocyathus* Allman, 1888 ("Nematophoren klein, mit rohrenförmiger Nematothek an der Basis jeder Theka") and *Ophiodissa* Stechow, 1919 (*Ophiodes* Hincks 1868 praeocc.—"Nematophoren sehr gross, mit becherförmiger Nematothek"), while to the diagnosis of *Phylactotheca* is added: "Nematotheken einkammerig, nicht beweglich, glockenförmig". It is the opinion of this author that these divisions based on the character of the nematophores are purely artificial, and that the first three genera at least should therefore be combined under a single head; while if the genus *Phylactotheca* is to be held valid it must be on the basis of characters other than the nematophores. Regarding first, the genus *Hydrodendron*, one must assume that Stechow has overlooked the account by Bonnevie (Bergens Mus. Aarbog., 1898, p. 11) of "*Halecium*" *gorgonoide* Sars, for the accommodation of which Hincks erected the genus. Bonnevie describes and figures the nematophore-cups, or sarcothecae, of this species, which were apparently overlooked by Sars; the genus then cannot be retained, and the Norwegian author does in fact refer Hincks' genotype to *Ophiodes*. Regarding next *Diplocyathus*, Billard (Ann. Sci. Nat., Zool., (9), xi., 1910, p. 4) and Jäderholm (Kungl. Svensk. Vetenskapsakad. Handl., lii., xii., 1916, p. 4) agree in referring Allman's genotype *D. dichotomus* also to *Ophiodes*, Billard stating: "Cet auteur (Allman) a créé à tort un genre nouveau, tout en faisant ressortir la grande resemblance entre son genre *Diplocyathus* et le genre *Ophiodes* de Hincks. Je crois qu'il est logique de maintenir seul ce dernier et d'y placer *toutes les espèces d'Haleciidae dont les hydrothèques sont semblables à celles d'Halecium mais qui possèdent des nématophores*" (italics by present author). In our present state of ignorance, lacking as we do any considerable knowledge as to the part played by different kinds of nematophores, by virtue of their different values in determining the degree of successful adaptation to environment of the animals bearing them, in the evolution of different generic types, the author regards Billard's definition as the most logical and the least confusing. Among the species apparently retained by Stechow in the genus *Ophiodissa* we find various forms of sarcothecae described, some (e.g., in *O. mirabilis*) slender and conical, approaching those of *Diplocyathus* in shape, others (e.g., in *O. australis* and *O. caciniformis*) vase-shaped, approaching those of *Phylactotheca*; while even in the disposition of the sarcothecae there is little or no ground for separation, as in all three genera they may occur at the bases of the hydrophores, and in both *Ophiodissa* and *Phylactotheca* on the internodes of the stem. Thus if *Phylactotheca* is to be regarded as a valid genus, it can only be, on the basis of Billard's definition, if the hydrophores are definitely not of the typical *Halecium*-form. Actually it seems that they are not, although the difference is much more marked in *P. pacifica* than in *P. armata*. The hydrophores of both these species are borne on distinct pedicillate processes, and even if it be conceded, as the present author formerly suggested (Proc. Roy. Soc. Vic., n.s., xlix., 1937, p. 365) that these processes in *P. armata* (referred to there under the name of "*Ophiodissa fragilis*") are "probably representing the proximal ends of the hydrophores", it must still be admitted that they are differentiated from the stem to an unusually high degree; furthermore the hydrophores are much more campanulate in form than those of any species of *Halecium*, and lack the marginal ring of puncta. For these reasons it appears that the genus *Phylactotheca* should be regarded as valid; the genera *Hydrodendron*, *Diplocyathus*, and *Ophiodissa* should however be regarded as falling under a single generic head, which must in accordance with the rules of scientific nomenclature be known as *Hydrodendron*, this being the earliest valid synonym of the preoccupied name *Ophiodes*.

Order: CALYPTOBLASTEA (LEPTOMEDUSAE).

Family: PLUMULARIIDAE.

Genus **Plumularia** Lamarck, 1816.

Plumularia obliqua (Johnston, 1847).

Laomedea obliqua Johnston, Hist. Brit. Zooph., 1847, p. 106, pl. xxviii., fig. i.

Plumularia obliqua (Johnston), Hincks, Ann. Mag. Nat. Hist., (3)., viii., 1862, p. 258.

Reevesby (5f.), Partney and Blyth Islands; gonosomes not present. Previously recorded from various south-eastern Australian waters; also from European waters and Japan.

Plumularia flexuosa Bale, 1893.

Plumularia flexuosa Bale, Proc. Roy. Soc. Vic., n.s., vi., 1893, p. 95, pl. v., figs. vi.-x.

Totton (Brit. Antarct. Exped. Rep., Zool., v., v., 1930, p. 221) refers this species to *P. pulchella* Bale; the described differences in the gonangium, however, appear to justify its retention as a separate species.

Reevesby Island (littoral); gonosomes not present. Previously recorded from various southern Australian waters; also South Africa.

Plumularia obesa sp. nov.

(Fig. 1.)

Hydrorhiza very broad, with transverse markings along the margins; hydrocaulus monosiphonic, unbranched, from 1.0 to 1.5 mm. in height; stem thick, divided into short equal internodes; pinnae alternate, each borne at about the middle of an internode, and each supporting a single hydrotheca; distal part of pinna curved, becoming gradually reduced in thickness behind the hydrotheca. Hydrothecae rounded at the base, somewhat compressed laterally, considerably protruded outwards, aperture at right angles to the pinna, margin somewhat everted in front; a prominent intrathecal ridge springing from the pinna just below the aperture. Sarcothecae bithalamic, canaliculate, with slender bases, one (mesial) below each hydrotheca, one (supracalycine) at each side above it, and two in each axil. Gonosomes not present. Color deep blackish-brown.

This species, by virtue of its bithalamic sarcothecae, would be referred on Stechow's system of classification to the genus *Monotheca Nutting*, 1900. Although there appear to be typically two sarcothecae in each axil, in some cases only one can be seen; this may of course be due to the other having been broken off: in no case are there any at all, however, on the internodes themselves. The blackish color renders the form fairly distinctive in the field, while in microscopic preparations it can easily be recognised by the very thick short internodes of the hydrocaulus, and by the very characteristic form of the hydrothecae. In this last respect, the species is possibly most similar to *P. spinulosa* Bale, although the greater outward extension from the pinna, the presence of a very sudden rather than a gradual upward curve, a gradual rather than a sudden diminution of the thickness of the distal end of the pinna behind the hydrotheca, the absence of a terminal spine and the fact that the intrathecal ridge is not noticeably directed towards the base of the hydrotheca again provide a basis for easy separation.

Reevesby (4-5f.) and Lusby Islands; on *Posidonia* weed.

PLUMULARIA COMPRESSA Bale, 1881.

Plumularia compressa Bale, Journ. Micr. Soc. Vic., ii., 1881, p. 43, pl. xv., fig. v.

Very common throughout the group; gonosomes sometimes present. Previously recorded from various southern Australian waters.

PLUMULARIA AUSTRALIS Kirchenpauer, 1876.

Plumularia obliqua Johnston var. *australis* Kirchenpauer, Abh. Ver. Hamburg, vi., 2, 1876, p. 49, pl. vi., fig. x.

Plumularia australis Kirchenpauer, Bale, Cat. Aust. Hyd. Zooph., 1884, p. 143, pl. xii., figs. vii.-viii., pl. xix., figs. xliii-xliv.

Reevesby (5f.) and Hareby Islands; gonosomes sometimes present. Previously recorded from Victorian waters.

PLUMULARIA ANGUSTA Stechow, 1923.

Plumularia setaceoides Bale vars. *a, b, d* Mulder and Trebilcock, Geel. Nat., (2), iv., 4, 1911, pp. 117-118, pl. iii., figs. iii.-iiiB., vi., pl. ii., fig. ix.

Plumularia angusta Stechow, Zool. Jahrb., Syst., xlvii., 1923 *a*, p. 226.

Blyth Island; gonosomes not present. Previously recorded from Victorian waters.

PLUMULARIA SECUNDARIA Marktanner-Turneretscher, 1890.

Plumularia secundaria Marktanner-Turneretscher, Ann. k.k.naturhist., Hofmus., v., 1890, p. 252, pl. vi., fig. i.

Blyth Island; gonosomes occasionally present. Previously recorded from Victorian waters if *P. dubiaformis* Mulder and Trebilcock is admitted as a synonym: also from European seas, the N.W. and E. coasts of Africa, Natal, Azores, Madeira, Ceylon, Mergui Archipelago, East Indies, Japan and Tonga.

Genus **Thecocaulus** Bale, 1915.

THECOCAULUS OPPOSITA (Mulder and Trebilcock, 1911), var.

(Fig. 2.)

Plumularia opposita Mulder and Trebilcock, *loc. cit.*, 1911, pp. 120-121, pl. ii., figs. v., v*a*.

Thecocaulus oxyrhynchus Stechow, *loc. cit.*, 1923 *a*, p. 223.

A single specimen of this species appears to constitute a distinct variety, by virtue of the stem-internodes; the alternate internodes which do not bear hydrothecae are much longer than in the typical form, being almost as long as the hydrotheca-bearing series, and each bears two sarcothecae, one above the other: the pinna-internodes are of the normal variety. The hydrothecae, though more or less campanulate in form, are slightly peaked in front, slightly sinuate behind, and exhibit the faintest traces of a rudimentary intrathecal ridge at the back; they may therefore be regarded as constituting a transition form between the hydrothecae of *T. opposita* and *T. opposita* var. *a*, for the second of which Stechow proposes the name *T. oxyrhynchus*, justifying this separation on the differences in the form of the hydrothecae. In view however of the existence of an intermediate form, the retention of the latter name for a separate species seems to the author unjustifiable.

Blyth Island; gonosomes not present. Previously recorded from Victorian waters.

Genus **Kirchenpaueria** Jickeli, 1883.

Kirchenpaueria mirabilis (Allman, 1883).

Diplocheilus mirabilis Allman, Rep. Sci. Res. "Challenger", Zool., vii., 1883, p. 49, pl. viii, figs. iv.-vii.
Kirchenpaueria mirabilis (Allman), Bale, *loc. cit.*, 1893, p. 109, pl. vi., figs. iv.-vii.
? *Diplocheilus allmani* Torrey, Univ. Calif. Pub. Zool., ii., 1904, p. 36.

Near Lusby Island (4f.); gonosomes not present. Previously recorded from various southern Australian waters; also from Natal, New Zealand, and Japan, as well as California if *K. allmani* is admitted as a synonym.

Kirchenpaueria producta (Bale, 1881).

Plumularia producta Bale, *loc. cit.*, 1881, p. 39, pl. xv., fig. iii.
Kirchenpaueria producta (Bale), Bale, *loc. cit.*, 1893, p. 111.
? *Diplocheilus allmani* Torrey, *loc. cit.*, 1904, p. 36.

These specimens agree with *K. producta* in the details of the hydrotheca-profile, but approach *K. mirabilis* in size (specimens up to 2 cm. in height being not uncommonly observed) and in the tendency observed in many cases for the apertures of the hydrothecae to be more circular than elliptical, with flaring margins. It thus appears possible that, as Totton (*loc. cit.*, 1930, p. 216) has already suggested, these two forms may actually be referable to the same species, *K. producta*, although the profile characteristics of the hydrothecae and mesial sarcothecae are nevertheless fairly distinct in the two forms.

Reevesby Island (2-5f.); gonosomes not present. Previously recorded from various south-eastern Australian waters; also from California if *K. allmani* is admitted as a synonym. The author has also noted this species from near the mouth of the Johnstone River, North Queensland.

KIRCHENPAUERIA BISEPTATA sp. nov.

(Fig. 3.)

Hydrorhiza cylindrical, creeping; hydrocaulus monosiphonic, unbranched, from 2.5 to 4.5 mm. in height; stem thick, divided into short equal internodes; pinnae alternate, each borne at the base of a stem-internode, divided into equal internodes by straight joints; each pinnae-internode bearing a single hydrotheca. Hydrothecae set at an angle of about 40° to the pinna, bowl-shaped, but with the back much produced upwards, and with the front wall deeply inflected immediately below the lip, forming an anterior intrathecal ridge which extends three-quarters across the cavity of the hydrotheca; also a rudimentary posterior intrathecal ridge springing from the pinna at the back of the hydrotheca, at a lower level than the other. A single (mesial) monothalamic sarcotheca below each hydrotheca, fixed, erect, upper portion forming a circular concave shield facing and parallel to the base of the hydrotheca; a single median (supracalycine) sarcostyle in the angle between the back of each hydrotheca and the pinna, not provided with a sarcotheca, but partly protected on each side by a narrow web which connects the pinna with the back of the hydrotheca; a single conical sarcotheca in each axil. Gonosomes not present.

Only very small specimens of this form have so far been discovered, with a maximum of seven alternating pinnae on one stem and of four hydrothecae on one pinna; this feature may however be far from constant. The most striking characteristic of the species is undoubtedly the presence of the posterior intrathecal ridge, which distinguishes it readily from all other members of the genus. Seen from the front, the aperture of the hydrotheca appears more or less oval. It may be noted that the polypiferous ramules, corresponding to the pinnae of the typical colony, may arise directly from the hydrorhiza; the author has noted this also for the Banks Islands specimens of *K. mirabilis* and *K. producta.*

Reevesby (5f.) and Hareby Islands; on *Posidonia* and *Cymodocea* weed.

Genus **Aglaophenia** Lamouroux, 1812.

AGLAOPHENIA PLUMOSA Bale, 1881.

Aglaophenia plumosa Bale, *loc. cit.,* 1881, p. 37, pl. xiv., fig. vi.

Hareby Island; gonosomes not present. Previously recorded from various southern Australian waters; also New Zealand and South Africa.

Family: SERTULARIIDAE.

Genus **Sertularia** Linnaeus, 1758.

Sertularia minuscula Bale, 1919.

Sertularia minima Thompson var. *tubatheca* Mulder and Trebilcock, Geel. Nat., (2), vi., 2, 1914 *b*, p. 40, pl. iv., figs. i-i*d*.

Sertularia minuscula Bale, Proc. Roy. Soc. Vic., n.s., xxxi., 1919, p. 340.

Very common throughout the group; gonosomes sometimes present. Previously recorded from various south-eastern Australian waters.

Sertularia minima Thompson, 1879.

Sertularia minima Thompson, Ann. Mag. Nat. Hist., (5), iii., 1879, p. 104, pl. xvii., fig. iii.-iii*b*.

Reevesby Island (littoral; 2-4f.); gonosomes not present. Previously recorded from various southern Australian waters; also New Zealand, Kermadec Islands, Chile, Falkland Islands, Suez, and the Cape of Good Hope.

Sertularia marginata (Kirchenpauer, 1864).

Dynamena marginata Kirchenpauer, Verh. K. L.—C. deutsch. Akad naturf., xxxi., 1864, p. 13, figs. viii.-viii*c*.

Sertularia marginata (Kirchenpauer), Bale, Proc. Roy. Soc. Vic., n.s., xxvi., 1913, p. 125, pl. xii., fig. ix.

Near Lusby Island (4f.); gonosomes sometimes present. Previously recorded from Victorian waters; also New Zealand, the Atlantic and Pacific Oceans, West Indies. Cape Verde Islands, E. and N.W. Africa, and Antarctica.

Sertularia xantha (Stechow, 1923).

Sertularia divergens Busk, Voy. "Rattlesnake", i., 1852, p. 392.

Tridentata xantha Stechow, Zool. Anz., lvi., 1923 *b*, p. 12.

Sertularia xantha (Stechow), Bale, Proc. Roy. Soc. Vic., n.s., xxxviii., 1926, p. 15.

Reevesby Island (littoral); gonosomes not present. Previously recorded from various south-eastern Australian waters: also New Zealand, and the Philippines.

Genus **Dynamena** Lamouroux, 1812.

Dynamena cornicina McCrady, 1858.

Dynamena cornicina McCrady, Proc. Elliot Soc., i., i., 1858, p. 204. *Idem.*, Billard, Sci. Res. Siboga-Expd., Mono. vii*b*., 1925, p. 71, pl. vii., fig. xxiii., text-fig. xl.

Sertularia complexa Clarke, Bull. Mus. Comp. Zool., v., x., 1879, p. 245, pl. iv., figs. xxvi.-xxviii*b*.

Reevesby Island (littoral; 5f.) and Lusby Islands; gonosomes not present. Previously recorded from New South Wales; also California, Carolina, Massachusetts, Nova Scotia, Yucatan, Bermuda, Brazil, Mediterranean, East Africa, Ceylon, and the East Indies.

DYNAMENA QUADRIDENTATA (Ellis and Solander, 1786).

Sertularia quadridentata Ellis and Solander, Nat. Hist. Zooph., 1786, p. 57.

Pasythea quadridentata (Ellis and Solander), Esper, Die Pflanzenthiere in Abbildungen, iii., 1788, p. 237.

Dynamena quadridentata (Ellis and Solander), Billard, *loc. cit.*, 1925, pp. 21, 78-82, text-figs. xlii., xliii.

Reevesby Island; gonosomes not present. Previously recorded from various southern and eastern Australian waters; also New Zealand, Loyalty Islands, Philippines, China, Hawaii, Carolina. Bahamas, Atlantic Ocean, Ascension, Natal, Mozambique, India, and the East Indies.

Genus **Sertularella** Gray, 1848.

SERTULARELLA PYGMAEA Bale, 1881.

Sertularella pygmaea Bale, *loc. cit.*, 1881, p. 25, pl. xii., fig. ix.

Roxby Island; gonosomes not present. Previously recorded from various south-eastern Australian waters; also New Zealand.

SERTULARELLA ROBUSTA Coughtrey, 1875.

Sertularia simplex Hutton, Coughtrey, Trans. N.Z. Inst., vii., 1874, p. 283 (pars), pl. xx., fig. x.

Sertularella robusta Coughtrey, Trans. N.Z. Inst., viii., 1875, p. 300.

In a former paper (Proc. Roy. Soc. Vic., n.s., 1, 1937, p. 172) the present author suggests the inclusion in the synonymy of this species of *Sertularella microgona* von Lendenfeld; Totton (*loc. cit.*, 1930, p. 195) whose reference to *S. robusta* had been overlooked at the time, confirms this in his statement that an examination of von Lendenfeld's types in the British Museum shows that the two species are in fact identical.

Reevesby Island (littoral); gonosomes not present. Previously recorded from Victorian waters; also New Zealand, the East Indies, and Tierra del Fuego.

Family: SYNTHECIIDAE.

Genus **Stereotheca** Stechow, 1919.

STEREOTHECA ELONGATA (Lamouroux, 1816).

Sertularia elongata Lamouroux, Hist. Polyp. Cor. Flex., 1816, p. 189, pl. v., figs. iii-iiic.

Stereotheca elongata (Lamouroux), Stechow, Zool. Jahrb., Syst., xlii., 1919, p. 103.

Reevesby Island; gonosomes often present. Previously recorded from various southern Australian waters; also New Zealand.

Family: CAMPANULINIDAE.

Genus **Parascyphus** Ritchie, 1911.

Parascyphus simplex (Lamouroux, 1816).

Laomedea simplex Lamouroux, *loc. cit.,* 1816, p. 206.

Thyroscyphus simplex (Lamouroux), Billard, C. R., Acad. Sci., cxlviii., 1909, p. 1065.

Parascyphus simplex (Lamouroux), Ritchie, Ann. Scot. Nat. Hist. Edinb., xx., 1911, p. 160, fig. i.

Partney Island; gonosomes not present. Previously recorded from various southern Australian waters; also New Zealand, Great Britain, and the South Atlantic.

Family: LINEOLARIIDAE.

Genus **Lineolaria** Hincks, 1861.

Lineolaria flexuosa Bale, 1884.

Lineolaria flexuosa Bale, *loc. cit.,* 1884, p. 62, pl. i., figs. vii.-ix.

In these specimens the hydrorhiza is actually more often straight, or nearly so, than flexuous, and the hydrothecae, instead of always lying parallel to it, are frequently disposed at right angles to it. The free part of the hydrotheca is generally as long as the adnate portion. A lateral wing or expansion may also be observed.

Reevesby Island; gonosomes present. Previously recorded from Victorian waters; also New Zealand.

Lineolaria inarmata sp. nov.

(Figs. 4-8.)

Hydrorhiza straight, convex above, slightly wrinkled transversely; branching processes given off at right angles, often anastomosing. Hydrothecae usually regularly alternate, occasionally opposite, not close, subsessile, projecting at right angles to the hydrorhiza, oblong, slightly broader at the base; aperture terminal, oval, looking upwards, with a slightly everted margin and a membranous operculum.

Gonosome (gonangium) compressed, about twice the length of a hydrotheca, irregularly ovate, tapering towards the base, with a row of strong spines running down each slide and meeting below, and a few scattered spines in the central area; orifice subterminal, circular, looking upwards, with a thickened and slightly elevated margin surrounded by a few minute denticles.

Hydrothecae and gonangia furnished with a delicate lateral wing or expansion, surrounding the whole margin and apparently adherent to the supporting substance.

This species forms very distinct regularly anastomosing patterns on the leaves of the *Posidonia* weed, and in this habit and in its superficial structure bears a very close resemblance to

L. spinulosa Hincks, though the latter form is stated by Bale to be peculiar to *Cymodocea*. There are however several points of difference between the two, of which the absence of a basal spine and marginal teeth in the species under discussion are perhaps the most conspicuous. The hydrothecae of this species are furthermore slightly longer than those of *L. spinulosa* and are generally more regularly oblong, the basal widening being rather less conspicuous, while the gonangium is usually much less regular in shape.

Reevesby (2-2½f.) and Lusby Islands; on *Posidonia* weed.

Family: HALECIIDAE.

Genus **Halecium** Oken, 1815.

Halecium mediterraneum Weismann, 1883.

Halecium tenellum Hincks var. *mediterranea* Weismann, Entstehung d. Sexualzellen b.d. Hydromedusen, 1883, p. 160, pl. xi., figs. v.-vi.

Halecium mediterraneum Weismann, Stechow, *loc. cit.*, 1919, p. 34.

Halecium flexile Allman, Rep. Sci. Res. "Challenger", Zool., xxiii., 1888, p. 11, pl. v., figs. ii., ii*a*.

Reevesby Island (2-5f.) and near Lusby Island (4f.); gonosomes sometimes present. Previously recorded from various south-eastern Australian waters; also New Zealand, Antarctica, Japan, Patagonia, Nicaragua, California, Puget Sound, West Africa, Mediterranean, Ceylon, and Marion Island.

Halecium sp.

Hydrorhiza creeping, more or less smooth; hydrocaulus very small, about 0.2 to 0.3 mm. in height and about 0.1 mm. in diameter, consisting of corrugated pedicillate stems each bearing a terminal hydrophore, with sometimes a secondary hydrophore arising on a short corrugated pedicillate "branch" from the side of the first; hydrophores not distinctly marked off from the stems, tumbler-shaped, margins somewhat expanded and distinctly everted, the whole hydrophore sometimes duplicated. Hydranths large, non-retractile, with about sixteen tentacles. Gonosomes not present.

This species appears to be fairly closely related to *H. corrugatum* Nutting, although the latter is often quite distinctly branched, with the stems much longer in proportion to their diameter, and with more broadly expanded and less distinctly everted hydrophore-margins. It may possibly represent a new species, but as the material is very scanty and so much obscured by foreign material as to render accurate figuring impossible, its exact systematic position must remain indefinite.

Reevesby Island (littoral).

Genus **Phylactotheca** Stechow, 1913.

PHYLACTOTHECA ARMATA Stechow, 1924.

Phylactotheca armata Stechow, Zool. Anz., lix., 1924, p. 59. *Idem,* Stechow, Zool. Jahrb., Syst., l., 1925, p. 204, fig. C.

Ophiodissa fragilis Blackburn, Proc. Roy. Soc. Vic., n.s., xlix., 1937, p. 365, fig. i.

The species, which the present author previously referred on account of its sarcothecae and capitate dactylozooids to the genus *Ophiodissa* and described as new under the name of *O. fragilis*, is unquestionably identical with *Phylactotheca armata*. In his original unfigured description Stechow states: "Der Stamm abwechselnd aus einem längeren cladientragenden und einem kürzeren cladienlösen Glied bestehend . . . "; this character is not to be observed in any of the Victorian specimens, and in the absence of any figure the author regarded the two forms as quite distinct. One of the specimens from the Banks Islands however exhibits to a very slight degree this tendency towards a differentiation of the internodes, and reference to Stechow's figure of *P. armata* in a later paper shows clearly that the two forms are in all other respects identical. One of these specimens also exhibits a slightly branching habit, each branch consisting, like the stem, of a regular succession of hydrophore-bearing internodes, in contrast to the branch-like elongated hydrophore-peduncles described by the author previously.

The question of the validity of this genus has already been discussed (*vide supra*).

Near Lusby Island (4f.); gonosomes not present. Previously recorded from various southern Australian waters.

Family: CAMPANULARIIDAE.

Genus **Campanularia** Lamarck, 1816.

CAMPANULARIA AUSTRALIS Stechow, 1924.

Campanularia tincta Hincks var. *c* Mulder and Trebilcock, Geel. Nat. (2), vi., i., 1914 *a*, p. 13, pl. ii., fig. xii., *idem,* Mulder and Trebilcock, Geel. Nat., (2), vi., iii., 1915, p. 56, pl. viii., figs. ii.-ii*f*.

Campanularia australis Stechow, *loc. cit.,* 1924, p. 61.

The bilateral symmetry of the hydrothecae, already referred to in this paper (*vide supra*) is well marked in these specimens.

Reevesby (5f.), Hareby and (?) Spilsby Islands; gonosomes not present. Previously recorded from various southern Australian waters.

(?) CAMPANULARIA PULCRATHECA Mulder and Trebilcock, 1914.

Campanularia pulcratheca Mulder and Trebilcock, *loc. cit.*, 1914 *a*, p. 11, pl. ii., figs. i.-ii.

Paracalix pulcratheca (Mulder and Trebilcock), Stechow, *loc. cit.*, 1923, *a*, p. 106.

The validity of the proposed genus *Paracalix* has already been discussed (*vide supra*); even after suppressing it however the species can only tentatively, in the absence of the gonosome, be referred to the genus *Campanularia*.

(?) Spilsby Island; gonosomes not present. Previously recorded from Victorian waters.

Genus **Orthopyxis** L. Agassiz, 1862.

ORTHOPYXIS cf. MACROGONA (von Lendenfeld, 1884).

Campanulina calyculata (Hincks) var. *makrogona* von Lendenfeld, proc. Linn. Soc., N.S.W., ix., 1884, p. 922.

Campanularia caliculata Hincks var. *makrogona* (von Lendenfeld), Bale, Proc. Linn. Soc. N.S.W., (2), iii., 1888, p. 755, pl. xiii., figs. iv.-viii.

Orthopyxis macrogona (von Lendenfeld), Bale, Proc. Roy. Soc. Vic., n.s., xxvii., 1914, p. 77, pl. xi., fig. ii., pl. xii., fig. ii.

Reevesby Island (5f.); gonosomes not present, rendering it difficult, in the absence of any considerable material, to diagnose the specimens exactly. *O. macrogona* has previously been recorded from various south-eastern Australian waters; also from New Zealand.

Genus **Silicularia** Meyen, 1834.

SILICULARIA UNDULATA (Mulder and Trebilcock, 1914).

Eucopella undulata Mulder and Trebilcock, *loc. cit.*, 1914 *a*, p. 10, pl. ii., figs. v.-vii.

Silicularia undulata (Mulder and Trebilcock), Bale, *loc. cit.*, 1914, p. 89.

Reevesby (4f.) and Lusby Islands; gonosomes not present. Previously recorded from Victorian waters.

Genus **Obelia** Péron and Lesueur, 1809.

OBELIA AUSTRALIS von Lendenfeld, 1884.

Obelia australis von Lendenfeld, *loc. cit.*, 1884, pp. 604, 920, pl. xliii., figs. xix.-xxii.

The hydrothecae in these specimens are often longitudinally pleated; this character is often given as a characteristic of *O. dichotoma* Linnaeus, to which this form is very closely related.

Reevesby (littoral; 5f.) and Lusby Islands; gonosomes not present. Previously recorded from Victorian waters, possibly also from New South Wales; also New Zealand.

Genus **Clytia** Lamouroux, 1812.

Clytia delicatula (Thornely, 1900).

Obelia delicatula Thornely, Willey's Zoo. Res., iv., 1900, p. 453, pl. xliv., fig. vii.

Clytia delicatula (Thornely), Stechow, Abh. Math.-Phys. Klasse K. Bayr. Akad. Wiss., iii., Suppl.-Bd., ii., Abh, 1913, p. 65, figs. xx., xxi.

One of these specimens has the distal half of the pedicel irregularly waved throughout. The longitudinal folding of the hydrotheca-walls is well seen in specimens in which the hydranths are retracted.

Reevesby (5f.) and Lusby Islands; a single distorted gonangium noted. Previously recorded from the eastern coast of Australia (Great Barrier Reef; Mallacoota Inlet); also New Britain, Japan, and the Philippines.

(?) Clytia stolonifera sp. nov.

(Figs. 9-10.)

Colony creeping, consisting of a smooth anastomosing hydrorhiza giving rise to erect thecate shoots and creeping stem-like stolons; stolons with about six annulations at the base, giving rise to erect thecate shoots similar to those arising directly from the hydrorhiza; shoots up to 4 mm. in height, generally much less, with a varying number of annulations at the base, generally slightly branched and bearing hydrothecae mounted on pedicels; branches arising singly at origins of pedicels, with about six annulations at the base, terminating in hydrotheca-pedicels from the bases of which similar branches may arise in like fashion. Hydrothecae campanulate, borne on pedicels, in the expanded condition about as deep as their greatest breadth, distal three-quarters very broadly conical, proximal quarter much more cylindrical, this latter part bounded distally by a thick diaphragm, margin with about 14 shallow rounded crenations; pedicels generally about as long as hydrothecae, tapering distally and with about four to eight annulations on the distal portion. Hydranths with trumpet-shaped hypostome and about 20 tentacles. Gonosomes not present.

This curious form differs from all other recorded Campanularians in the extent of its adaptation to an epiphytic way of life: the stolons are annulated at the base as in the erect shoots, which, like them, originate from the hydrorhiza; but they appear, instead of assuming an erect posture and giving off a more or less regular succession of hydrotheca-pedicels and branches as the shoots do, to remain approximated like the hydrorhiza to the supporting seaweed, pursuing a quite irregular creeping course and giving off short erect shoots at rather irregular intervals. These stolons can be sharply distinguished from the shoots in microscopic preparations by the character of the perisarc, which is as one might expect as thick as that of the hydrorhiza, in contrast to that of the shoots, which is quite thin, except sometimes at their bases; the last observation points to a creeping habit here also, possibly representing a stage in the formation of the stolons, though this was not specifically noted *in situ*.

This form of growth appears to have arisen as a result of the assumption in great part by the stems of the colony of a creeping posture, as a result of which these structures have lost almost all trace (except the basal annulations) of their typical form. The author has compared it with descriptions of all recorded Campanularian genera and species to which references were available, and with descriptions of many other Hydrozoan forms, and has found no mention of a similar case. A certain type of secondary stoloniferous growth, in which the ends of the erect branches may be occasionally produced into creeping growths from which other shoots arise, has been described in various forms for a few species of Hydrozoa: under aquarial conditions, colonies of *Syncoryne eximia* Allman and *Bougainvillia muscus* Allman (Browne, Journ. Mar. Biol. Ass. Plymouth, n.s., viii., 1907, p. 37) and of *Kirchenpaueria* (*Plumularia*) *pinnata* Linnaeus (Nutting, Amer. Hyd., Plum., 1900, p. 43) have been known to attach themselves to the glass walls by means of such stolons; in *Cnidoscyphus marginatus* Allman (*Campanularia insignis* Allman) "the outgrowths arise from the ends of the stems and branches or may replace the latter. They are present in colonies of all sizes and are most abundant at the distal end. By their elongation, sometimes aided by a bending of the colony, their tips come in contact with the substratum. A group of rhizoids forms and a new colony rises from them. Only a small proportion of the stolons were engaged in this process" (Congdon, Proc. Amer. Acad. Arts. Sci., xlii., 1907, p. 469); in *Obelia surcularis* Calkins (Nutting, Amer. Hyd. Camp., 1915, p. 84) and *Campanularia angulata* Hincks (Hincks, Hist. Brit. Hyd. Zooph., 1868, p. 170), as well as in the form under discussion, the branches are sometimes found to terminate in elongated tendril-like filaments which may represent stolons of this type, although shoots have not been observed to arise from them; and in (?) *Campanularia serrulatella* Borradaile (*Obelia serrulata* (Bale), Thornely, Willey's Zoo. Res., iv., 1900, p. 453) and *Obelia nodosa* Bale (Bale, Trans. N.Z. Inst., lv., 1924, p. 230) the lower part of the stem is often fascicled owing to the downgrowth of such stolons towards the hydrorhiza. Except in the last instance, however, and possibly even there, none of these types of stoloniferous growth are of regular occurrence and none are of so fundamental a character as that found in this species.

The hydrothecae of this form are also quite characteristic; they are extremely broadly conical in the relaxed condition, though in other cases (apparently to be correlated with the retraction of the hydranths) they may appear relatively much more cylindrical. In their superficial appearance they approach fairly closely those of (?) *Campanularia obtusidens* Jaderholm, (?) *C. serrulatella* Borradaile and *Obelia coughtreyi* Bale, but even here the combination of characters found in the form under discussion (character of diaphragm, number and shape of teeth, relative dimensions, &c.) provide for easy separation.

In the absence of any gonosomal structures the generic position of this species must remain very obscure; it is here tentatively referred to *Clytia* on account of the nature of its branching, the presence of a thick diaphragm and the character of the hydranths, although none of these features are absolutely characteristic of this genus and all may be found in other genera.

Reevesby Island (4f.); on Posidonia weed.

Incertae Sedis.

Gen. and sp. indet. (medusa).

Two specimens of a species of Leptomedusan are included in the collection. They are however so much crumpled that it has proved impossible to mount them in such a way as to be able to determine whether or not otocysts are present, as a result of which it is impossible to assign the form even to its family.

Near Marum Island, floating.

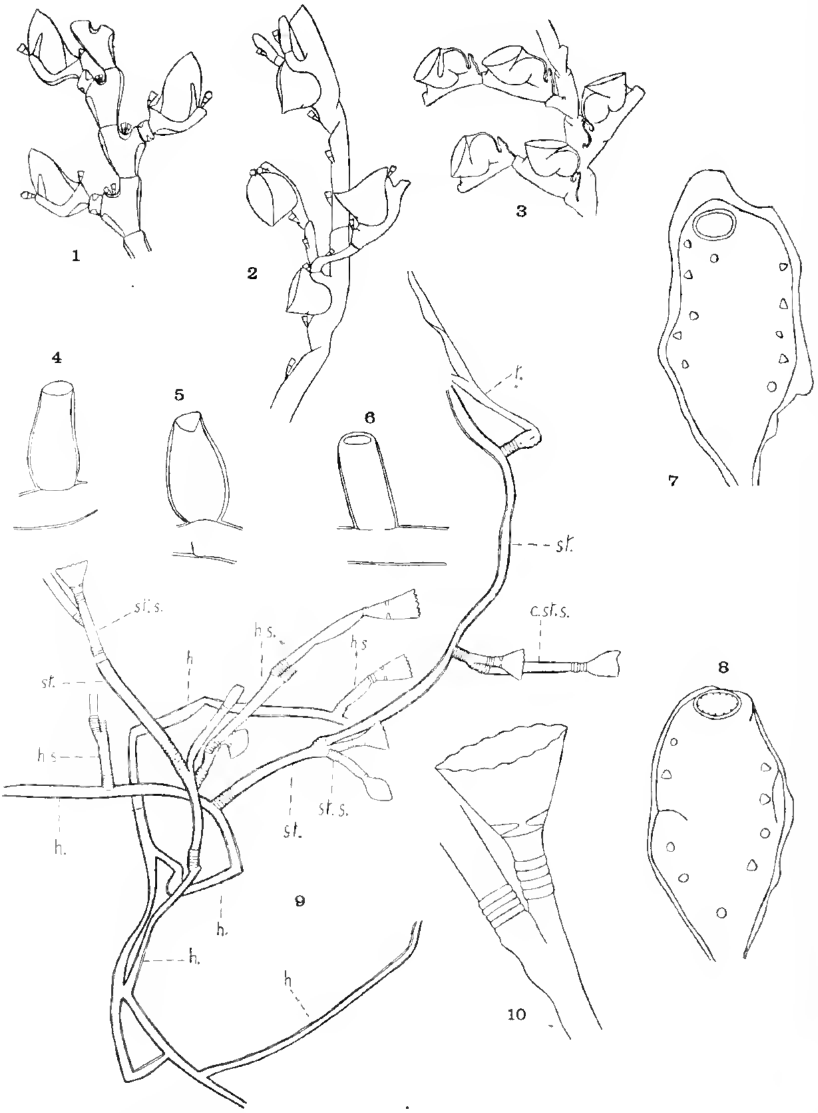


Fig. 1. *Plumularia obesa* sp. nov. (× 28).

Fig. 2. *Thecocaulus opposita* (Mulder and Trebilcock) var. (× 28).

Fig. 3. *Kirchenpaueria bisceptata* sp. nov. (× 14).

Figs. 4–6. *Lineolaria inarmata* sp. nov., hydrothecae (× 28).

Figs. 7, 8. *Lineolaria inarmata* sp. nov., gonangia (× 28).

Fig. 9. (?)*Clytia stolonifera* sp. nov., whole colony (× 8); h., hydrorhiza; st., stolon; h.s., hydrorhizal shoot; st.s., stolonic shoot; c.st.s., creeping stolonic shoot; t., tendril-like, (?) stolonic filament of shoot.

Fig. 10. (?)*Clytia stolonifera* sp. nov., hydrotheca (× 28).

4. *Echinodermata.*

By LEO. W. STACH, M.Sc.

The prolific echinoderm fauna of the coast and offshore waters of Reevesby Island afforded opportunity for the study of the distribution of species in relation to habitat. Two environments were the subject of particular study and showed striking faunal dissimilarity.

Along the coast, granitic reefs are exposed at low tide. Collections were made from the reef at the south end of McCoy Bay on the east side of the island and an isolated patch at the end of a long sand spit on the west coast, known locally as Middle Rocks. These two localities consisted of rounded outcrops of granitic rock dissected by deep narrow joint planes with areas of boulders and small pebbles; there were but few algae at the former locality, and large boulders with clumps of the alga *Scaberia Agardhii* Greville growing between at the latter locality. Both these habitats carry abundant specimens of *Patiriella gunnii*, *Tosia australis* (predominantly *astrologorum* type), *Allostichaster polyplax*, *Ophionereis schayeri* and *Heliocidaris erythrogramma*, while *Petricia vernicina* was found abundantly on the granitic reef at McCoy Bay, but not at Middle Rocks. At the latter locality, however, one specimen of *Coscinasterias calamaria* and a juvenile *Goniocidaris geranioides tubaria* were collected.

The offshore locality intensively studied was the *Posidonia australis* bank off the east end of Lusby Island, facing Reevesby Island and connected to it by a probably granitic barrier at little depth. Just on the northern side of this barrier a sand accumulation has afforded a suitable environment for the development of a dense growth of *Posidonia australis* J. Hooker which affords protection for large numbers of razor shells and scallops. The tidal outflow at this point is surprisingly rapid and thus increases food supply and aeration. At low tide the *Posidonia* bank is covered by only one to two feet of water and a thorough examination of the fauna could be made by wading. The echinoderms are particularly abundant, as many as twenty to thirty occurring in one square yard. *Tosia australis* (predominantly *australis* type), *Uniophora sinusoida* and *U. multispina*, *Goniocidaris* and *Amblypneustes pallidus* are very common, while *Nectria ocellata* and *Petricia vernicina* are of rarer occurrence.

This occurrence of *Goniocidaris* is remarkable, since, from the writer's experience in Western Port, Victoria, it is never found there at depths of less than three or four fathoms and is very common at greater depths. The restriction of all the *Uniophora* to the *Posidonia* habitat is also noteworthy.

The large *Uniophora sinusoida* apparently feeds on the abundant bivalves of the *Posidonia* bank, while *Heliocidaris erythrogramma* forms part of the diet of the Pacific Gull, *Gabianus pacificus* (Latham, 1801), which catches them at low tide and breaks them by dropping on to the granitic platforms of the east coast, which are strewn with broken tests.

Class: ASTEROIDEA.

Order: PHANEROZONIA.

Family: GONIASTERIDAE.

Nectria ocellata Perrier, 1876.

Nectria ocellata Perrier, 1876, Arch. Zool. Exp. v., p. 4.

A single specimen only from the *Posidonia* bank off the east end of Lusby Island. Victorian specimens in the National Museum, Melbourne, are from Beaumaris, in Port Phillip Bay.

Tosia australis Gray, 1840.

(Plate XVIII., figs. 3, 4.)

Tosia australis Gray, 1840, Ann. Mag., Nat. Hist., ser. 1, vi., p. 281.

Livingstone, 1932, Rec. Aust. Mus., xviii., (7), p. 375.

This species occurred prolifically at both localities mentioned below and less commonly at Middle Rocks. The "*australis*" form predominates greatly (seven out of the eight) in the series from the *Posidonia* bank off the east end of Lusby Island, one specimen only showing a variation in that the superomarginal plates of one side are reduced to five. Five of the series of six from the granitic reef at the south end of McCoy Bay are of the "*astrologorum*" type and four show marked variation in the number of superomarginal plates. The specimen of the *australis* type has two sides with eight plates and three sides with seven; the remaining specimens have (*a*) one side with six plates, two with seven, one with eight, and one with nine, (*b*) one side with six plates, three with seven, and one with eight, (*c*) four sides with six plates and one with seven.

It is of interest to note the predominance of the two extremes of this species in two widely different habitats, those from the granite reef also showing much greater variation, always in the form of an increase in the number of superomarginal plates, which is probably due to regeneration of fragmented plates damaged by stones rolled about by wave action on the exposed reefs.

Family: ASTEROPIDAE.

Petricia vernicina (Lamarck, 1816).

(Plate XVIII., figs. 1, 2.)

Asterias vernicina Lamarck, 1816, Anim. s. Vert., ii., p. 554.
Petricia vernicina (Lamarck), Clark, 1928, Rec. Sth. Aust. Mus., iii., (4), p. 388.

This species occurs commonly on the granitic reef at the south end of McCoy Bay and only rarely on the *Posidonia* bank off the east end of Lusby Island. In life it is a brilliant brick-red in colour. One four-armed specimen (Plate XVIII., fig. 1), with the typical large pedicellariae at the base of three only of the rays, was collected from the *Posidonia* bank. Victorian specimens in the National Museum, Melbourne, are from Cheltenham, Beaumaris, and South Brighton, in Port Phillip Bay.

Order: SPINULOSA.

Family: ASTERINIDAE.

Patiriella gunnii (Gray, 1840).

Asterina gunnii Gray, 1840, *loc. cit.*, p. 289.
Patiriella gunnii (Gray), Clark, 1928, *loc. cit.*, p. 392.

Abundant at the granitic reef in McCoy Bay and at Middle Rocks.

Family: ASTERIIDAE.

Coscinasterias calamaria (Gray, 1840).

Asterias calamaria Gray, 1840, *loc. cit.*, p. 179.
Coscinasterias calamaria (Gray), Clark, 1928, *loc. cit.*, & p. 399.

Found only at Middle Rocks, off the west coast of Reevesby Island.

Allostichaster polyplax Verrill, 1914.

Allostichaster polyplax Verrill, 1914, Harriman Alaska Exped., Starfishes, p. 363.

Fairly common on the granitic reef at the south end of McCoy Bay and at Middle Rocks.

Uniophora sinusoida (Perrier, 1875).

(Plate XVIII., figs. 5, 6.)

Asterias sinusoida Perrier, 1875, Arch. Zool. Exp., iv., p. 338.
Uniophora sinusoida (Perrier), Clark, 1928, *loc. cit.*, p. 411.

This large *Uniophora*, of which two examples were collected, one having R = 85 mm. and the other R = 70 mm., is fairly common on the *Posidonia* bank off Lusby Island. In the radii of the large specimen and, less conspicuously, in the smaller specimen, the zigzag row of capitate carinal spines combines with the dorsolateral spines to enclose unarmed polygonal areas which are characteristic of this form. The detail of the armature of the actinal surface is shown in Plate XVIII., fig. 5.

Uniophora multispina multispina Clark, 1928.

(Plate XVIII., fig. 9.)

Uniophora multispina Clark, 1928, *loc. cit.*, p. 407, text-figs. 119, *a, b*.

Four specimens from the *Posidonia* bank off the east end of Lusby Island.

Uniophora multispina uniserialis Clark, 1928.

(Plate XVIII., figs. 7, 8.)

Uniophora uniserialis Clark, 1928, *loc. cit.*, p. 413, text-figs. 122, *a, b*.

Including the four specimens recorded above as *U. multispina multispina*, a series of fourteen small *Uniophora* all having the conspicuous madreporite surrounded by nine to twelve unequal spines were gathered from the *Posidonia* bank off the east end of Lusby Island. The carinal series of the radii of ten specimens has the fifteen stout conical spines described by Clark for *U. uniserialis*. The remaining four specimens (listed above as *U. multispina multispina*) agree in all characters with the *uniserialis* series except for an increase in the number of carinal spines, which tend to become capitate, and a slightly greater number of dorsolateral spines in two cases; in the remaining two specimens the number of dorsolateral spines is much greater, the carinal series being unaffected. This series demonstrates an intergradation between *U. multispina* and *U. uniserialis*, the latter being here regarded as a variety of the former.

One specimen of *U. multispina uniserialis* has six radii.

Class: OPHIUROIDEA.

Order: CHILOPHIURIDA.

Family: OPHIOCHITONIDAE.

Ophionereis schayeri (Müller and Troschel, 1844).

Ophiolepis schayeri Müller and Troschel, 1844, Arch. für Naturg., x., p. 182.

Ophionereis schayeri (M. and T.), Stach, 1937, Proc. Roy. Soc. Vic., n.s., xlix., p. 373.

This form occurs fairly commonly at Middle Rocks and the granitic reefs of the east coast of Reevesby Island.

Class: ECHINOIDEA.

Order: CIDAROIDA.

Family: CIDARIDAE.

GONIOCIDARIS GERANIOIDES TUBARIA (Lamarck, 1816).

(Plate XVIII., figs. 10*a-e*.)

Cidarites tubaria Lamarck, 1816, *loc. cit.*, p. 57.
Goniocidaris geranioides tubaria (Lamarck), Clark, 1928, *loc. cit.*, p. 455.

This form is excessively common on the *Posidonia* bank off the east end of Lusby Island, where as many as six or seven per square yard were found. All the specimens from this habitat are very constant in their dimensions and in the form of the spines, those from the middle region of the test being broad and flat distally and marked with narrow ridges, spinous projections being absent; in the abactinal region, the spines are pointed and bear a few low conical elevations. The single specimen (juvenile), collected from Middle Rocks, contrasts strongly in that the spines are conspicuously thorny and taper distally.

Order: CENTRECHINOIDA.

Family: TEMNOPLEURIDAE.

AMBLYPNEUSTES OVUM OVUM (Lamarck, 1816).

Echinus ovum Lamarck, 1816, *loc. cit.*, p. 48.
Amblypneustes ovum (Lamarck), Clark, 1928, *loc. cit.*, p. 464.

One specimen dredged at six to eight fathoms on *Posidonia* off the north-west corner of Spilsby Island.

AMBLYPNEUSTES OVUM PACHISTA Clark, 1912.

Amblypneustes pachistus Clark, 1912, Mem. Mus. Comp. Zool., xxxiv., p. 327.
A. ovum pachista Clark, 1928, *loc. cit.*, p. 465.

One specimen washed up in Nicholas Bay.

AMBLYPNEUSTES PALLIDUS (Lamarck, 1816).

Echinus pallidus Lamarck, 1816, *loc. cit.*, p. 48.
Amblypneustes pallidus (Lamarck), Clark, 1928, *loc. cit.*, p. 465.

This form occurs fairly commonly on the *Posidonia* bank off the east end of Lusby Island and specimens were also found washed up in Nicholas Bay, McCoy Bay, and Moreton Bay. In the series from the *Posidonia* bank, the primary spines are constantly light green and the small spines white, while those washed up in Nicholas Bay have light purple primaries and pale green small spines.

Family: STRONGYLOCENTROTIDAE.

Heliocidaris erythrogramma (Valenciennes, 1846).

Echinus erythrogrammus Valenciennes, 1846, Voy. "Venus", Zooph., pl. vii., fig. 1.
Heliocidaris erythrogramma (Val.), Clark, 1928, *loc. cit.*, p. 468.

This species occurs commonly on the reefs of the east coast of Reevesby Island where it forms part of the diet of the Pacific Gull and also at Middle Rocks on the west coast. It is a typical member of rocky reef faunas along the southern coast of Australia.

Class: HOLOTHUROIDEA.

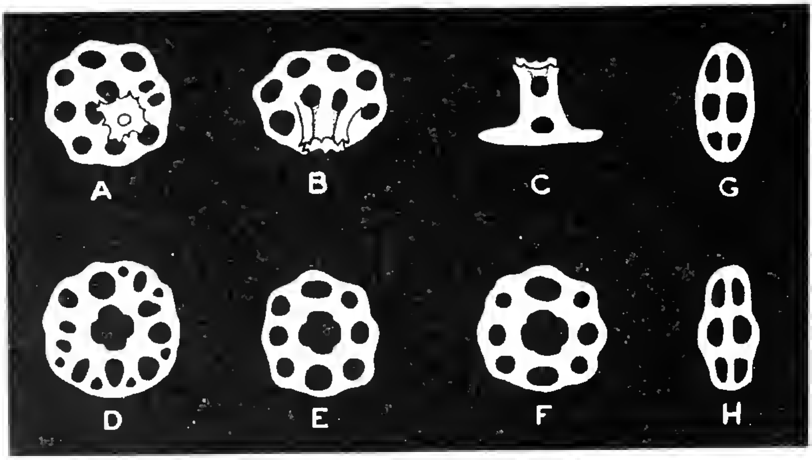
Order: ASPIDOCHIROTAE.

Family: HOLOTHURIIDAE.

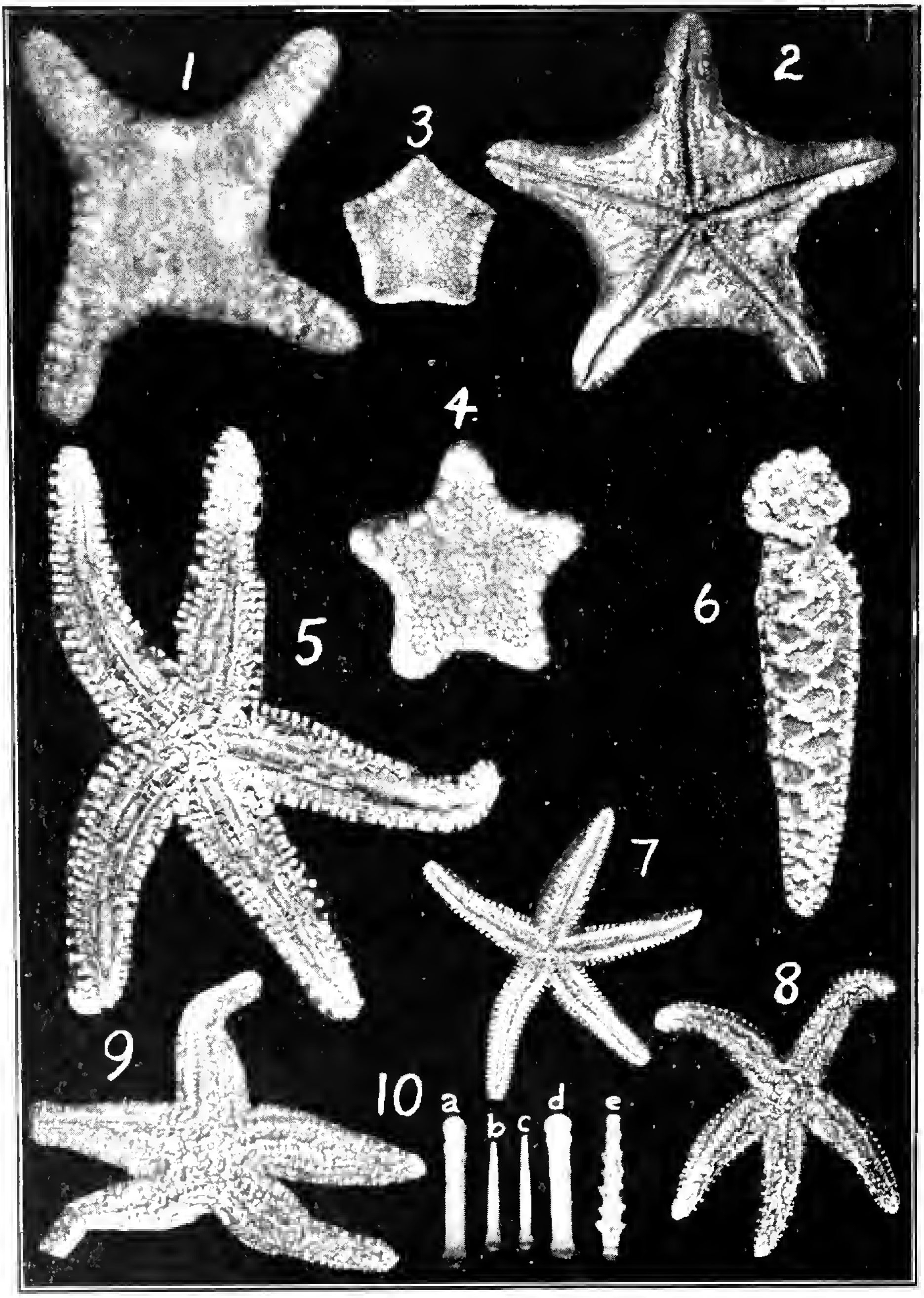
Holothuria aff. monacaria Lesson, 1830.

Holothuria monacaria Lesson, 1830, Cent. Zool, pl. viii., fig. 10.
Théel, 1885, Challenger Repts., Zool., pt. xxxix., p. 172

This single specimen dredged from the *Posidonia* banks between Reevesby and Winceby Islands at four fathoms is very contracted, but approaches closely to Théel's description of such examples. The calcareous deposits (text-figs. 1A-H) are very similar to those figured for *H. monacaria.* The buttons are identical, but the perforations of the discs of the tables vary slightly in their arrangement.



Text-figure 1.—Calcareous deposits of *Holothuria* aff. *monocaria* from four fathoms between Reevesby and Winceby Islands. X 280. A-C, tables showing spire; D-F, various arrangements of the perforations of the discs of the tables; G, H, two variations of the buttons.



Echinodermata of Banks Group.

Order: DENDROCHIROTAE.

Family: CUCUMARIIDAE.

CUCUMARIA MUTANS Joshua, 1914.

Cucumaria mutans Joshua, 1914, Proc. Roy. Soc. Vic., n.s., xxvii., (1), p. 4, pl. i., figs. 1 *a-d*.

One typical purplish-black juvenile was collected at Middle Rocks.

Explanation of Plate XVIII.

(Magnification × .5.)

Fig. 1.—*Petricia vernicina* (Lamarck, 1816). Four-armed specimen from *Posidonia* bank off east end of Lusby Island, Nat. Mus. Coll. No. 70625.

Fig. 2.—*P. vernicina.* Actinal surface of five-armed specimen., Nat. Mus. Coll. No. 70626.

Fig. 3.—*Tosia australis* Gray, 1840. Abnormal specimen of "*australis*" type from reef at south end of McCoy Bay, Nat. Mus. Coll. No. 70628.

Fig. 4.—*T. australis.* Abnormal specimen of "*astrologorum*" type due to fragmentation of superomarginal plates, Nat. Mus. Coll. No. 60627.

Figs. 5, 6.—*Uniophora sinusoida* (Perrier, 1875). From *Posidonia* bank off east end of Lusby Island, Nat. Mus. Coll. Nos. 70622, 70620.

Figs. 7, 8.—*U. multispina uniserialis* Clark, 1928. From *Posidonia* bank off east end of Lusby Island, Nat. Mus. Coll. Nos. 70624, 70621.

Fig. 9.—*U. mutispina multispina* Clark, 1928. Same locality as *U. multispina uniserialis*, Nat. Mus. Coll. No. 70623.

Fig. 10.—*Goniocidaris geranoides tubaria* (Lamarck, 1816). A-D. Spines from specimen from *Posidonia* bank off east end of Lusby Island; E. Spine from specimen taken from Middle Rocks.

5. *Mollusca, Part I.: The Spermatophore of* Rossia australis *Berry.*

By BERNARD COTTON, Conchologist, South Australian Museum.

Four specimens of *Rossia australis* Berry, one male and three females, were taken from off the west coast of Reevesby Island, South Australia, at a depth of 4 feet, during December, 1936. The species has not been previously taken in South Australia.

The male was dissected and the Needham's Sac was found to be filled with spermatophores. A large number of these were mounted in gum chloral instead of glycerine jelly as previously used by the author. Photo-micrographs are here reproduced, and the different features of the spermatophores are indicated on the plates. The photo-micrographs were made by projection through a microprojector directly on to a sheet of photographic paper.

Except for six specimens the spermatophores were mature and a typical specimen (pl. XIX., fig. 2), and an immature one (pl. XIX., fig. 1) are figured. The following is a description of the spermatophore.

An average mature spermatophore measures in length 6.5 mm., and 0.5 mm. across the sheath near the sperm tube. It will be noticed that the sperm tube in the one specimen is twice as long as in the immature, while the so-called false tube is inversely proportional in length. In the immature specimen the sheath is more globular and blunt aborally. It is in this immature state that the spermatophore enters the Needham's Sac, while the outer sheaths, "thin and presumably in the process of formation" (Verco and Cotton) (Proc. Mal. Soc., XIX., pt. IV., Mar., 1931, p. 169), are found in the seminal vesicle. One concludes that the sperm tube is completely developed shortly after entering into the Needham's Sac, and simultaneously there is a reduction in the length of the false tube.

This relative state of development is mentioned here as it has been stated by Russell (Fisheries Scotland, Sci., Invest., 1921, III. Feb., 1922, p. 31), that "there is every reason for supposing the shape of the spermatophore to be a good specific character; for it is just these apparently insignificant and non-adaptive characters which are the best distinguishing marks of allied species." This statement seems reasonably correct providing mature spermatophores are examined, but it appears that microscopic structural peculiarities should also be studied as well as the mere shape, before any specific identification can be confirmed.

An enlargement of the median portion of the spermatophore (pl. XX., left, fig. 1) shows the upper and lower sac, the connective, the base of the oral tube, the false tube and the upper end of the sperm tube. The oral tube (pl. XX., right, fig. 2) coiled at the oral end is shown greatly enlarged and the position of the asteroid corpuscles can be distinguished as minute grains in the axial canal.

Verco and Cotton (*loc. cit.*, p. 170) described an experimental method of inducing the rupture of spermatophores. After preserving fresh specimens in glycerine, water was added drop by drop to reduce the specific gravity of the liquid and the spermatophores absorbed the solution slowly and finally ruptured. It has since been found that after three months' immersion in glycerine the rupture still occurs within fifteen seconds of immersion in water. The specimens of *Rossia australis* examined had been preserved in weak formalin for a period of nine months, so that it was thought that the spermatophores would not react to this experiment. They were, however, removed from the Needham's Sac and placed in glycerine prior to mounting. A few days later odd ones were transferred to water, and each ruptured within 30 seconds of immersion. The oral tube coiled at the oral end as the sperm tube was thrust upward, and finally the sheath ruptured. It seems that the coiling of the oral tube merely adds to the elasticity of the pressure in preparation for the final rupture whereas with fluid pressure alone the rupture would be less violent.

It will be noticed that the oral tube is two-thirds of the total length of the spermatophore in the present species, but contains no "spiral spring" as noted in *Sepioteuthis australis* by Verco and Cotton. In the latter species it is significant that this is only one-fifth of the total length of the spermatophore. From a study of these two, and of other kinds of Cephalopod spermatophores, the following conclusions may be drawn.

1. The action of the spermatophore in ejecting the spermatozoa is mechanical.

2. The function of the oral tube, normally somewhat compressed but more so just previous to rupture, is to induce greater elasticity in the internal pressure of the spermatophore, probably with the object of violently scattering the spermatozoa and avoiding the concentration of them on the rupture of the spermatophore.

3. The immature spermatophore in the Needham's Sac has a considerably smaller sperm tube and proportionately longer false tube than the mature, the overall length of the structure being constant.

4. Where there is an increase in the comparative length of the sperm tube, as in higher forms of Cephalopoda, there is a consequent complication in the ejaculatory apparatus to retain its efficiency.

5. The shape and structure of the mature spermatophore, being non-adaptive, are good specific characters.

NOTE.—The terms oral and aboral, as suggested by Racovitza, are used here, as they are generally accepted.

Explanation of Plates.

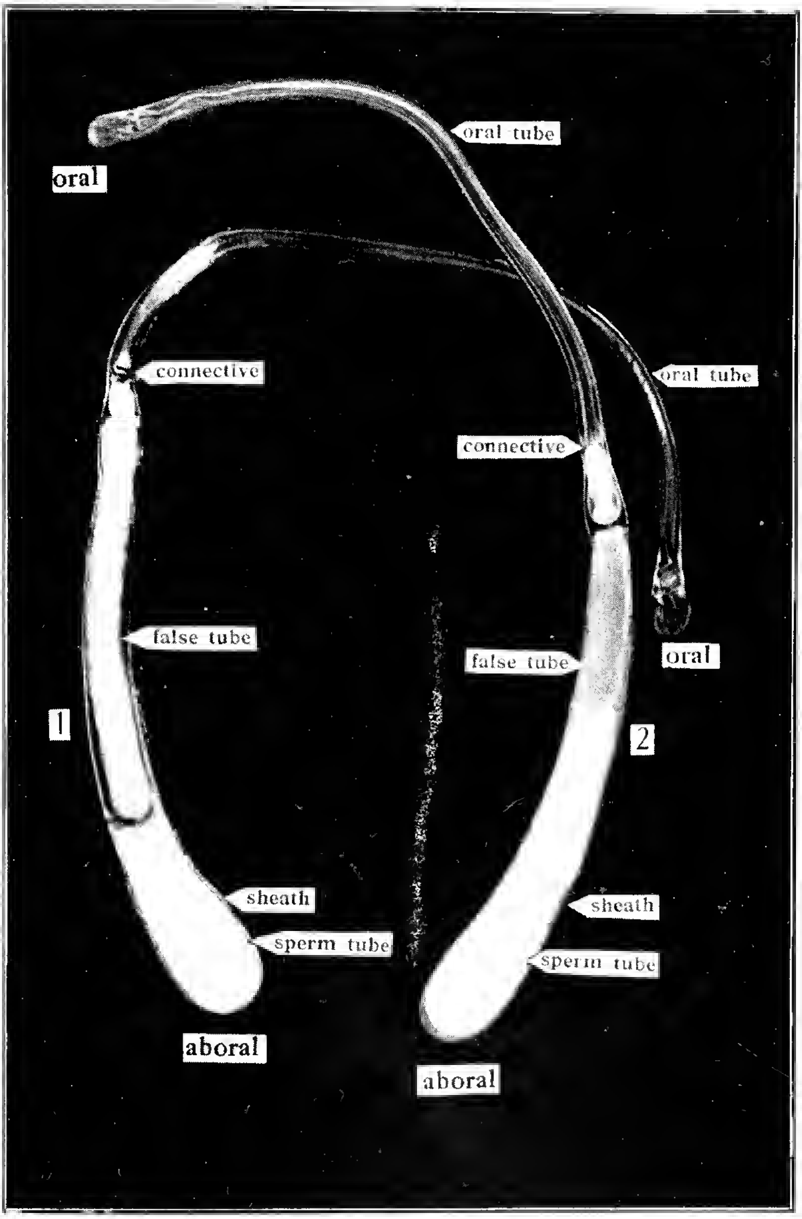
PLATE XIX.

Fig. 1.—The spermatophore of *Rossia australis,* immature. × 43.
Fig. 2.—The spermatophore of *Rossia australis,* mature. × 43.

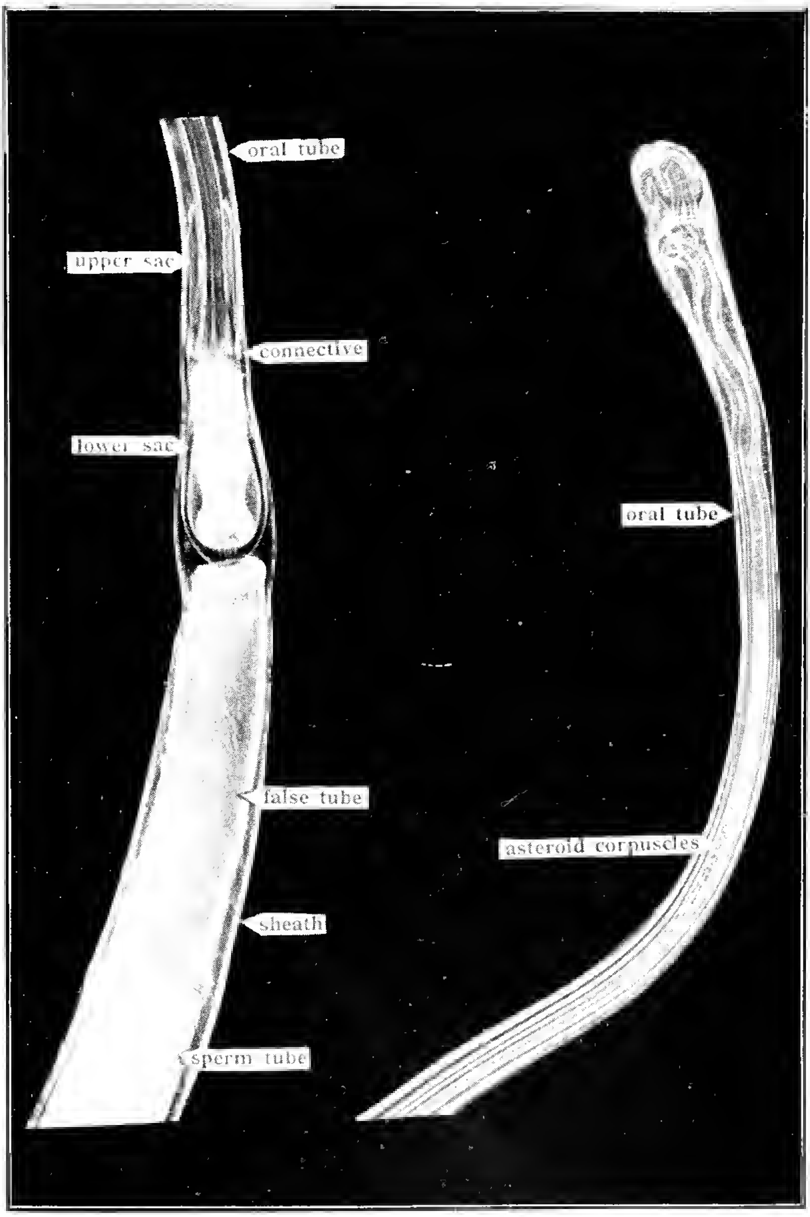
PLATE XX.

Left.—The median portion of the spermatophore of *Rossia australis.* × 90.

Right.—The Oral tube of the spermatophore of *Rossia australis.* × 90.



Spermatophore of *Rossia australis.*



Spermatophore of *Rossia australis.*

6. *Sipunculoidea.*

By MARY B. WHEELER.

Genus **Physcosoma** Selenka, 1897.

PHYSCOSOMA SCOLOPS (Selenka and de Man, 1883).

Phascolosoma annulata Hutton, 1880, Trans. N.Z. Inst., xii., p. 278.

Phymosoma scolops Selenka and de Man, 1883, Die Sipunculiden, Semper's Reis. den Philippien, Wiesbaden, iii., 4, p. 131, Pl. XIV.

Physcosoma annulatum (Hutton), Benham, 1904, Trans. N.Z. Inst., xxxvi., p. 173.

Physcosoma scolops (Selenka and Man), Benham, 1912, *ibid.*, xliv., p. 137.

Benham in 1904 described *Phascolosoma annulata* Hutton as *Physcosoma annulatum*. In 1912 he stated that the same species is identical with Selenka's *P. scolops*, described several years later than Hutton's species. "Hutton's brief diagnosis, depending only on externals, is insufficient for identification, and must give way to Selenka's specific name ———." Hence *P. annulatum* became *P. scolops*.

Selenka (Zool. Anz. 1897, xx., p. 460) substituted *Physcosoma* nom. nov., for *Phymosoma* auct. id. since the latter name was preoccupied.

Several specimens of this species were obtained on Reevesby Island (littoral to 4 fathoms), and it has also been collected from Western Port, Victoria.

The species has been recorded from the Philippine Islands, Singapore, Red Sea, Mozambique, Zanzibar, Kermadec Island, Sunday Island, Meyer Island, New Zealand and Tasmania. If Fischer (Die Gephyrea, Abh. ausd. Geb. Naturwiss., 1895, xiii., p. 10.) is correct in regarding *P. scolops* as a variety of the Mediterranean *P. granulatum*, the range must be extended to include European waters.

7. *Ixodoidea.*

By J. A. TUBB, M.Sc.

Family: ARGASIDAE.

Genus: **Ornithodorus.**

ORNITHODORUS TALAJE var. CAPENSIS Neumann, 1901.

Ornithodorus talaje var. *capensis* Neumann, 1901, Mém. Soc. Zool. de France, xiv., p. 258.

One female was found on English Island. The host was not observed but was probably the Fairy Penguin (*Eudyptula minor*), which frequents this island and which was observed to harbor this tick on Lady Julia Percy Island.

Recorded from Cape Colony, St. Paul's Rocks, Cargados Carajos and Lady Julia Percy Island.

Family: IXODIDAE.

Genus: **Ixodes.**

IXODES PERCAVATUS Neumann, 1906.

Ixodes percavatus Neumann, 1906, Arch. de Parasitologie, xi., p. 200, figs. 4, 5.

A number of engorged females and one nymph were taken from the body of a dead Fairy Penguin (*E. minor*) on Langton Island.

Recorded from Nightingale Island (Tristan d'Acunha Group), and Lady Julia Percy Island.

Genus: **Amblyomma.**

Sub-genus: **Aponomma.**

APONOMMA HYDROSAURI (Denny, 1843).

Ixodes hydrosauri Denny, 1843, Ann. Mag. Nat. Hist., xii., p. 314, pl. XVII., fig. 4.

Aponomma hydrosauri Fielding, 1926, Serv. Publ. Aust., ix., p. 87, fig. 33.

Adults, nymphs, and larvae of this species were found parasitic on *Trachysaurus rugosus* Gray, and *Notechis scutatis* var. *niger* Kinghorn.

In the original description of the species, Denny states that the host from which his specimens were taken was the "Guana (probably the *Hydrosaurus Gouldii* of Mr. Gray)." The "Guana" or "Goanna" of Tasmania is not a varanid, but a *Tiliqua*, either *T. nigrolutea* or *T. scincoides*, and the confusion of colloquial names must be blamed for the error in the designation of the host of this tick as *Varanus gouldii* (Gray).

The writer has found this parasite on *Tiliqua nigrolutea* (Gray) captured at Mornington (Victoria) and on the same species captured at Fern Tree Gully (Victoria).

Previously recorded from Tasmania.

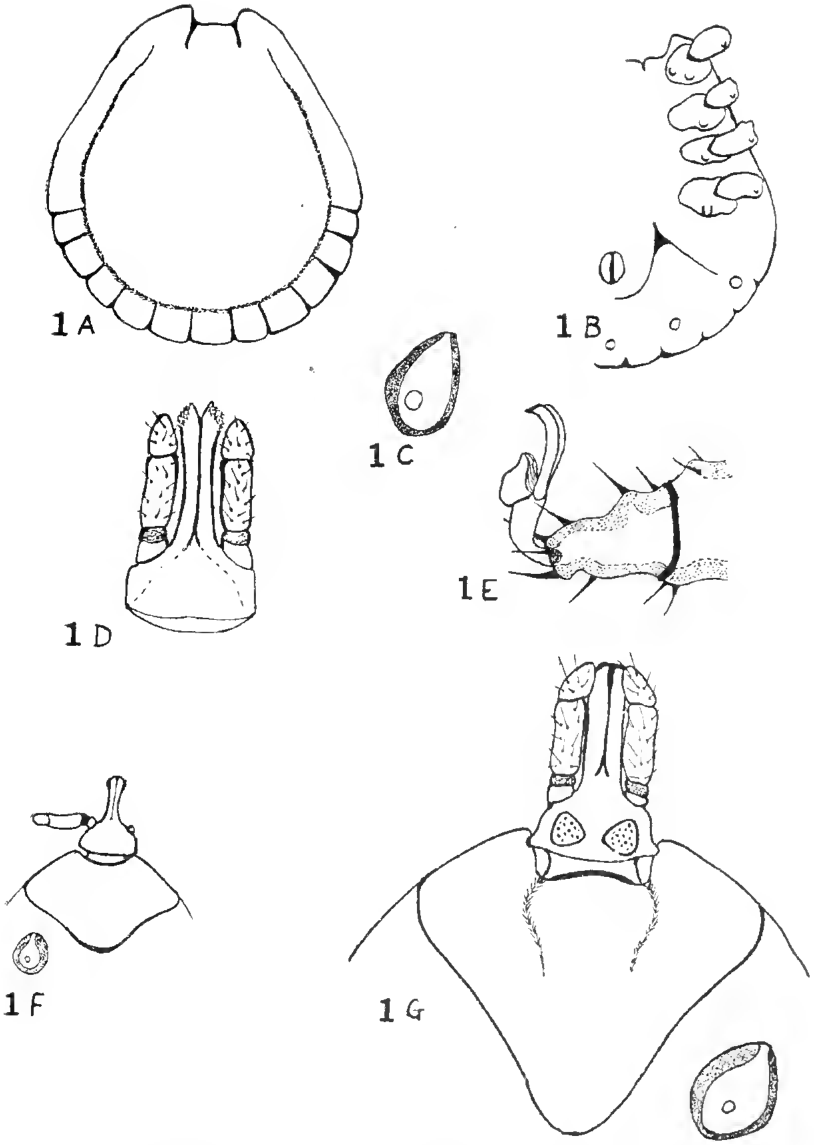


Fig. 1.—*Aponomma hydrosauri.*—a–e, Male, a, dorsum, x 10; b, venter, x 10; c, spiracle, x 17; d, capitulum, x 20; e, tarsus I, x 40; f, Nymph, dorsum and spiracle, x 17; g, female, dorsum and spiracle, x 17.

8. *Decapoda.*

By BERYL H. ANDERSON, B.Sc.

Twenty-one genera and twenty-three species were collected, all species having been previously listed for South Australian waters by Hale (Crustaceans of South Australia, 1927-29). The only details submitted in the following list are those relating to sex, locality and points of description differing from those given by previous authors. Only the most significant references to synonymy are given.

Order: DECAPODA.

Sub-Order: BRACHYURA.

Family: DROMIIDAE.

PETALOMERA LATERALIS (Gray, 1831).

Dromia lateralis Gray, Zool. Misc., 1831, p. 40.

Cryptodromia lateralis (Gray), Stimpson, Proc. Acad. Nat. Sci. Phil., x., 1858, p. 226.

Petalomera lateralis (Gray), Borradaile, Ann. Mag. Nat. Hist (7), xi., 1903, p. 301.

A female was collected on a reef off the sand spit on the west coast of Reevesby Island. The specimen carried on its back a colonial Ascidian, and was completely obscured from above.

CRYPTODROMIA OCTODENTATA (Haswell, 1881).

Dromia octodentata Haswell, Proc. Linn. Soc. N.S.W., vii., 1881 p. 755.

Cryptodromia octodentata (Haswell), Rathbun, Sci. Res. "Endeavour," v., iii., 1923, p. 151, pl. xli.

A male carrying a large sponge was taken on the west coast of Reevesby Island and a female from a *Posidonia* bank off Lusby Island.

DROMIDIOPSIS EXCAVATA (Stimpson, 1858).

Dromidia excavata Stimpson, *loc. cit.*, 1858, p. 239.

Dromidiopsis excavata (Stimpson), Rathbun, *loc. cit.*, 1923, p. 146, pl. xxxviii.

A female was collected from the north end of Reevesby Island.

Family: HYMENOSTOMATIDAE.

HALICARCINUS OVATUS Stimpson, 1858.

Halicarcinus ovatus Stimpson, *loc. cit.*, 1858, p. 109.

Numerous specimens of both sexes were collected from rocks around Reevesby Island.

Family: MAJIDAE.

SCHIZOPHRYS ASPERA (Milne-Edwards, 1834).

Mithrax aspera Milne-Edwards, Hist. Nat. Crust., i., 1834, p. 320.

Schizophrys aspera (Milne-Edwards), Alcock, Journ. Asiat. Soc. Bengal., lxiv., 1895, p. 243.

Five males of this species were collected in rock pools on the west coast of Reevesby Island.

Family: PORTUNIDAE.

OVALIPES PUNCTATUS (de Haan, 1833).

Corystes (Anisopus) punctata de Hann, Faun. Japon., Crust., 1833, p. 13.

Ovalipes punctatus (de Haan), Rathbun, U.S. Nat. Mus. Bull., clii., 1930, p. 24, pls. v-viii.

Platyonichus bipustulatus Milne-Edwards, *loc. cit.*, 1834, p. 437, pl. xvii., figs. vii-x.

Ovalipes bipustulatus (Milne-Edwards), Rathbun. Proc. U.S. Nat. Mus., xxi., 1898, p. 597.

This species was common in shallow water along the coast of Reevesby Island. A number were taken in the fishing net.

NECTOCARCINUS INTEGRIFRONS (Latreille, 1825).

Portunus integrifrons Latreille, Encycl. x., 1825, p. 192.

Nectocarcinus integrifrons (Latreille), Milne-Edwards, Ann. Sci. Nat. (4), xiv., 1860, p. 220.

Three specimens were taken. A male and a female were found in the fish net on the west coast of Reevesby Island and a male was dredged at a depth of five fathoms between Reevesby and Marum Islands.

Family: XANTHIDAE.

OZIUS TRUNCATUS Milne-Edwards, 1834.

Ozius truncatus Milne-Edwards, *loc. cit.*, 1834, p. 406, pl. xvi., fig. xi.

Two females were obtained from the west coast of Reevesby Island.

Family: PINNOTHERIDAE.

PINNOTHERES SUBGLOBOSA Baker, 1907.

Pinnotheres subglobosa Baker, Trans. Roy. Soc. S. Aust., xxxi., 1907, p. 179.

Numbers of these were obtained from mussel shells. All the specimens were females.

Family: GRAPSIDAE.

Leptograpsus variegatus (Fabricius, 1793).

Cancer variegatus Fabricius, Ent. Syst., iii., 1793, p. 450.

Leptograpsus variegatus (Fabricius), Milne-Edwards. Ann. Sci. Nat. (3), xx., 1853, p. 171.

A female specimen showing red and yellow coloration was taken under rocks on the north coast of Reevesby Island.

Brachynotus octodentatus (Milne-Edwards, 1837).

Cyclograpsus octodentatus Milne-Edwards, Hist. Nat. Crust., ii., 1837, p. 80.

Brachynotus octodentatus (Milne-Edwards), Hale, Crust. S. Aust., 1929, p. 182.

A male specimen was collected on the rocks in Moreton Bay.

Plagusia chabrus (Linnaeus, 1766).

Cancer chabrus Linnaeus, Syst. Nat., 1766, p. 1044.

Plagusia chabrus (Linnaeus), White, Ann. Mag. Nat. Hist., xvii., 1846, p. 497.

A number of specimens were taken from rock pools at the north end of Reevesby Island.

Family: LEUCOSIIDAE.

Philyra laevis Bell, 1855.

Philyra laevis Bell, Trans. Linn. Soc., xxi., 1855, p. 300, pl. xxxii., fig. vii.

Two males and one female were collected off the reef on the west coast of Reevesby Island.

Sub-Order: ANOMURA.

Family: GALATHEIDAE.

Galathea australiensis Stimpson, 1858.

Galathea australiensis Stimpson, *loc. cit.*, 1858, p. 251.

A number of specimens were dredged at a depth of four fathoms between Lusby and Partney Islands, and also in Moreton Bay. In living specimens the fingers of the chelae were bright crimson and the rest of the body pale yellow.

Family: PAGURIDAE.

Paguristes frontalis (Milne-Edwards, 1836).

Pagurus frontalis Milne-Edwards, Ann. Sci. Nat. (2), vi., 1836, p. 283, pl. xiii., fig. iii.

Paguristes frontalis (Milne-Edwards), Alcock, Cat. Ind. Decap. Crust., ii., 1905, p. 155.

Four females and two males were collected between Marum and Reevesby Islands and in rock pools on the west coast of Reevesby Island. All the females were larger than the males and carried a large brood pouch formed by a thin flap on the side of the abdomen. They were obtained from the following shells—*Amoria undulata* (Lamarck), *Xenophalium sp.*, *Polinices conicus* (Lamarck), *Lyria* sp.

PAGURISTES BREVIROSTRIS, Baker, 1905.

Paguristes brevirostris Baker, Trans. Roy. Soc. S. Aust., xxix., 1905, p. 256, pl. xxxiii., figs. i., i*a*.

A female was obtained from a shell of *Nerita melanotragus* (E. A. Smith) dredged between Reevesby and Lusby Islands.

Family: LITHODIDAE.

LOMIS HIRTA (Lamarck, 1816).

Porcellana hirta Lamarck, Hist. Anim. s. Vert., v., 1816, p. 229.
Lomis hirta (Lamarck), Milne-Edwards, *loc. cit.*, 1837, p. 188.

This species was common on rocks around Reevesby Island.

Sub-Order: MACRURA.

Family: PALAEMONIDAE.

LEANDER INTERMEDIUS Stimpson, 1858.

Leander intermedius Stimpson, Proc. Acad. Nat. Sci. Phil., xii., 1860, p. 41.

This species was very common at a depth of two and a half fathoms on a *Posidonia* bank between Reevesby and Lusby Islands, and also off Spilsby at a depth of seven to nine fathoms.

LEANDER SERENUS Heller, 1865.

Leander serenus Heller, Reise der Novara., Crustacea, 1865, p. 110, pl. x., fig. v.

Specimens were readily collected in rock pools surrounding Reevesby Island.

Family CRAGONIDAE.

PONTOPHILUS INTERMEDIUS (Bate, 1863).

Crangon intermedius Bate, Proc. Zool. Soc., 1863, p. 503, pl. xli., fig. vi.
Pontophilus intermedius (Bate), Hale, *loc. cit.*, 1929, p. 62.

One specimen was dredged at a depth of eight fathoms off Spilsby Island.

Family: SYNALPHEIDAE.

CRANGON VILLOSUS (Olivier, 1811).

Palaemon villosus Olivier, Encycl., Hist. Nat. Insectes., v., 1811, p. 664.

Crangon villosus (Olivier), Hale, *loc. cit.*, 1929, p. 46.

A number of specimens were dredged at a depth of four to five fathoms in Moreton Bay, and between Lusby and Partney Islands. In spirit specimens the large chelae showed blue coloration.

CRANGON EDWARDSI (Audouin, 1809).

Athanasus edwardsi Audouin, Explic. planches de Savigny, Descr. de l'Egypte, Atlas, 1809, pl. x., fig. i.

Crangon edwardsi (Audouin), Hale, *loc. cit.*, 1929, p. 47.

A number of specimens was collected at a depth of four fathoms between Lusby and Partney Islands. After remaining in spirit for some time the last third of the large chelae showed green and purple coloration.

Family: PENEIDAE.

PENEUS LATISULCATUS Kishinouye, 1900.

Peneus latisulcatus Kishinouye, Journ. Fish. Bureaux, Tokyo, viii., 1, 1900, p. 12, pl. ii., fig. ii., pl. vii., fig. ii*a*.

Specimens were commonly caught in the fish net at the south end of Reevesby Island.

Family: PALINURIDAE.

JASUS LALANDII (Milne-Edwards, 1837).

Palinurus lalandii Milne-Edwards, *loc. cit.*, 1837, p. 293.

Jasus lalandii (Milne-Edwards), Parker, N.Z. Journ. Sci., i., 1883, p. 584.

One specimen was found washed up on the beach on the east coast of Reevesby Island.

9. *Isoptera.*

By GERALD F. HILL, Senior Research Officer, Division of Economic Entomology, Canberra.

The collection of termites comprises four species, all of which occur on Kangaroo Island, and are widely distributed on the mainland.

Family: CALOTERMITIDAE.

Genus **Calotermes** (Hagen) Holmgren.

Sub-genus **Calotermes** (Hagen) Holmgren.

CALOTERMES (CALOTERMES) CONDONENSIS Hill.

Calotermes (Calotermes) condonensis Hill, 1922, Proc. Linn. Soc. N. S. Wales, xlvii., p. 275, text-figs. 1-4.

Calotermes (Calotermes) oldfieldi Hill, 1925, Proc. Roy. Soc. Vict., xxxviii., p. 207, pl. xxiii., figs. 1, 2.

This species, the only representative of the sub-genus known from Australia, was described from Condon, Western Australia. *C. oldfieldi* was described from winged adults and soldiers from Kiata, Victoria. An examination of complete series from Reevesby Island (J. Clark, December, 1936), and from Kangaroo Island (Wynis Kent Hughes, November, 1931) establishes the above synonymy. It is a very variable species in both castes in all the characters ordinarily used in descriptions. A small form, *C. condonensis* var. *chryseus* Hill occurs commonly in eastern New South Wales.

Distribution.—The typical form occurs in the following localities:—Western Australia: Condon, Ludlow; South Australia: Reevesby Island, Kangaroo Island; Victoria: Kiata, Bamawm, Frankston; New South Wales: Eden; Queensland: Dalby.

Biology.—All species of the family *Calotermitidae* live exclusively in wood excepting for a brief period when the recently developed winged males and females leave the parent colony for the purpose of founding new colonies. *C. condonensis* is usually found in dead branches or branch stubs, and in the adjacent truewood of living trees. There is a recent record from Victoria of the occurrence of a colony in the butt of a power pole. On Reevesby Island, where this species is abundant, most of the colonies were found in fallen trees of *Myoporum insulare* R. Br.

Family: RHINOTERMITIDAE.

Genus **Heterotermes** (Froggatt).

Heterotermes ferox (Froggatt).

Termes ferox Froggatt, 1897, Proc. Linn. Soc. N. S. Wales, xxii., p. 724, pl. xxxiv., figs. 1, 1A, 1B.

Described from specimens collected near Sydney, this species is now known to have a wide distribution in southern Australia. The soldiers and workers of several species are difficult to classify satisfactorily in the absence of winged adults. The Reevesby Island material (workers and soldiers only) agrees with authenticated specimens from New South Wales and Kangaroo Island. It is of interest to note that the last-mentioned island is the type locality of the genotype, *H. platycephalus* Froggatt, which occurs also in Western Australia.

Distribution.—New South Wales, Victoria, South Australia, and possibly Western Australia.

Biology.—This species, like others of the genus, is subterranean in its nesting habits. The colonies are small, and usually are found attacking decaying wood. Imported softwoods are very susceptible to attack. In some localities soldiers and workers, and occasionally winged adults also, are found in flattened galleries under stones, and at the margin of mounds of the common "meat-ant" (*Iridomyrmex detectus* Sm.). These galleries extend deeply into the ground, and doubtless communicate with the nest, which has not been described. The Reevesby Island specimens (coll. J. Clark) were found in a branch of a dead tree.

Family: TERMITIDAE.

Genus **Eutermes** Fritz Muller.

Eutermes exitiosus Hill.

Eutermes exitiosus Hill, 1925, Proc. Roy. Soc. Vict., xxxvii., p. 222, pl. xxv., figs. 30-35.

This species was described from Western Australia, and has since been recorded from many localities in southern Australia.

Distribution.—Southern districts of Western Australia and South Australia, Victoria (excepting Gippsland and Otway districts), and New South Wales (excepting on the summit of the highest mountain ranges).

Biology.—It is a mound-building, wood-eating species of very considerable economic importance in the destruction of seasoned timber. Certain phases of its biology have been studied intensively by the Council for Scientific and Industrial Research, by whom it is being used in the laboratory and under natural conditions in the field for the purpose of testing the termite-resisting properties of timbers, timber-preservatives and other materials. Several small mounds were found on Reevesby Island, the largest of which was in a stump of *Casuarina distyla* Vent.

Genus **Hamitermes** Silvestri.

Hamitermes neogermanus Hill.

Hamitermes neogermanus Hill, 1921, Bull. Ent. Res., xii, p. 390, text-fig. 22.

This species was described from Mount Lofty Ranges, South Australia, and is known to occur in many places in southern Australia.

Distribution.—Southern districts of Western Australia and South Australia (including Kangaroo Island); Victoria and New South Wales (in the drier grassland areas).

Biology.—The genus is widely distributed throughout the Australian mainland, and is represented by about 35 described species with very diverse feeding and nesting habits. A few wood-eating species are of economic importance. Many species feed on grass and vegetable debris, which they gather into mounds or into subterranean galleries. Several grass-eating, mound-building species build small to very large mounds on certain northern aerodromes, and thus render these landing places unsafe for the purpose for which they are intended. The well-known "meridional" or "compass" mounds of North Australia are constructed by a species of this genus (*H. meridionalis* (Froggatt)). *H. neogermanus* lives in subterranean galleries and appears to feed only on grass and grass-debris.

10. *Formicidae* (*Hymenoptera*).

By JOHN CLARK, Entomologist, National Museum of Victoria.

The collecting was confined almost entirely to Reevesby Island. The ant fauna is typical of South and Western Australia, and it is interesting to note that Reevesby Island, 3 miles long by 1 mile wide, contains almost twice the number of species of ants found in the British Isles or in New Zealand. Both these countries have about twenty species each. Thirty-three species, in twenty genera, representing four sub-families, were obtained on Reevesby Island, seven of these were found also on Winceby Island and two on English Island. Four of the species belong to genera not recorded previously from South Australia. One species is known only from South Australia, two only from Western Australia, nine from the dry inland area of Western Australia, South Australia, and Victoria, and seven are common in most parts of all the States; only four of the total number have been found in Tasmania. Fourteen species are new; one of these is found also on the mainland and extends westward to Balladonia. The hot weather and dry conditions on the island were not favourable for ant life. Most of the species were found in their nests under the shelter of small shrubs, whilst a few had their nests beneath the leaf debris under the large shrubs and some of the sun-loving species were nesting in the open, clear of all shade. Most of the Myrmicinae and Formicinae were found in rotten trunks and stumps of the "Native juniper" or "Boobialla", the nest of some species being of considerable size.

The Ponerinae, or stinging ants, are represented by seven species in six genera. Of these *Rhytidoponera punctata* (Smith) is the most common species, their small crater-like mounds being abundant. Numerous nests of the slender bull ant *Myrmecia gracilis* Emery were found near the middle of the island, particularly near the camp. Several small nests of the interesting genus *Eubothroponera*, were found beneath the accumulated debris under large shrubs near the middle of the island. In the same situations also were found nests of a jumping bull ant *Myrmecia* (*Promyrmecia*) *dichospila* sp. n. described herein and *Euponera* (*Brachyponera*) *nigra* Clark a black species found in various parts of Western Australia. The common "green head ant" *Chalcoponera metallica* Smith is abundant; it is found throughout the Commonwealth. *Myrmecia*, *Eubothroponera*, and *Chalcoponera* are purely Australian genera; *Rhytidoponera* is a Papuan genus and *Acanthoponera* is found in New Zealand and South America.

The sub-family Myrmicinae is represented by ten species in eight genera. Nests of *Crematogaster* and *Dacryon* were found in fallen rotten trunks of "Native juniper", and in several instances the trunks were occupied also by the large termite

Calotermes condonensis Hill. The only arboreal species found is the common "tree ant" *Podomyrma adelaidae* (Smith); it is widely distributed on the mainland.

The sub-family Dolichoderinae is represented by seven species in two genera. Several large nests of the "meat-ant" *Iridomyrmex detectus* Smith were found. This is the most common and widely distributed ant in Australia. The blue or greenish-blue variety of this species is common at the north end of Reevesby Island. Described originally from Killalpaninna, South Australia, it extends westward to Balladonia. The nests of the variety are inconspicuous and indicated by small entrance tunnels without traces of a mound. The mounds of *I. detectus* generally are several feet in diameter and almost 2 feet high.

The sub-family Formicinae is represented by nine species in five genera. Four of the species are new, the remainder are widely distributed in Australia.

Family FORMICIDAE Latreille, 1810.

Sub-family PONERINAE Lepeletier.

Genus **Myrmecia** Fabricius.

MYRMECIA GRACILIS Emery.

M. gracilis Emery, Ren. Accad. Sc. Bologna, p. 232, fig. 2, 1898, ☿.
M. crudelis Sm. var. *gracilis* Emery, Gen. Insect., fasc. 118, p. 19, 1911, ☿.

(Fig. 1.)

Worker.—Length 20–22 mm.

Head and gaster black, thorax, node and postpetiole ferruginous, mandibles yellow, clypeus, antennae and tarsi reddish yellow, femora and tibiae brownish.

Hair yellow, abundant, slender and erect on head and thorax, sub-erect on legs, none on scapes, very long on gaster. Pubescence greyish, very abundant and adpressed, particularly on gaster.

Mandibles shining, feebly punctate-striate. Head coarsely and irregularly rugose, finely and densely reticulate between the rugae. Pronotum transversely arched striate, mesonotum and epinotum transversely striate. Node punctate-rugose, rugae obsolete. Postpetiole, gaster and legs microscopically punctate.

Head as long as broad, strongly rounded behind, occiput not truncate. Mandibles as long as head, linear and parallel, external border concave in middle. Clypeus broadly and deeply excised in middle, borders convex, anterior angles sharp pointed. Labrum broader than long, projecting in front of clypeus, anterior border broadly convex. Frontal carinae twice as long as broad in front, parallel. Frontal area large and triangular. Scapes extend beyond occipital border by one-third their length. Second segment of funiculus one and one-half times longer than first, third very slightly longer than first, remainder sub-equal to apical. Eyes large and convex. Ocelli small and close together. Thorax three times longer than broad. Pronotum as long as broad, strongly convex in all directions. Mesonotum circular, as long as broad, convex above. Metanotum deep and wide, one-third as long as mesonotum. Epinotum slightly longer than broad, strongly rounded in all directions. In profile pronotum strongly convex from base to apex. Mesonotum strongly convex, much higher than pronotum, higher in front than behind. Metanotum deep and long. Epinotum feebly convex, strongly rounded into declivity. Node circular, as long as broad, convex on top, one-fourth longer than stalk in front. In profile dome-shaped, anterior face concave below, the spine in front below very short and blunt. Postpetiole one-third broader than long, two-thirds broader behind than in front, sides feebly convex. Gaster slightly longer than broad. First segment one-sixth broader than long, broader behind than in front, sides strongly convex. Legs long and slender.

Female.—Length 24.5–26 mm.

Similar to worker, but more robust. Colour darker and sculpture coarser. Head almost square and more truncate behind. Mayrian and parapsidal furrows strongly impressed on scutellum. A deep narrow impression between metanotum and epinotum. Legs more robust. Wings missing.

Male.—Length 18–19 mm.

Colour and pilosity as in the worker. Sculpture finer, more punctate-reticulate, the punctures large and shallow.

Head, across the eyes, one-fourth broader than long, strongly convex behind. Mandibles short, triangular, edentate. Clypeus flatly convex above, feebly indented in middle in front. Frontal carinae short and elevated. Frontal area small. Scapes one-third longer than first segment of funiculus, second segment three and one-half times longer than scape, third, fourth, and fifth equal in length, one-third shorter than second, remainder sub-equal to apical. Eyes large, occupying almost one-half of sides. Ocelli large and convex. Thorax barely twice as long as broad. Pronotum short, strongly convex in front. Scutellum broader than long, bluntly cone-shaped in front, mayrian and parapsidal furrows deeply impressed, a fine short longitudinal groove in front. Mesonotum slightly broader than long, anterior edge straight, sides feebly, posterior border strongly convex. Epinotum short, strongly convex transversely. Node as long as broad, circular, longer than stalk in front, in profile dome-shaped, evenly convex, the ventral spine very short and blunt. Postpetiole very slightly broader than long, fully two and one-half times broader behind than in front, sides straight to posterior fourth then strongly convex. Gaster fully one-fourth longer than broad. First segment one-fourth broader than long, sides strongly convex. Pygidium retracted. Legs long and slender. Wings hyaline.

Habitat.—Reevesby Island.

Numerous nests of this species were found, particularly near the middle of the island, and around the camp. All the nests are the usual crater-shaped mounds about ten inches high. Several nests were dug out; all were 2 feet deep and contained about 200 workers. Although described as a species by Emery he later regarded it as a variety of *M. crudelis* Smith. It is related to *M. vindex* Smith not to *M. crudelis* as supposed by Emery; *M. crudelis* was unknown to him. *M. gracilis* was described from a single, damaged specimen from Kangaroo Island and has not been recorded since. It is abundant and widespread in South Australia, parts of Western Australia and Victoria.

Sub-genus **Promyrmecia** Emery.

MYRMECIA (PROMYRMECIA) DICHOSPILA sp. n.

(Fig. 2.)

Worker.—Length 7–9 mm.

Black, dorsum of node and a large spot on epinotum red. Mandibles yellow at base, reddish yellow towards apex, teeth brown. Labrum reddish yellow. Scapes brown, funiculi reddish yellow. Tarsi and apex of tibiae brownish yellow.

Mandibles finely striate-reticulate with a row of large deep punctures along the inner borders. Head finely striate-rugose longitudinally, densely and finely reticulate between the rugae. Clypeus and frontal area finely and densely reticulate, not striate. Pronotum striate-rugose, transversely arched. Mesonotum striate-rugose longitudinally. Epinotum and node coarsely and irregularly rugose. Postpetiole and gaster very finely reticulate.

Hair yellowish, long and erect, particularly on clypeus and last three segments of gaster. None on antennae, very short and sparse on legs. Pubescence greyish, very fine and adpressed, longer and more abundant on gaster.

Head as long as broad, sides and occipital border straight, angles broadly rounded. Mandibles one-fifth shorter than head, external border concave, inner border strongly dentate, the third, fifth, seventh, and ninth teeth twice as large as the others, the ninth forming a slight angle. Clypeus deeply excised in middle in front. Labrum convex in front. Frontal area large and deep, semi-circular. Frontal carinae swerving behind, twice as long as wide in front. Scapes not extending to occipital border by twice their thickness at apex. First and second segment of funiculus equal length, third one-fourth shorter. Eyes large, occupying half the length of sides. Ocelli small. Thorax two and one-half times longer than broad. Pronotum one-third broader than long, strongly convex in all directions. Mesonotum circular, as long as broad. Epinotum slightly longer than broad, strongly convex transversely. In profile pronotum strongly convex from apex to base. Mesonotum higher than pronotum, dropping behind, strongly convex. Epinotum feebly convex on dorsum, strongly rounded into and united with declivity. Node slightly broader than long, fully twice as long as the stalk in front, convex in all directions. In profile slightly higher than long, apical third straight and vertical, sloping gradually to apex of stalk in front, dorsum convex, rounded into posterior face, ventral spine long and broad, sharp pointed, directed forward. Postpetiole almost one-third broader than long, broadest at middle, strongly convex in all directions; constriction deep and wide. Gaster one and two-thirds times longer than broad. First segment of gaster one-fifth broader than long, much broader behind than in front, sides convex. Legs long and slender.

Female.—Length 11 mm.

Colour, sculpture and pilosity similar to worker. Mandibles broader and straighter, teeth larger. Pronotum twice as broad as long, one-third shorter than scutellum, convex in all directions. Scutellum short, one-fourth broader than long, sides and front semi-circular, convex both ways on top. Parapsidal furrows distinct. Wing stumps present. Mesonotum circular, as long as broad, dome-shaped above. Epinotum feebly convex transversely. Node one-fifth broader than long. Postpetiole almost twice as broad as long. Legs slender.

Male.—Length 9.5 mm.

Head and gaster black. Thorax, node, postpetiole and legs brownish yellow, mandibles and scapes brown, funiculi yellowish red.

Head finely punctate-reticulate, more coarsely punctate behind. Thorax and node finely and densely reticulate, with numerous large shallow punctures scattered throughout, coarser and more abundant on epinotum. Postpetiole and gaster finely and densely reticulate. Pilosity as in worker but the erect hairs longer.

Head almost one-third broader than long, strongly convex behind. Mandibles short, furnished with four strong sharp teeth. Clypeus broad, convex above, concave in middle in front. Frontal area large, triangular. Frontal carinae one-third longer than broad in front. Scapes two and one-half times longer than first segment of funiculus, second segment six times longer than first, remainder sub-equal to apical. Eyes large, occupying almost all the sides. Ocelli large. Thorax two and one-half times longer than broad.

Pronotum short, strongly convex. Scutellum one-fifth broader than long, convex in front, mayrian and parapsidal furrows and frontal groove in centre deeply impressed. Mesonotum one-third broader than long, anterior edge feebly convex, sides and posterior edge strongly convex. Epinotum strongly convex transversely. Node circular, as long as broad, fully four times as long as the stalk in front, in profile like node of worker but ventral spine straight. Postpetiole as long as broad, almost three and one-half times broader behind than in front, sides straight to basal third than strongly convex. Gaster fully twice as long as broad. First segment almost one-third broader than long, much broader behind than in front. Genitalia retracted. Legs long and slender. Wings hyaline.

Habitat.—Reevesby Island.

One nest and numerous workers were found. The male was obtained by Mr. Croll at a light late in January. This species is related more closely to *P. urens* Lowne than to any other known species. The workers vary slightly in size and colour. The smallest workers have epinotum and node black; these are red in the majority of workers.

Genus **Eubothroponera** Clark.

Eubothroponera brunnipes sp. n.

(Fig. 3.)

Worker.—Length 5 mm.

Castaneous. Mandibles, antennae and legs brown, posterior margin of node black.

Very finely and densely reticulate throughout, with some shallow obsolete punctures. Node coarsely punctate, more rugose.

Hair reddish, sub-erect and abundant, shorter on scapes and legs. Pubescence greyish, abundant and adpressed throughout.

Head one-sixth longer than broad, sides strongly, occipital border feebly convex, angles rounded. Mandibles triangular, abruptly bent at their bases, anterior edge of masticatory border sharp, edentate on the apical half and four or five obsolete teeth behind. Clypeus strongly convex in all directions. Frontal carinae flat, lobe-like, overhanging the antennal insertions in front. Scapes extend beyond occipital border by fully their thickness, second and third segments of funiculus equal length, one-fourth shorter than first, apical bluntly pointed, twice as long as the preceding. Eyes convex, placed in front of the middle of the sides. Thorax barely twice as long as broad. Pronotum almost one-third broader than long, convex in all directions. Pro-mesonotal suture deeply impressed. Meso-epinotum one-fourth longer than broad, strongly convex transversely, posterior border feebly margined. In profile convex longitudinally, pro-mesonotal suture deeply impressed, pronotum dropping abruptly in front, epinotal declivity at an obtuse angle, sides and top feebly margined. Node almost one-third broader than long, front and sides strongly convex, posterior border sharply margined, feebly concave, with a slight tubercle-like projection in the middle; in profile one-fourth higher than long, anterior face and dorsum convex, posterior face concave, feebly margined, ventral surface concave, with indications of a feeble spine behind. Postpetiole one-fourth broader than long, sides straight, parallel, anterior angles broadly rounded, a deep constriction between postpetiole and gaster. First segment of gaster slightly broader than long, sides convex. Legs short and robust.

Habitat.—Reevesby Island.

Euponera sub-genus **Brachyponera** Emery.

Euponera (Brachyponera) rufonigra Clark.

Euponera (Brachyponera) rufonigra Clark, Mem. Nat. Mus. Vict., Melbourne, viii., p. 30, pl. vi., figs. 12-13, 1934, ☿ ♀.

Several small nests of this species were found throughout Reevesby Island. The nests were never more than 4 inches deep in the soil amongst leaf debris under bushes. No nest contained more than one dozen individuals.

There are no differences on which to separate this from the Western Australian form. It has a wide range along the South-Western coast.

Genus **Acanthoponera** Mayr.

Acanthoponera imbellis Emery

Acanthoponera imbellis Emery, Ann. Soc. Ent. Belg., xxxix., p. 346, 1895, ☿.

Two nests of this species were found, both in rotten tree stumps in the ground, on Reevesby Island. A single worker was found under a stone on Winceby Island. Originally described from Queensland, this species has been recorded previously from Adelaide.

Genus **Chalcoponera** Emery.

Chalcoponera metallica (Smith).

Ponera metallica Smith, Cat. Hymn. Brit. Mus., vi., p. 94, pl. vi., figs. 17, 18, 1858, ☿ ♀.

First recorded from Adelaide, this species is widely distributed throughout Australia. It was abundant on Reevesby Island.

Genus **Rhytidoponera** Mayr.

Rhytidoponera punctata (Smith).

Ectatomma punctata Sm., Cat. Hymn. Brit. Mus., vi., p. 104, 1858, ☿.
Rhytidoponera punctata Clark, Mem. Nat. Mus. Vict., ix., p. 57, pl. 5, fig. 34, 1936, ☿.

Previously known only from Port Lincoln, this species was most abundant on Reevesby Island. The nest is typical of this group, a crater-shaped mound with the entrance covered with leaves and twigs. Several males were obtained from nests. They have not been described previously.

Male.—Length 9–10 mm.

Blackish brown, mandibles, antennae and legs reddish brown. Wings hyaline with a slight brownish tinge.

Mandibles finely and densely reticulate, with some obsolete striae near base. Head and thorax with scattered large shallow punctures, finely and densely reticulate between the punctures. Node and gaster microscopically punctate and with more scattered obsolete punctures.

Hair reddish, sparse, short and erect, longer on apical segments of gaster, very short and adpressed on antennae and legs. No pubescence.

Head as long as broad, strongly arched behind eyes. Mandibles triangular, with numerous fine sharp teeth. Clypeus broad, flatly convex above, sharply convex in front. Frontal carinae as long as broad in front, swerving outward behind. Second and third segments of funiculus equal length, one-fourth longer than scape, first segment one-fourth of length of scape. Eyes placed at middle of sides. Ocelli large. Thorax barely twice as long as broad. Pronotum hardly seen from above. Scutellum slightly broader than long, strongly convex in front and above, mayrian furrows wide and deep in front, obsolete behind, parapsidal furrows sharply impressed. Mesonotum one-fifth broader than long, anterior edge straight, sides and posterior edge convex. Epinotum strongly convex transversely. In profile pronotum short and erect, convex. Scutellum erect in front, convex from apex to base, almost hemispherical. Mesonotum dome-shaped, longer than high. Epinotum convex from base to foot of declivity. Node stalk-like, one-fifth longer than broad behind, sides almost parallel; in profile twice as long as high, slightly higher behind than in front. Postpetiole as long as broad, pear-shaped, sides convex behind, constriction deep and wide. First segment of gaster much broader than long, sides convex. Genitalia retracted. Legs long and slender.

Habitat.—Reevesby Island, Winceby Island.

Sub-family MYRMICINAE Lepel, 1836

Genus **Dacryon** Forel.

DACRYON NITIDA sp. n.

(Fig. 4.)

Worker.—Length 3.5–4.5 mm.

Head, thorax and nodes brown, gaster black, mandibles and antennae yellow.

Shining. Mandibles finely striate longitudinally. Head with five sharp longitudinal striae between antennal grooves. Thorax almost smooth, with some traces of fine longitudinal striae. Node with two longitudinal carinae on top. Postpetiole with six or seven strong longitudinal striae. First segment of gaster finely and densely striate longitudinally at base, remainder of gaster smooth and shining.

Hair yellow, long and erect on head, scapes and apical segments of gaster, very sparse elsewhere. Pubescence grey, very short and adpressed on gaster, longer on funiculi, not apparent on rest of body.

Head slightly longer than broad, sides and occipital border feebly convex, angles rounded. Mandibles triangular, with five or six large sharp teeth. Clypeus convex above and in front, with a feeble indentation in the middle of anterior edge. Antennal grooves deep and wide, edges sharply margined, extending backward almost to occipital border. Scapes not extending to occipital border by fully their thickness. First segment of funiculus as long as the second and third together. Eyes small, placed at middle of sides. Thorax, to end of spines, barely twice as long as broad. Pro-mesonotum as long as broad, sharply margined in front and sides, anterior border convex in middle, angles sharp and projecting, sides convex broader in front than behind, a deep and wide constriction at meso-epinotal suture. Epinotum broader than long, sharply margined on sides, each posterior angle produced in a long sharp spine directed backward, longer than their distance apart at base. In profile pro-mesonotum strongly convex, dome-shaped, borders sharp, with an erect blunt tubercle-like spine on each side marking junction of pronotum and mesonotum. Epinotum flat and straight, declivity straight, as long as dorsum, spines on posterior angles almost as long as dorsum, straight and parallel, directed backward almost level with dorsum. Node with a long broad spine at the middle of each side, directed outward and upward, sharply convex in front, apex turned up, erect, tubercle-like, dorsum flattened, in profile triangular, anterior superior edge forming the apex, dorsum and posterior faces united, straight, as long as anterior face, lateral spines sharp pointed, broad at base, slightly longer than their distance from anterior edge. Ventral spine long and broad, bluntly pointed, directed forward at an acute angle. Postpetiole one-third broader than long, broadest just behind middle. First segment of gaster slightly broader than long, strongly convex, egg-shaped. Legs short and robust. Femora incrassated.

Female.—Length 5 mm. (Deälated.)

Similar to worker but larger and more robust. Sculpture slightly coarser. Wing sclerites fully developed, wing stumps present. Spines on epinotum shorter and stouter.

Male.—Length 3.5 mm.

Black; mandibles, antennae and tarsi yellow, femora and tibiae brown.

Shining. Mandibles finely striate at base. Head with some widely spaced longitudinally striae, densely reticulate between the striae. Thorax and node finely and densely reticulate, coarser on mesonotum. Postpetiole very finely striate longitudinally, base of gaster finely striate longitudinally.

Hair yellow, short and erect, sparse throughout. Pubescence grey, apparent only on gaster.

Head, including mandibles, slightly longer than broad across eyes, strongly convex behind, straight and parallel in front of eyes. Mandibles short, triangular, finely dentate. Clypeus broad, convex above and in front. Frontal area large, triangular. Frontal carinae indicated, antennae with thirteen segments, insertions exposed. Scapes extend to posterior fourth of head, first segment of funiculus twice as long as broad, second segment half as thick and one-third longer than first, first to eighth at least twice as long as broad, increasing in thickness from the ninth to apical, somewhat clavate, apical bluntly pointed, as long as the three preceding together. Eyes hemispherical, protruding, placed in front of the middle of sides. Ocelli small, not prominent. Thorax twice as long as broad. Pronotum hardly seen from above, appearing as a narrow margin to scutellum, strongly convex in front and sides. Scutellum very slightly longer than broad, strongly convex in front, mayrian furrows deep and wide, parapsidal furrows sharply impressed. Mesonotum as long as broad, feebly convex in front, strongly convex transversely. In profile pronotum short and erect, top edge projecting slightly. Scutellum high, dorsum slightly concave in middle, anterior face concave, ending in a short rounded projection at apex below. Mesonotum fully twice as long as high, convex above, overhanging epinotum. Dorsum and declivity of epinotum short and convex. Node as long as broad, hexagonal, dorsum convex, in profile dome-shaped, ventral spine obsolete. Postpetiole almost one-third broader than long, broadly hexagonal, sides angular and broadest at middle, dorsum convex. First segment of gaster as long as broad, sides evenly convex. Legs slender, femora slightly thickened near base. Genitalia retracted.

Habitat.—Reevesby Island.

A large nest of this species was found in a dead tree.

Genus **Crematogaster** Lund.

CREMATOGASTER (ACROCOELIA) LAEVICEPS Smith var. CHASEI Forel.

Crematogaster (Acrocoelia) laeviceps Smith var. *chasei* Forel, Rev. Suisse Zool., x., p. 413, 1902, ☿.

Very abundant in most parts of Reevesby Island. Most of the dead trees contained a nest, with workers, females and males.

Originally described from Perth, Western Australia, it is widely distributed throughout Australia.

Genus **Xiphomyrmex** Forel.

XIPHOMYRMEX FLAVIGASTER sp. n.

(Fig. 5.)

Worker.—Length 3–3.5 mm.

Head, thorax and nodes reddish brown, mandibles, antennae and legs reddish yellow, gaster lighter.

Mandibles finely striate longitudinally. Clypeus smooth and shining. Head longitudinally striate-rugose. Thorax and nodes irregularly rugose. Gaster and legs smooth and shining.

Hair yellow, abundant, long and erect, shorter and sub-erect on antennae and legs. Pubescence not apparent except on antennae.

Head as long as broad, almost circular. Mandibles short, triangular, furnished with four sharp teeth. Clypeus raised, slightly concave in middle above, the concavity bordered at each side by a sharp ridge, anterior edge produced forward, concave in middle, sides straight, angles sharp. Frontal area small, continued backward as a short groove. Frontal carinae short, flattened, as long as broad in front. Scapes barely extend to occipital border. First segment of funiculus as long as second and third together, apical segment as long as the three preceding together. Eyes small, convex, placed at middle of sides. Thorax one-fourth longer than broad, suture not marked. Pro-mesonotum strongly convex in all directions, epinotum short, convex transversely, each posterior angle produced as a long slender, sharp spine, directed backward and slightly outward, twice as long as their distance apart at base, two shorter and thicker spines at bottom of declivity. In profile strongly convex from apex to base of epinotal spines, declivity vertical, short, dorsal spines slender, twice as long as spines at bottom. Node slightly broader than long, convex in all directions; in profile dome-shaped, slightly longer than stalk in front, ventral surface concave in middle. Postpetiole barely twice as broad as long, ovate, dorsum convex. First segment of gaster as long as broad, sides strongly convex. Legs slender.

Habitat.—Reevesby Island.

Small nests at roots of small shrubs.

Genus **Meranoplus** Smith.

Meranoplus excavatus sp. n.

(Fig. 6.)

Worker.—Length 2.5–3 mm.

Reddish yellow, mandibles, antennae and legs lighter yellow.

Head, thorax, node and postpetiole coarsely and densely punctate, thimble-like, punctures shining at bottom. Mandibles finely striate longitudinally. Gaster very finely and densely reticulate, with some large scattered punctures.

Hair yellow, erect, short, abundant throughout. No pubescence.

Head as long as broad, occipital border and sides convex, angles rounded. Mandibles triangular, furnished with small sharp teeth. Clypeus broad, overhanging mandibles, widely and deeply excavated in front. Frontal carinae straight and parallel, widely separated, forming a strong ridge to antennal scrobe, the latter deep, extending to occipital border. Scapes extend slightly beyond posterior margin of eye, subclavate. First segment of funiculus as long as second and third together, apical segment bluntly pointed as long as three preceding together. Eyes convex, placed at posterior third of sides. Thorax slightly broader than long, sutures not indicated. Pronotum convex in front, anterior angles sharply produced, directed outward and forward. Sides of pronotal region straight, much broader in front than behind, basal half of sides fringed with a translucent membrane, this membrane occupies a large cavity at the place of the pro-mesonotal suture, at the place of the meso-epinotal suture is another large cavity also filled by a transparent membrane; between these cavities is a broad plate-like projection with a sharp point directed forward. Posterior angles of epinotum spine-like, rather long and pointed, between the outer spines are two short tubercle-like projections At the middle of epinotal declivity at each side is a long slender sharp spine directed backward and slightly outward, extending to posterior face of node; in profile strongly convex above, pronotal spine sharp, directed forward and upward, epinotal spine shorter and thicker, sharp pointed, directed backward, epinotal declivity straight, at an obtuse angle, lateral spines slender, directed straight backward. Node three times broader than long, anterior border straight or feebly concave, posterior strongly convex; in profile triangular, the apex, or dorsum, sharp pointed, anterior face feebly concave, posterior face convex, a blunt spine directed forward on ventral surface. Postpetiole as long as broad, feebly convex in front, strongly convex behind and on sides; in profile dome-shaped. Gaster pear-shaped, one-sixth longer than broad, concave in front. First segment as long as broad, sides strongly convex. Legs short and stout.

Habitat.—Reevesby Island.

Several workers were found amongst leaf debris under shrubs. No nest was found.

Genus **Podomyrma** Smith.

PODOMYRMA ADELAIDAE (Smith).

Myrmica adelaidae Smith, Cat. Hymn. Brit. Mus., vi., p. 128, 1858, ☿.

Two workers were found on the Eucalypts at the north end of Reevesby Island. This species is widely distributed in Australia.

Genus **Monomorium** Mayr.

MONOMORIUM (NOTOMYRMEX) RUBRICEPS Mayr var. RUBA Forel.

Monomorium (Notomyrmex) rubriceps Mayr var. *rubra* Forel, Arkiv. f. Zool., 9, 16, p. 72, note, 1915, ☿.

A small nest was found in a rotten log on Reevesby Island. Originally described from New South Wales, this form has a wide distribution in southern Australia.

MONOMORIUM (NOTOMYRMEX) INSULARIS sp. n.

(Fig. 7.)

Worker.—Length 3–3.8 mm.

Reddish yellow throughout, apical margins of segments of gaster darker.

Smooth and shining. Mandibles and head with numerous small shallow punctures. Sides only of mesonotum and epinotum rugose, finely on top more coarsely below.

Hair yellow, erect, long and abundant on body, shorter and sub-erect on antennae and legs.

Head one-fifth longer than broad, sides and occipital border convex, angles strongly rounded. Mandibles furnished with five large sharp teeth. Clypeus bicarinate above, flattened between carinae, strongly produced in front, sides and front straight. Frontal carinae short, diverging outward behind. Scapes not extending to occipital border by fully their thickness. First segment of funiculus as long as second, third and fourth combined, apical segment as long as the three preceding together. Eyes placed slightly in front of middle of sides. Thorax twice as long as broad, meso-epinotal suture feebly defined. Pronotal area strongly convex in all directions, meso-epinotal area constricted. Epinotum very slightly longer than broad, posterior edge and angles sharp. In profile dorsum straight, meso-epinotal suture feebly impressed, pro-mesonotal suture indicated. Pronotum erect and strongly convex. Epinotal declivity at an obtuse angle, sub-bordered. Node oval, twice as broad as long, convex in all directions, in profile bluntly cone-shaped, higher than long, anterior face convex above, concave below, stalk slender. Postpetiole one-third broader than long, slightly broader in front than behind, convex in all directions, in profile dome-shaped. Gaster one-third longer than broad. First segment one-sixth broader than long, twice as broad behind as in front, sides convex. Legs long and slender.

Female.—Length 4.5 mm.

Colour and pilosity as in worker, sculpture slightly coarser.

Head broader, eyes larger, ocelli large and prominent. Scutellum large, convex, parapsidal furrows feebly indicated. Epinotum slightly concave in middle behind, transversely striate, angles sharp. Nodes similar; gaster larger.

Habitat.—Reevesby Island.

A small nest in ground under a small shrub.

Monomorium (Notomyrmex) flavipes sp. n.

(Fig. 8.)

Worker.—Length 2.5–3 mm.

Head, thorax and gaster dark yellow, antennae, nodes and legs pale yellow.

Smooth and shining, some fine scattered piligerous punctures throughout, sides of mesonotum and epinotum reticulate.

Hair yellow, erect, long, abundant on gaster, sparse on head and thorax, short and sub-erect on antennae and legs.

Head one-fifth longer than broad, as broad in front as behind, sides evenly convex, occipital border straight or feebly concave, angles sharply rounded. Mandibles with five strong sharp teeth.

Clypeus convex above, with two sharp central carinae, anterior border sharply convex in middle. Frontal carinae straight, parallel. Scapes not extending to occipital border by their thickness. First segment of funiculus as long as four following combined, apical not as long as two preceding combined. Eyes small, placed in front of the middle of sides. Thorax twice as long as broad, meso-epinotal suture sharply impressed. Promesonotum one-fourth longer than broad, sides and front strongly convex, constricted at mesonotum, dorsum convex transversely. Epinotum longer than broad, convex transversely; in profile pronotum high, strongly convex in front, dorsum straight with a slight excision at meso-epinotal suture, epinotal declivity at an acute angle, half as long as dorsum, superior border sharply rounded. Node twice as broad as long, anterior and posterior edges straight, sides convex, in profile high and slender, longer than stalk in front, anterior face straight, dropping at an acute angle. Postpetiole twice as broad as long, convex in all directions; in profile hemispherical. First segment of gaster as long as broad, much broader behind than in front, sides convex. Legs robust.

Female.—Length 3.3 mm. (Deälated.)

Similar to worker but slightly larger and more robust. Colour darker. Sculpture on sides and epinotum coarser. Hairs longer and more abundant.

Habitat.—Reevesby Island.

A small nest was found under a stone at the north end of the island.

Genus **Solenopsis** Westwood.

Solenopsis insculptus sp. n.

(Fig. 9.)

Worker.—Length 1–1.3 mm.

Pale yellow throughout, apex of mandibles darker.

Smooth and shining, with some fine scattered piligerous punctures, more numerous on head than elsewhere.

Hair yellow, long and erect, particularly on clypeus and apical segments of gaster, shorter and sub-erect on antennae and legs.

Head one-fifth longer than broad, sides convex, occipital border straight, angles rounded. Mandibles furnished with four large sharp teeth, all about equal in size. Clypeus strongly projecting and excised in front, the dorsal carinae terminating as spine-like projections at each side of excision. Frontal area small. Frontal carinae narrow. Scapes not extending to occipital border by one-third of their length. First segment of funiculus as long as the five following combined, the two apical segments one and one-half times longer than rest of funiculus. Eyes small, slightly in front of anterior fourth of sides. Thorax one and three-quarter times longer than broad, meso-epinotal suture sharply impressed. Pro-mesonotum as long as broad, strongly convex in all directions; constricted at meso-epinotal suture; epinotum slightly longer than broad, convex transversely, in profile dorsum straight, meso-epinotal suture sharply impressed. Pronotum high and convex in front, epinotum evenly convex from base to bottom of declivity. Node one and one-half times broader than long, oval; in profile higher than long, anterior face straight, sloping forward below at an obtuse angle, dorsum bluntly pointed in front, convex and merged into declivity behind, ventral surface convex. Postpetiole one-fifth broader than long, convex in all directions; in profile dome-shaped. First segment of gaster as long as broad behind, strongly convex in front, feebly on sides. Legs short and stout.

Habitat.—Reevesby Island.

A small nest was found in the galleries of a termite (*Calotermes condonensis* Hill) in a dead tree. Near *S. clarki* Crawley from Western Australia, but is distinguished by the form of the thorax and nodes.

Genus **Pheidole** Westwood.

Pheidole pyriformis sp. n.

(Figs. 10-11.)

Worker major.—Length 4.2 mm.

Mandibles, head and legs brownish red, mandibles edged with black, thorax and nodes brown, gaster black, funiculi and tibiae yellowish red.

Mandibles smooth and shining, finely punctate. Head finely striate longitudinally in front, smooth and shining behind, from frontal carinae to occipital border, with some fine shallow scattered punctures. Pro-mesonotum densely reticulate, some obsolete rugae in middle. Epinotum more coarsely reticulate. Sides of thorax reticulate as on epinotum, more rugose on epinotum. Nodes very finely and densely reticulate.

Hair yellow, erect, long and abundant throughout, shorter and sub-erect on antennae and legs.

Head very slightly longer than broad, anterior half of sides straight and parallel, anterior angles sharp, posterior half convex, narrowing behind, occipital border deeply indented in middle giving the border a bilobed appearance, both lobes strongly convex. Mandibles massive, coarsely and irregularly dentate.

Clypeus short, raised and bicarinate in middle, concave between carinae, anterior edge almost straight, with a sharp projection at end of each carina, concave between projections. Frontal area large and deep, triangular. Frontal carinae not raised, widely diverging behind. Scapes extend beyond middle of head by almost their thickness. First segment of funiculus longer than the four following combined, apical as long as three preceding segments combined. Eyes very small, convex, their posterior edge placed at anterior third of sides. Thorax one and three-quarter times longer than broad, pronotum one-fourth broader than long, strongly convex, broadest behind. Mesonotum small and circular, very slightly broader than long. Epinotum one-fourth broader than long, concave in middle, ending at each side in a long sharp spine; in profile pro-mesonotum high, hemispherical, sutures not indicated, a slight tubercle-like projection near end of mesonotum. Meso-epinotal suture sharply impressed. Epinotum slightly convex, spines slender and sharp, directed upward and slightly backward, twice as long as their width at base, declivity abrupt, straight, as long as dorsum. Node twice as broad as long, anterior and posterior faces convex, dorsum concave transversely, the angles bluntly pointed; in profile bluntly pointed above, anterior face twice as long as posterior face. Post-petiole two and one-half times as broad as long, anterior and posterior faces convex, sides and dorsum bluntly pointed; in profile bluntly pointed above, both faces convex. First segment of gaster one-fourth broader than long, strongly convex above. Legs short and stout.

Worker minor.—Length 2.2–2.5 mm.

Colour and pilosity as in major worker, but mandibles yellow.

Mandibles finely striate near apex. Head shining, finely reticulate on cheeks and clypeus, a few short striae on cheeks. Pro-mesonotum smooth and shining. Epinotum and node finely and densely reticulate-punctate on top and sides.

Head as long as broad, occipital border concave in middle sides convex, angles broadly rounded. Mandibles furnished with two large sharp teeth in front, five or six small obsolete teeth behind. Clypeus short, truncate, very slightly produced in front. Frontal area triangular, large and deep. Scapes extend to occipital border. Eyes placed in front of middle of sides. Thorax twice as long as broad. Pro-mesonotum one-fifth longer than broad, pear-shaped, strongly constricted at mesonotum, convex in all directions. Epinotum sub-bordered, flat transversely. Spines directed more backward. Node straight, or very feebly concave, on top. Legs longer and more slender. Remainder as in major.

Habitat.—Reevesby Island (many nests), Winceby Island (one nest), and English Island (one specimen).

Sub-family DOLICHODERINAE Forel, 1878.

Genus **Iridomyrmex** Mayr.

IRIDOMYRMEX DETECTUS (Smith).

Formica detecta Sm., Cat. Hymn. Brit. Mus., vi., p. 36, 1858, ♀.
Formica purpurea Sm., l. c., p. 40, ☿.

Commonly known as the "Meat ant", this is the most abundant and widely distributed ant in Australia.

IRIDOMYRMEX DETECTUS Sm. var. VIRIDIAENUS Viehmeyer.

Iridomyrex detectus Sm. var. *viridiaeneus* Viehmeyer, Arch. f. Naturg., 79, 12, p. 41, 1913, ☿.

The colour of this variety is deep metallic blue on the head, thorax and legs, the gaster brassy-green, in many examples the colour is violet, while some have the colour of the typical *I. detectus* Sm. This ant is common in the dry interior of Australia. Several nests were found on Reevesby Island. The nests are inconspicuous and are indicated by very small holes without a mound.

IRIDOMYRMEX PUNCTATISSIMA Emery.

Iridomyrmex punctatissima Emery, Ann. Mus. Stor. Nat. Genova, xxiv., p. 251, 1887, ☿.

Many small nests were found under loose bark on dead trees on Reevesby Island, one example was found on English Island. Widely distributed in Southern Australia.

IRIDOMYRMEX BICKNELLI Em.

Iridomyrmex bicknelli Emery, Rend. Accad. Sc. Bologna, p. 236, figs 6-7, 1897-8, ☿.

Abundant on Reevesby Island, this species nests in the ground. The workers run about rapidly during the heat of the day. This ant was recorded first from Tasmania, but is widely distributed throughout Australia.

IRIDOMYRMEX MATTIROLI Em. var. CONTINENTIS Forel.

Iridomyrmex mattiroli Emery var. *continentis* Forel, Fauna Sudwest Austral, i., p. 290, 1907, ☿ ♀ ♂.

Several small nests of this common Western Australian ant were found on Reevesby and Winceby Islands. The nest is in the ground and surmounted by a small crater-shaped mound about 1-inch high.

IRIDOMYRMEX DROMUS sp. n.

(Fig. 12.)

Worker.—Length 3.3 mm.

Pale yellow, head and gaster darker.

Very finely and densely reticulate throughout.

Hair yellow, short and sparse, longer and more abundant on apical segments of gaster. Pubescence abundant, yellow, very short and adpressed.

Head slightly longer than broad, much broader behind than in front, occipital border straight or feebly convex, sides strongly convex, angles broadly rounded. Mandibles broad, two and one-half times shorter than head, apical border furnished with five large sharp teeth, directed backward, and some fine denticles between the teeth, inner border finely denticulate. Clypeus convex both ways, anterior border straight, angles sharp. Frontal area large and shallow, triangular. Frontal carinae short and parallel, antennal insertions exposed. Scapes extend beyond occipital border by almost one-third their length. First segment of funiculus one-fourth longer than second, others sub-equal, apical as long as the two preceding combined. Eyes large, rather flatly convex, placed at middle, more on front than on sides. Thorax two and one-half times as long as broad. Pronotum one-fifth broader than long, front, sides and dorsum convex. Mesonotal suture sharply impressed. Mesonotum as long as broad, convex in all directions, broader in front than behind. Meso-epinotal suture deep and wide, spiracles prominent, placed on dorsum. Epinotum as long as broad, strongly convex transversely; in profile pro-mesonotum strongly convex, almost hemispherical, highest at suture. Dorsum and declivity of epinotum combined in a strong convexity. Node slender, fully twice as broad as long, convex on all sides, bluntly pointed; in profile higher than long, bluntly pointed above, anterior face convex, posterior face concave, stalk behind joined to gaster almost at ventral surface. Gaster one and two-thirds times longer than broad, all segments broader than long. Legs very long and slender.

Habitat.—Reevesby Island.

Nests of this species are abundant on the sand-dunes.

Genus **Bothriomyrmex** Emery.

BOTHRIOMYRMEX PUSILLUS (Mayr).

? *Tapinoma pusillum* Mayr, Jour. Mus. Godeff., xii., p. 83, 1876, ☿ ♀ ♂

One small nest, containing the queen and several workers, was found in a dead tree stump on Reevesby Island.

Sub-family FORMICINAE Lepeletier, 1836.

Genus **Melophorus** Lubbock.

MELOPHORUS TURNERI Forel s. sp. AESOPUS Forel.

Melophorus turneri Forel s. sp. *aesopus* Forel, Rev. Suisse Zool., xviii., p. 64, 1910, ☿ ♀ ♂.

Many nests of this form were found in all parts of Reevesby Island.

Genus **Notoncus** Emery.

NOTONCUS ECTATOMMOIDES (Forel).

Camponotus cstatommoides Forel, Mitth. Schwiez. Ent. Ges., viii., p. 333, 1892, ☿.

Notoncus ectatommoides Emery, Ann. Soc. Ent. Belg., xxxix., p. 353, 1895, ☿.

No nest was found but many examples were found amongst leaf debris under shrubs on Reevesby Island.

Genus **Stigmacros** Forel.

STIGMACROS AEMULA Forel.

Acantholepis (Stigmacros) aemula Forel, Fauna Sudwest Austral, i., p. 298, 1907, ☿.

Several workers were found amongst leaf debris on Reevesby Island. This species is a common coastal form in Western Australia.

STIGMACROS FLAVINODIS sp. n.

(Fig. 13.)

Worker.—Length 2–2.3 mm.

Head, thorax, gaster and anterior coxae black, mandibles antennae, node and legs yellow.

Shining. Head, mandibles and gaster very finely punctate. Thorax very finely and densely reticulate, anterior face of node finely reticulate.

Hair yellow, long, very sparse, confined to clypeus and apical segments of gaster. Pubescence yellow, very short, fine and adpressed throughout.

Head as long as broad, occipital border feebly, sides strongly convex, angles rounded. Mandibles furnished with six large sharp teeth. Clypeus convex above, short, anterior border straight at middle. Frontal area feebly defined, triangular. Frontal carinae short and parallel, antennal insertions exposed. Scapes extend beyond occipital border by their thickness. First segment of funiculus as long as the two following combined, apical as long or longer than the two preceding combined. Eyes large and convex, placed at middle of sides. Thorax one-third longer than broad, sutures sharply impressed. Pronotum fully twice as broad as long, sides and front feebly convex, angles broadly rounded. Mesonotum one-fourth broader than long, almost twice as broad in front as behind, sides and front convex, posterior border straight, meso-epinotal suture wide and very deep. Epinotum twice as broad as long, broadest behind, sides feebly convex, posterior border feebly concave; in profile feebly convex, superior border margined, pro-mesonotal suture sharply impressed, meso-epinotal suture very deep and wide, twice as deep as wide, wedge-shaped. Pronotum dropping abruptly in front, concave, dorsum convex. Mesonotum feebly convex, truncate behind, three times longer than the truncate face behind, posterior angle sharply rounded. Epinotum straight, one-third shorter than declivity, the spine as long as broad at base, posterior border of dorsum bluntly rounded, anterior face dropping at an acute angle, straight. Node scale-like, broad, convex in front, concave behind, the angles feebly produced backward, in profile slender, anterior face convex, posterior face concave, dorsum sharp, midway between base and apex at each side is a small blunt spine. Gaster one-third longer than broad strongly convex. Legs short and robust.

Habitat.—Reevesby Island.

Several specimens were found amongst dead leaves.

Genus **Camponotus** Mayr.

Camponotus (Myrmophyma) chalceoides sp. n.

(Figs. 14-16.)

Worker major.—Length 9.3–9.7 mm.

Head, thorax and node metallic bronze-black, gaster irridescent bronze with the anterior and apical margins of segments metallic green, femora and tibiae brownish black, tarsi reddish brown. On several specimens the epinotum more or less red.

Mandibles coarsely striate-rugose and punctate, whole body finely and very densely reticulate throughout except on legs, scapes and legs shining, finely punctate.

Hair yellow, erect, short and abundant throughout, some extra long hairs on clypeus. Pubescence not apparent.

Head as long as broad, occipital border straight, sides convex, angles broadly rounded. Mandibles furnished with four long, broad sharp teeth. Clypeus flatly convex above, strongly projecting in front, convex, with a short deep concave excision in middle.

Frontal area triangular, feebly defined. Frontal carinae as long as broad behind, much broader behind than in front, a fine longitudinal groove between them. Scapes extend beyond occipital border by one-fifth their length. First segment of funiculus one-fifth longer than second, remainder sub-equal, apical as long as the two preceding combined. Eyes small, rather flat, their anterior edge behind the middle of sides. Anterior ocellus very small, placed in a large puncture, posterior ocelli lacking. Thorax barely twice as long as broad, sutures sharply impressed. Pronotum two and one-half times broader than long, sides, front and top strongly convex, concave behind. Mesonotum slightly broader than long, almost circular, strongly convex in all directions. Spiracles prominent. Epinotum slightly longer than broad, strongly convex transversely; in profile pronotum strongly convex from apex to base. Mesonotum feebly convex, highest in front. Epinotum feebly concave in middle one and one-half times longer than declivity into which it is rounded. Node fully twice as broad as long, bluntly pointed above, sides and anterior face convex, posterior face straight; in profile twice as high as long, anterior and posterior faces convex, bluntly pointed above. Gaster longer than broad. First segment twice as broad as long, strongly convex in front, almost hemispherical. Legs long and slender.

Worker media.—Length 7.5–8 mm.

Colour, sculpture and pilosity as in the major, with the epinotum more often rose-red.

Head one-fifth longer than broad, sides almost parallel. Scapes extend beyond occipital border by one-third their length. Epinotum, in profile, much more concave, and lower than mesonotum. Node thicker, more rounded on top.

Worker minor.—Length 6.5–7 mm.

Colour, sculpture and pilosity as in the major, epinotum red.

Head one-fifth longer than broad, strongly convex behind eyes, sides convex. Scapes extend beyond occipital border by half their length, epinotum more concave than in major and media, and node thicker, convex on top.

Habitat.—Reevesby Island.

South Australia: Port Lincoln, Kyancutta.

Western Australia: Balladonia.

Several nests were found in rotten trees on Reevesby Island. Many single examples of the worker minor have been received in the past from the other localities. This species is more highly coloured than *Camponotus chalceus* Crawley from Western Australia, but has a slight resemblance.

CAMPONOTUS (MYRMOPHYMA) CERISEIPES sp. n.

(Figs. 17-19.)

Worker.—Length 12 mm.

Mandibles and head dark brown, with some lighter and darker tints. Thorax reddish brown, tinged darker in places. Scapes, node and gaster black, femora reddish yellow, tibiae and tarsi brown. Apical half of mandibles coarsely striate-rugose, smooth and punctate at base. Remainder of body very finely and densely reticulate, with fine shallow scattered punctures.

Hair yellow, long and erect on mandibles, clypeus and gaster, sparse elsewhere. Pubescence short and adpressed, apparent only on legs.

Head one-seventh broader than long, occipital border straight, sides strongly convex, angles rounded. Mandibles furnished with six large sharp teeth. Clypeus convex above and in front, subcarinate, anterior edge feebly crenulate. Frontal area triangular, small and shallow. Frontal carinae as long as broad behind, twice as broad behind as in front. Scapes extend beyond occipital border by almost one-fourth their length. First and third segments of funiculus equal in length, slightly longer than second, apical segment twice as long as the preceding. Eyes rather small and flatly convex. Only anterior ocellus present, very small, situated in a rather deep pit. Thorax one and one-half times longer than broad. Pro-mesonotal suture deeply impressed, meso-epinotal suture wide and shallow. Pronotum fully twice as broad as long, sides strongly convex. Mesonotum very slightly broader than long, circular, dorsum strongly convex all ways. Epinotum convex transversely, as long as broad; in profile pronotum and mesonotum convex, excised at suture, epinotum straight in front, rounded into declivity behind, declivity feebly concave, as long as dorsum. Node slender, scale-like, convex in front, straight behind; in profile twice as high as long, sharply pointed, anterior face convex, posterior face straight. Gaster one and one-half times longer than broad. First segment twice as broad as long, strongly convex in front. Legs long and stout.

Worker media.—Length 9.5–10 mm.

Black, femora light yellowish red, funiculi brown.

Sculpture and pilosity as in worker major.

Head very slightly broader than long, occipital border slightly convex. Scapes extend beyond occipital border by almost one-fourth their length. In profile the epinotum lower and node much thicker than in worker major.

Worker minor.—Length 7–7.5 mm.

Colour, sculpture and pilosity as in worker media.

Head one-seventh longer than broad, strongly convex behind eyes. Scapes extend beyond occipital border by almost half their length, thorax one and three-quarter times longer than broad; in profile mesonotum higher in front and more convex. Node thicker, as long as high, parallel, dorsum rounded.

Habitat.—Reevesby Island

A small nest was found in the ground at the north end of the island.

CAMPONOTUS (TANAEMYRMEX) MYOPORUS sp. n.

(Figs. 20-22.)

Worker major.—Length 8–9 mm.

Mandibles, front of head, scapes and gaster black; occiput, thorax and node brown, funiculi and all legs yellow.

Mandibles finely striate near apex, shining at base, remainder of body very finely and densely reticulate with scattered small shallow punctures.

Hair yellow, long and erect, rather scattered on thorax and gaster, very short and sub-erect on antennae and legs. Pubescence very fine and adpressed throughout.

Head a fraction broader than long, occipital border feebly, sides strongly convex, angles rounded. Mandibles with five or six large sharp teeth. Clypeus flatly convex above, strongly projecting in front, anterior border straight, fully half the width of clypeus, angles sharp. Frontal area triangular, small and shallow. Frontal ridges one-fourth longer than broad behind, a faint longitudinal groove in middle. Scapes extend beyond occipital border by almost one-fourth their length, first and third segments of funiculus equal in length, one-sixth longer than second, apical very slightly longer than preceding segment. Eyes large, rather flatly convex. Thorax almost twice as long as broad, promesonotal suture sharply and deeply impressed, meso-epinotal suture feebly impressed. Pronotum one and three-quarter times broader than long, strongly convex in front and on sides. Mesonotum very slightly broader than long, convex in all directions. Epinotum slightly longer than broad, convex transversely; in profile evenly convex longitudinally, sutures sharply defined, epinotal declivity barely as long as dorsum into which it is broadly rounded. Node twice as broad as long, oval, sharply pointed above; in profile barely twice as high as long, anterior and posterior faces convex, sharp pointed on top. Gaster one-fifth longer than broad. First segment three times broader than long, strongly convex in front. Legs long and stout.

Worker media.—Length 6.5–7 mm.

Mandibles and gaster black, head and scapes brown, thorax, funiculi and node reddish yellow, legs yellow.

Sculpture and pilosity as in worker major.

Head as long as broad, occipital border and sides convex, angles broadly rounded. Mandibles with six large sharp teeth, decreasing in size towards base. Clypeus convex above, projecting and sharply convex in front, bluntly pointed. Frontal area large and shallow, triangular. Scapes extend beyond occipital border by one-third their length, funiculus as in major worker. Eyes more convex, placed far back, almost their diameter from occipital border. Thorax twice as long as broad, strongly constricted at meso-epinotal junction; in profile like major worker, but epinotal declivity shorter. Node and gaster similar. Legs more slender.

Worker minor.—Length 4.5–5 mm.

Colour, sculpture and pilosity as in worker media.

Head one-sixth longer than broad, strongly convex behind eyes, feebly convex in front. Scapes extend beyond occipital border by almost half their length. Thorax fully twice as long as broad; in profile pronotum feebly convex. Mesonotum high and convex in front, forming a straight edge with epinotum behind, declivity short, strongly rounded into dorsum. Node one-fourth broader than long, oval, top edge sharp, transversely convex; in profile higher than long, bluntly pointed above. Gaster and legs as in worker media.

Habitat.—Reevesby Island.

A small nest was found in a dead limb of the "Native juniper" or "boobialla" (*Myoporum insulare* R. Br.).

Camponotus (Colobopsis) mutilatus (Smith).

Formica mutilata Sm., Jour. Linn. Soc., Lond., iii., p. 137, 1858, ☿.

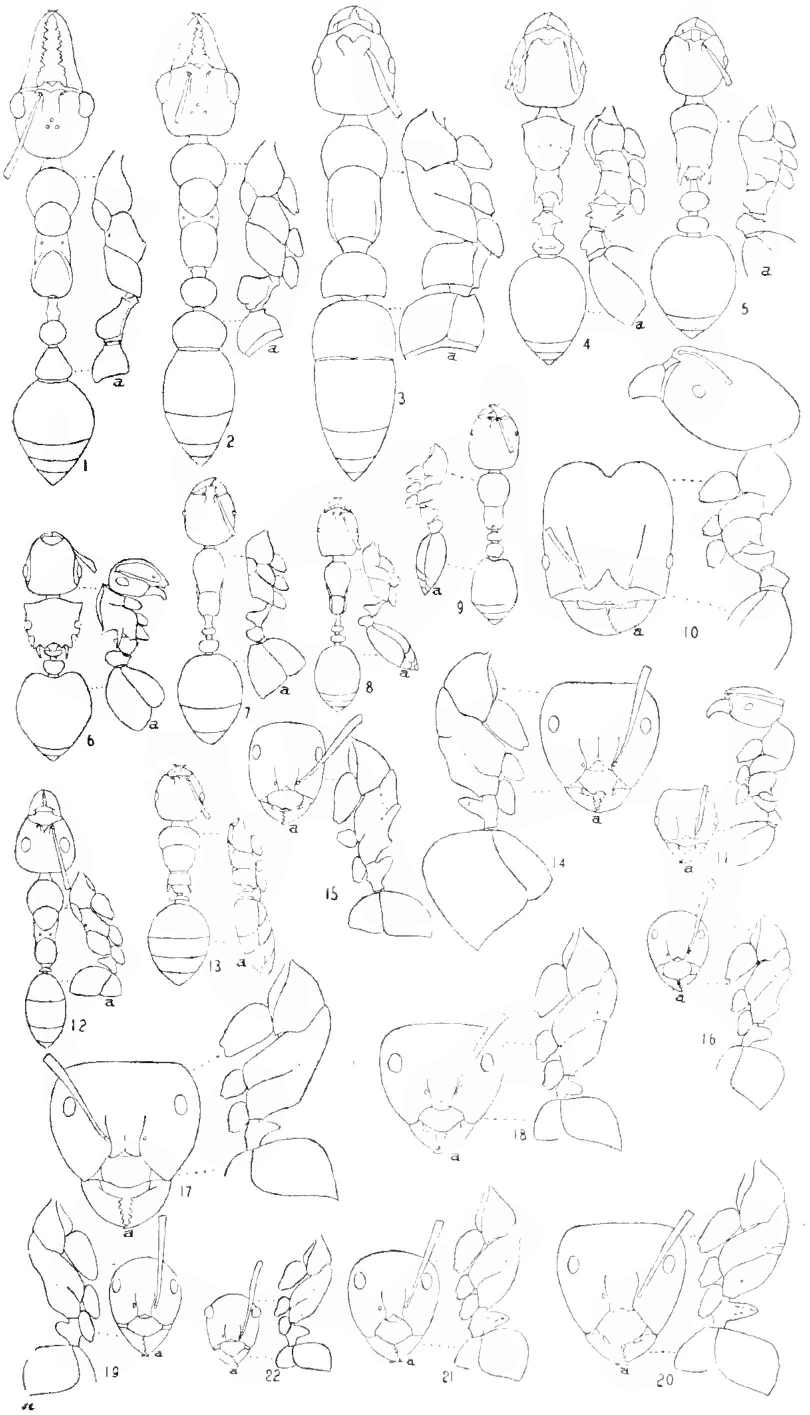
Many major and minor workers were taken from a nest in a small tree near the camp.

Genus **Polyrhachis** Shuckard.

Polyrhachis (Campomyrma) sidnica Mayr.

Polyrhachis (Campomyrma) sidnica Mayr, Verh. Zool. bot. Ges. Wien., xvi., p. 886, 1866, ☿ ♀.

Three nests of this widely distributed species were found on Reevesby Island.



Figs. 1–20.

Explanation of Figures.

1. *Myrmecia gracilis* Emery. Worker. a. Side view.
2. *Myrmecia (Promyrmecia) dichospila* sp. n. Worker. a. Side view.
3. *Eubothroponera brunnipes* sp. n. Worker.
4. *Dacryon nitida* sp. n. Worker.
5. *Xiphomyrmex flavigaster* sp. n. Worker.
6. *Meranoplus excavatus* sp. n. Worker.
7. *Monomorium (Notomyrmex) insularis* sp. n. Worker.
8. *Monomorium (Notomyrmex) flavipes* sp. n. Worker.
9. *Solenopsis insculptus* sp. n. Worker.
10. *Pheidole pyriformis* sp. n. Worker major.
11. *Pheidole pyriformis* sp. n. Worker minor.
12. *Iridomyrmex dromus* sp. n. Worker.
13. *Stigmacros flavinodis* sp. n. Worker.
14. *Camponotus (Myrmophyma) chalceoides* sp. n. Worker major.
15. *Camponotus (Myrmophyma) chalceoides* sp. n. Worker media.
16. *Camponotus (Myrmophyma) chalceoides* sp. n. Worker minor.
17. *Camponotus (Myrmophyma) ceriseipes* sp. n. Worker major.
18. *Camponotus (Myrmophyma) ceriseipes* sp. n. Worker media.
19. *Camponotus (Myrmophyma) ceriseipes* sp. n. Worker minor.
20. *Camponotus (Tanaemyrmex) myoporus* sp. n. Worker major.
21. *Camponotus (Tanaemyrmex) myoporus* sp. n. Worker media.
22. *Camponotus (Tanaemyrmex) myoporus* sp. n. Worker minor.

11. *Reptilia, Part 1: General.*

By J. A. TUBB, M.Sc.

Representatives of the twelve species described and figured were found on Reevesby Island, which was the most intensively surveyed of the Group, and it is probable that many of these forms, notably the smaller skinks, will be found on the other Islands.

Correlated with the habitat, all forms except the Black Tiger Snake (*Notechis scutatus* var. *niger* Kinghorn) are grey or brown, with lighter markings. Also, species with the limbs reduced or absent form an important part of the population. Well developed limbs occur in *Sphenomorphus australis* (Gray), three of the four species of *Ablepharus* and in *Phyllodactylus marmoratus* (Gray), the former are active non-burrowing species and the Gecko is a typical climbing form. The conspicuous coloration and abundance of *Notechis* may be attributed to the absence of natural enemies, except possibly the *Varanus.*

Only the most significant references are given, and the measurements of all species are expressed in millimetres.

OPHIDIA.

Family: COLUBRIDAE.

Subfamily: ELAPINAE.

Genus **Notechis**

NOTECHIS SCUTATUS var. NIGER Kinghorn, 1921.

(Fig. 1, *a-d.*)

Notechis scutatus var. *niger* Kinghorn, 1921, Rec. Aust. Mus. Sydney, xiii., p. 145, pl. xxvi.

Eye as long or little shorter than distance from mouth in adult, larger in young. Rostral broader than deep, portion visible from above less than half as long as distance from frontal; frontal as long as, or slightly longer than, broad, once and one half to twice as broad as supraocular, as long as it's distance from rostral, half to two-thirds as long as parietals; nasals in contact with single pre-ocular; two post-oculars; temporals usually 2 plus 2, lower anterior very large, wedged between fifth and sixth upper labials, sometimes reaches lip; six upper labials, third and fourth entering orbit; three lower labials in contact with anterior chin shields; anterior chin shields as long as or little shorter than posterior. Scales in 17-21 rows; ventrals 163-173; anal entire; subcaudals 48-54.

Dorsum shining black; venter dark grey, occasionally with light grey or white markings on the neck and lips. Young forms sometimes show traces of transverse bands, the bands appear as narrow light grey lines. Transverse bands are visible in some adults when preserved in spirit.

Specimen.	Length.	Tail.	Ventrals.	Subcaudals.	Rows.	Upper Labials.
A	1,232	215	172	54	18–21	6
B	654	107	163	48	17	6
C	632	94	166	49	17–18	6
D	1,131	160	173	50	17–18	6
*E	..	..	..	..	..	5
†F	..	..	..	..	..	6
†G	..	..	..	..	..	6

* Lower anterior temporal fused with sixth upper labial on each side, almost complete fusion on left, distinct cleft on right, parietals and anterior nuchals much distorted. (Fig. 1 *a-b*).

† Head only.

The specimens agree closely with the observations of Kellaway and Thomson (1932, Aust. J. Exp. Biol., x., pp. 35-46, figs. 1-16) on melanotic Tiger Snakes from Chappell Island.

Specimen B corresponds almost exactly with Kinghorn's redescription of *Notechis ater* Krefft, but possesses six upper labials on each side. Also, in this specimen, the anterior and posterior chin shields are of equal length, although in the other snakes examined the posterior shields are the longer. These facts support the suggestion of Kellaway and Thomson (1932, *loc. cit.*) that *N. ater* Krefft should be relegated to the synonymy of *N. scutatus* var. *niger* Kinghorn. The observations of Kellaway and Williams (1935, Aust. J. Exp. Biol. xiii., pp. 17-21) support the elevation of the melanotic form to varietal but not to specific rank, since the "venoms are too nearly alike antigenically to support the erection of a new species."

N. scutatus var. *niger* Kinghorn was observed on Reevesby and Roxby Islands, and was reported to occur on Marum, Partney, and Lusby Islands. Mr. Scrubby, lessee of Spilsby Island, reported that "Black Snakes" had been plentiful on that island, but had been completely exterminated by "Goannas" (*Varanus* sp.) which he had introduced from the mainland.

The black Tiger Snakes were shy and generally sluggish in their movements. They were usually found basking under the edges of thick bushes. One case was noted in which the snake was resting on top of a leafy shrub, and several of these reptiles were observed climbing through the branches of dead bushes.

When alarmed, the snakes flatten the neck, giving a cobra-like appearance. This flattening may occur when the reptile is coiled or when it is moving slowly along. In the latter case, the anterior one-third to one-quarter of the body is raised above the ground and the head moved slowly from side to side. The strike is very rapid, and the bite usually of short duration. In a few instances, when under provocation, the snake was observed to bite and chew the object struck. The food of these snakes appears to consist largely of birds, and the stomachs of specimens from the south end of Reevesby Island invariably yielded traces of one or more Storm Petrels (*Pelagodroma marina*). Specimens from the south end of the island were consistently larger and in better condition than those from the centre and north of the island.

Acanthophis antarcticus (Shaw, 1794).

The Death Adder was reported to occur on Reevesby Island but was not observed by the Expedition.

LACERTILIA.

Family: GECKONIDAE.

Genus **Phyllodactylus**

Phyllodactylus marmoratus (Gray, 1845).

(Fig. 2.)

Diplodactylus marmoratus Gray, 1845, Brit. Mus. Cat. Lizards, p. 149.
Phyllodactylus marmoratus Boulenger, 1885, Brit. Mus. Cat. Lizards, i., p. 88, pl. vii., fig. 6.

Dorsally light brown, marbled with darker brown, white and deep yellow; tail similar, usually with more pronounced yellow markings; venter white, often with minute brown spots.

Specimen.	Length.	Head.		Body.	Forelimb.	Hindlimb.	Tail.
		Length.	Width.				
A	72	10	7	18	10·5	13	40
B	76	10	7	21	12	16	41
C	72	10	7	18	10·5	13·5	40
D	69	9	6·5	17·5	10	12	38
E	52	8·5	5·5	15	9	11	31
F	82	10	7	22	12	15	43
*G	72	11	8	22	12·5	17	35
*H	75	11	8	22·5	12·5	15	40

* Tail regenerating.

This species was found on Reevesby, Spilsby, Roxby, Stickney and English Islands, under stones, in the debris at the bases of shrubs or tussocks or ascending the branches of the undergrowth.

Nocturnal in habit. Fresh eggs were common, usually occurring in twos or threes. On January 8th, two "community nests" (?) were discovered, one containing five eggs, the other containing fourteen.

The species has been recorded from southern Australia, Norfolk, Lord Howe, and Kangaroo Islands, and the islands of the Nuyts Archipelago and the Investigator Group.

Family: VARANAIDAE.

Genus **Varanus**

Varanus varius (Shaw, 1794).

(Fig. 3.)

Lacerta varia Shaw, 1794, in White's Voy. N.S.Wales, p. 246, pl. iii., fig. 2.

Varanus varius Boulenger, 1885, Brit. Mus. Cat. Lizards, ii., p. 319.

Habit robust. Teeth acute, compressed. Snout depressed at tip, measuring 1.2 times distance from anterior border of orbit to ear. Digits short stout. Tail compressed, keeled. Scales of head small simple, equal to those of temples, temporal scales tectiform; supraocular scales very small, equal; sublabial scales slightly larger than anterior gular scales. Scales on upper surfaces small, oval, tectiform; abdominal scales similar but larger, in 100-110 transverse series. Caudal scales enlarged, keeled; caudal keel on posterior two-thirds of tail; keel with doubly toothed crest.

Upper surfaces black with numerous minute white spots which are arranged to form indistinct light bands; limbs black with larger white spots. Basal half of tail similar to trunk, distal half with numerous black and grey annuli; ventral surfaces white.

Specimen.	Length.	Head.	Neck.	Body.	Forelimb.	Hindlimb.	Tail.
A	1,129	84	110	270	110	160	665
B	975	70	90	250	110	150	565
C	759	52	70	175	95	120	462

This monitor differs in several minor respects from both *V. varius varius* and *V. varius bellii*, notably in coloration, in which it appears to be intermediate between the two subspecies, and in the short stout digits. Mr. Arthur Loveridge, of the Museum of Comparative Zoology, Harvard, who was consulted on this point, considers that the form may be worthy of subspecific rank, particularly since it is an insular animal, but it is felt that since no mainland forms from similar country in South Australia are available for comparison, it is better to list the species as *Varanus varius sens. lat.* until more material comes to hand.

This form was found only on Reevesby Island, where it occurs in fairly large numbers. They are burrowing forms, and the burrows appear to be quite regular in size and arrangement of passages (Fig. 3). The burrows are 3-4 feet long and about 6 inches in diameter, the main gallery is L-shaped, with a second L-shaped gallery opening near the angle. The roofs of the burrows examined were never more than 1 foot, usually 6-9 inches below the surface of the ground.

Family SCINCIDAE.

Genus **Trachysaurus.**

TRACHYSAURUS RUGOSUS Gray, 1827.

Trachysaurus rugosus Gray, 1827, King's Voy. Aust., ii., p. 430.

Dorsum black, sparsely spotted with creamy white, spots in 7-9 irregular transverse bands; sides cream, spotted with black; venter mottled black and grey; under surface of tail with alternating bands of black and cream. Under suitable conditions, the whole of the back and sides may become black, with a corresponding darkening of the ventral surfaces.

Specimen.	Length.	Head.		Body.	Tail.
		Length.	Width.		
A	360	52	57	200	85
B	335	52	55	175	83
C	335	50	53	180	80
D	345	50	50	190	80
E	300	45	48	150	70
F	275	45	43	145	70
G	295	47	45	150	70
H	310	47	48	160	77
I	340	58	55	175	85
J	345	60	55	175	80
K	300	49	49	155	70

The species was found on Reevesby, Duffield, Spilsby, Hareby, Kirkby, Langton and Winceby Islands. Most common on Reevesby and Duffield Islands, this lizard appears to feed mainly on the seeds of the Boobyalla (*Myoporum insulare*) and of *Mesembryanthemum crystallinum*. Very young specimens were found early in December.

Recorded from New South Wales, Western and South Australia, Victoria, Gayndah (Queensland), Houtman's Abrolhos, Dirk Hartog Island, and Kangaroo Island (introduced).

Genus **Sphenomorphus.**

SPHENOMORPHUS AUSTRALIS AUSTRALIS (Gray, 1838).

(Fig. 4.)

Tiliqua australis Gray, 1838, Ann. Nat. Hist., ii., p. 291.
Sphenomorphus australis australis Loveridge, 1934, Bull. Mus. Comp. Zool. Harvard, lxxvii., 6, p. 345.

Prefrontals separate; frontal in contact with frontonasal (Specimen A); prefrontals in contact, frontal and frontonasal separate (Specimen B). Hindlimb pressed forward reaches shoulder (Specimen A). Hindlimb reaches elbow of adpressed forelimb (Specimen B).

Upper surface dark brown to black, with four continuous lines of white or light brown and four longitudinal lines of light-brown spots; sides mottled brown and white, venter white.

Specimen.	Length.	Head.		Body.	Forelimb.	Hindlimb.	Tail.
		Length.	Height.				
A	185	13	10	37	23	36	120
B	190	14	10	45	21	34	118

This species was found on Reevesby, Roxby, Stickney, Partney, Marum and Spilsby Islands, and was extremely common.

Recorded from many parts of Australia and adjacent islands.

Genus **Hemiergis.**

HEMIERGIS PERONII (Fitzinger, 1826).

(Fig. 5.)

Seps peronii Fitzinger, 1826, Neue Classif. Rept., p. 53.
Lygosoma (Hemiergis) peronii Boulenger, 1887, Brit. Mus. Cat. Lizards, iii., p. 326.

Golden or light brown above, with numerous black spots arranged in more or less continuous lines. Sides heavily spotted with black. Ventral scales white, each with a central black spot, one or two rows near the midventral line may be without spots. Subcaudal scales heavily barred with black.

Specimen.	Length.	Head.		Body.	Forelimb.	Hindlimb.	Tail.
		Length.	Width.				
A	164	7·5	6·5	50	8	12·5	97
*B	159	9	7	43	8	15	97
†C	130	8	6·5	32	8	12·5	68
†D	156	7·5	6	46	7	12	41
†E	131	8	6	41	7	12·5	75
†F	114	8	6·5	51	7	12	58
†G	108	9	7	40	7	12	53
†H	111	8	6·5	37	8	13	59
†I	97	7·5	6	35	7·5	12	37

* Each interparietal divided into two by a transverse suture.
† Tail regenerating.

This species was found on Reevesby, English, Stickney, Roxby and Marum Islands.

Recorded from Western and South Australia, Victoria, and the South Neptunes, Black Rock, St. Francis, Kangaroo, Flinders, Price and Pearson Islands.

Genus **Rhodona.**

Rhodona tetradactyla Lucas and Frost, 1895.

(Fig. 6.)

Rhodona tetradactyla Lucas & Frost, 1895, Proc. Roy. Soc. Vict., vii., n.s., p. 268.

non *Mocoa tetradactyla* O'Shaugnessy, 1879, Ann. Mag. Nat. Hist., (5), iv., p. 300.

Lygosoma (*Rhodona*) *frosti* Zeitz, 1920, Rec. S. Aust. Mus., i., p. 217.

Body slender, elongate; limbs short, tetradactyle. Snout short obtuse. Lower eyelid with transparent disc. Nostril pierced in large nasal; frontonasal forming short suture with rostral, broadly in contact with frontal; prefrontals present, small, widely separated; frontal large, broad, in contact with first and second supra-oculars; 4 supra-oculars, second largest; 5 supraciliaries; 3 upper labials anterior to subocular; frontoparietals in contact behind interparietal; frontoparietals and interparietal small, subequal; 2 pairs of nuchals. Ear opening small, distinct. Eighteen scales around middle of body; subdigital lamellae keeled, 15-16 lamellae under third toe.

Dorsally silver-grey or light brown with four longitudinal rows of black spots, spots in the two inner rows almost confluent; a well marked lateral black stripe extending from the nostril to the tail; ventral surface silvery or bluish white, with a few irregularly spaced black spots.

Specimen.	Length.	Head.		Body.	Forelimb.	Hindlimb.	Tail.
		Length.	Width.				
A	99	6	4	36	6	12	49
B	78	6	4	42	6	11·5	..
*C	78	5·5	3·5	32	5	11·5	39

* Tail regenerating.

Found on Reevesby Island, not common.

Recorded from Central and South Australia and Flinders and the South Neptune Islands.

Rhodona picturatum Fry, 1914.

(Fig. 7.)

Rhodona picturatum Fry, 1914, Rec. W. Aust. Mus., i., iii., p. 186, text-fig. 5, pl. xxvii., fig. 3.

Body elongate, slender. Snout subconical, projecting beyond lower jaw. Eye small; lower eyelid with transparent disc, rostral large, swollen; nasals in contact; frontonasals united into single shield which is broadly in contact with frontal; prefrontals present; frontal large, slightly longer than broad; frontoparietals and interparietals distinct; frontoparietals in contact behind interparietal; 2 pairs of nuchals; 5 upper labials, fourth entering orbit; 5 lower labials. Ear opening barely discernible. Eighteen scales around middle of body; 2 enlarged preanals. Forelimbs present as minute scaly spurs; hindlimbs didactyle, outer toe twice as long as inner.

Silver grey above, a broad lateral brown band extends from the nuchal scales almost to the tip of the tail; a short row of widely separated brown spots on each side from above the anus to about halfway along the tail; ventral surfaces white. Head scales edged with brown.

Specimen.	Length.	Head.		Body.	Forelimb.	Hindlimb.	Tail.
		Length.	Width.				
A	72	4·5	2·5	28	trace	7	30

One specimen was taken on Reevesby Island.

Recorded from Perth and Boulder (West Australia).

Genus **Ablepharus.**

Ablepharus lineo-ocellatus Dumeril and Bibron, 1839.

(Fig. 8.)

Ablepharus lineo-ocellatus Dumeril & Bibron, 1839, Erpétologie Générale, v., p. 817.

Olive brown above, a black-edged white stripe extending from the nostril to the thigh, dorsally with numerous indistinct ocelli which extend over the tail; venter greenish white.

Specimen.	Length.	Head.		Body.	Forelimb.	Hindlimb.	Tail.
		Length.	Width.				
A	112	8·5	6	26	14	20·5	67

One specimen was found on Reevesby Island.

The species is widely distributed throughout Australia and has been found on Kangaroo and Flinders Islands.

Ablepharus taeniopleurus Peters, 1874.

(Fig. 9.)

Ablepharus (Morethia) taeniopleurus Peters, 1874, Mon.-Ber. Ak. Wiss. Berlin, p. 375.

Form and head scalation closely similar to *A. lineo-ocellatus* Dumeril and Bibron; supranasals present; four supraciliaries on each side; dorsal circumorbital scales concealed; 30 scales around middle of body; ear opening without projecting lobules; scales on palms of hands and soles of feet acutely keeled; subdigital lamellae acutely keeled; 19 lamellae under fourth toe.

Olive brown above, with two lines of black spots; a black-edged white line extends from the nostril to a short distance behind the vent; venter bluish white; hands and feet pink.

Specimen.	Length.	Head.		Body.	Forelimb.	Hindlimb.	Tail.
		Length.	Width.				
A	93	8·5	5	30	14·5	19	48

One specimen was found on Reevesby Island.

Recorded from Bowen (Queensland) and Mount Robinson (West Australia).

ABLEPHARUS BOUTONII var. PERONII (Cocteau, 183–).

(Fig. 10.)

Cryptoblepharis peronii Cocteau, 183–, Et. Scinc., p. 1. (*fid. Blgr.*).
Ablepharus boutonii var. *peronii* Boulenger, 1887, *loc. cit.*, p. 346.

Brown to olive above, with a well-defined light-grey lateral band; sides and legs marbled brown and grey; venter bluish white; head occasionally metallic.

Specimen.	Length.	Head.		Body.	Forelimb.	Hindlimb.	Tail.
		Length.	Width.				
A	88	8	6	22	11·5	14·5	47
B	77	7·5	5	21·5	13	15	39
C	77	7·5	5·5	20	12	14·5	39
D	66	7·5	5	18	12	15	34
*E	67	7	5	19	11	14	34
*F	47	7	4·5	20	11	14	10
*G	31	5·5	3·5	11·5	6·5	9	12

* Tail broken.

This species was found on Reevesby, Roxby and Stickney Islands, fairly common.

Recorded from the greater part of Australia.

ABLEPHARUS GREYII (Gray, 1845).

(Fig. 11.)

Menetia greyii Grey, 1845, *loc. cit.*, p. 66.
Ablepharus greyii Boulenger, 1887, *loc. cit.*, p. 349.

Olive brown above, spotted with black, a narrow black stripe on each side; throat and lower jaw white spotted with black; venter white.

Specimen.	Length.	Head.		Body.	Forelimb.	Hindlimb.	Tail.
		Length.	Width.				
A	82	5	4	20·5	7·5	11	48

One specimen was found on Reevesby Island.

Recorded from the northern and southern parts of West Australia.

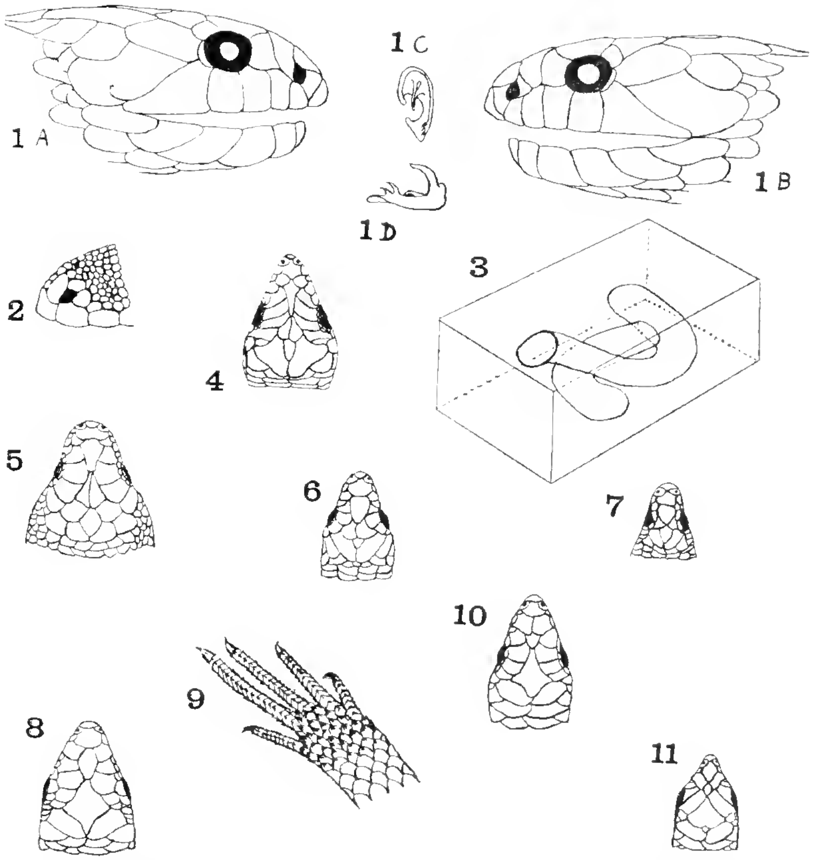


Fig. I.—1. *Notechis scutatus* var. *niger*. A. Head of Specimen E, from right side. B. Ditto, from left side. C. Left Maxilla from below. 4. Left Maxilla from left. 2. *Phyllodactylus marmoratus*. Snout, × 4½. 3. Diagram of Burrow of the Reevesby Island *Varanus varius*. 4. *Sphenomorphus australis*. Head, × 2. 5. *Hemiergis peronii*. Head, × 2. 6. *Rhodona tetradactyla*. Head, × 2. 7. *R. picturatum*. Head, × 2. 8. *Ablepharus lineo-ocellatus*. Head, × 2. 9. *A. taeniopleurus*. Right manus, × 3½. 10. *A. boutonii* var. *peronii*. Head, × 2. 11. *A. greyii*. Head, × 2.

12. *Reptilia, Part 2; The Venom of* Notechis scutatus *variety* niger, (*Reeveshy Island*).

By F. G. MORGAN, Director, Commonwealth Serum Laboratories, Melbourne.

The following notes on this venom are supplied at the request of the McCoy Society. Special attention has been paid in them to the toxicity of the venom and to the saving qualities of anti-venene prepared for use against the Mainland Tiger snake in treating the bite of the Reevesby Island snake.

In the year 1934 we received several reports at the Commonwealth Serum Laboratories that death adders abounded in the Joseph Banks group of islands, and it was decided that Mr. T. E. Eades, of the staff of the Laboratories, should visit the locality to obtain death adders.

He visited Reevesby Island on the 8th to the 13th February, 1935. After a very careful search he was disappointed by being unable to find any trace of death adders, but acquired three good, living specimens of a handsome jet black snake. These snakes varied in length from 3 ft. 6 in. to 4 ft. 6 in. In appearance they do not resemble superficially the Mainland Tiger snake, nor the variety found on Chappell Island in the Bass Straits. The scalation, however, numerically resembled closely that of both other varieties.

These specimens were maintained in captivity for several months and "milked" for venom on numerous occasions.

From the three snakes, in sixteen "milkings," 257 mg. of dried venom were obtained; the average yield per "milking" being 16 mg.

If Table I. be consulted it will be observed that the average yield per snake steadily diminished during successive periodical extractions of venom.

TABLE I.

Number of Snakes.	Date of Extraction.	Yield in Dried Venom.	Average per Snake.
3	12.3.35	103 mg.	34·3 mg.
3	2.4.35	44 ,,	14·7 ,,
3	23.4.35	40 ,,	13·3 ,,
3	24.5.35	24 ,,	8 ,,
2	30.7.35	} 54·4 ,,	13·6 ,,
2	27.8.35		
9	5.1.36	187 ,,	20·8 ,,

In January, 1937, the McCoy Society kindly supplied to us nine snakes from Reevesby Island, following their expedition to the Joseph Banks group. From these, 187 mg. of dried venom were obtained from one " milking " per snake. An average yield from this group was therefore 20.8 mg. These snakes varied in length from 18 inches to 4 ft. 6 in.

It is to be noted that the yield of venom from the first three snakes at the first " milking " averaged 34.3 mg.

The venom of these snakes, when dried, was glistening, pure white in colour and differed sharply in appearance from the rich yellow colour of the Chappell Island variety, and from the creamy-white colour of the Mainland Tiger snake venom. Obviously, individual snakes of the latter varieties occasionally yield venoms which are white in colour, but our experience is that dried pooled venoms from the latter invariably possess the above characters.

Table II. shows the result of testing for the lethal dose of the Reevesby Island snake venom for guinea-pigs, each weighing 300 grammes. All doses were administered in a constant volume for injection of 4 c.c.

TABLE II.—CERTAINLY LETHAL DOSE OF THE VENOM OF THE BLACK TIGER SNAKE (REEVESBY ISLAND, S.A.) FOLLOWING SUBCUTANEOUS INJECTION IN GUINEA-PIGS.

Number of Animals.	Dose in Mg. per 100 Gm. Body Wt.	Percentage Mortality.	Number of Animals Dying within Specified Periods.					
			Less than 17 Hours.	17 to 48 Hours.	48 to 120 Hours.	120 to 240 Hours.	Living and Gaining Weight.	Percentage Living After Fourteen Days.
1 ..	0·33	100	(d. 1 hr.)	..	..	..	..	..
1 ..	0·1	100	1	..	..	..	..	..
1 ..	0·033	100	1	..	..	..	..	..
1 ..	0·01	100	1	..	..	..	..	..
3 ..	0·0033	100	3	..	..	..	..	..
3 ..	0·002	100	..	3	..	..	..	..
10 ..	0·0015	100	..	8	..	2	..	..
10 ..	$0\cdot001\dot{3}$	100	..	9	1	..	..	..
20 ..	$0\cdot0011\dot{6}$	100	..	12	4	4	..	..
20 ..	0.001	95	..	7	5	7	1	5
10 ..	$0\cdot0008\dot{6}$	100	..	1	2	7	..	..
10 ..	$0\cdot0007\dot{3}$	70	..	1	1	5	3	30
10 ..	0·0006	70	..	3	3	1	3	30
10 ..	$0\cdot0004\dot{6}$	100	..	5	1	4	..	..
10 ..	$0\cdot0003\dot{3}$	80	..	3	1	4	2	20

Weights of guinea-pigs were 300 gm. ± 10 gm.

Large numbers of animals are necessary to determine accurately the certainly fatal dose for guinea-pigs of various ages and weights. At the time of testing only limited supplies were available, but Table II. indicates sufficiently clearly the degree of toxicity of this venom; thus it was found that a dose of 0.00087 mg. per 100 grammes given subcutaneously into 300 gramme guinea-pigs killed all members of that group. For all doses greater than that amount, 100 per cent. of pigs succumbed, with the exception of the group of 0.001 mg. per 100 grammes, in which one animal only survived, giving a 95 per cent. mortality.

The toxicity of this sample of Reevesby Island venom appears therefore to be nearly $2\frac{1}{3}$ times as potent as that of the average sample of Mainland tiger snake. C. H. Kellaway(1) has previously determined the certainly lethal dose for guinea-pigs subcutaneously of Mainland tiger venom as 0.002 mg. per 100 grammes.

As it has been claimed previously that the Australian Tiger snake (*Notechis scutatus*) yields a venom more potent than any other dried venom, weight for weight, it would appear that the venom of the Reevesby Island Black Tiger snake would displace the Mainland Tiger snake from this position. The toxicity of the venom of the other insular variety of tiger snake (*Notechis scutatus* var. *niger*, Chappel Island, Bass Strait) was determined by Kellaway and Thomson(2), when given subcutaneously, as 0.006 mg. per 100 grammes.

We have as yet had no opportunity of determining the intravenous certainly fatal dose of the Reevesby Island venom, nor, consequently, the subcutaneous-intravenous index.

When making these observations it was our object rather to determine the saving qualities of Mainland tiger snake antivenene against Reevesby Island snake venom, than to conduct detailed investigation of the nature of the venom.

Table III. shows the protective effect of monovalent Mainland Tiger antivenene against both Reevesby Island and Mainland snake venoms.

The test dose of venom for each guinea-pig weighing 300 grammes was 0.06 mg. This quantity of venom is equal to 10 certainly fatal doses of the Mainland venom, and 23 certainly fatal doses of Reevesby Island venom. In the case of the former venom, 0.2 c.c. of serum saved both pigs against the test dose, and 0.16 c.c. saved one pig out of two; the other dying after a relatively prolonged period, namely 120 hours.

In the case of the Reevesby Island venom, 0.25 c.c. of antivenene saved both pigs, and 0.2 c.c. saved one; the other dying after 96 hours. All doses of this test were made up to a total volume of 4 c.c. and injected subcutaneously.

TABLE III.—PROTECTIVE EFFECT OF MONOVALENT MAINLAND TIGER ANTIVENENE.

Pig Number.	Date.	Type of Venom.	Dose of Venom (mg.).	Dose of Antivenene 2624.	Result.
14	18.11.36	Black tiger, Reevesby Is.	0·06	0·5 cc.	Lived
15	18.11.36	,, ,, ,,	0·06	0·5 ,,	Lived
16	18.11.36	,, ,, ,,	0·06	0·33 ,,	Lived
17	18.11.36	,, ,, ,,	0·06	0·33 ,,	Lived
18	18.11.36	,, ,, ,,	0·06	0·25 ,,	Lived
19	18.11.36	,, ,, ,,	0·06	0·25 ,,	Lived
20	18.11.36	,, ,, ,,	0·06	0·2 ,,	Died 96 hours
21	18.11.36	,, ,, ,,	0·06	0·2 ,,	Lived
22	18.11.36	,, ,, ,,	0·06	0·166 ,,	Died 48–72 hours
23	18.11.36	,, ,, ,,	0·06	0·166 ,,	Died 48–72 hours
24	23.11.36	Mainland tiger snake ..	0·06	0·25 cc.	Lived
25	23.11.36	,, ,, ,, ..	0·06	0·25 ,,	Lived
26	23.11.36	,, ,, ,, ..	0·06	0·20 ,,	Lived
27	23.11.36	,, ,, ,, ..	0·06	0·20 ,,	Lived
28	23.11.36	,, ,, ,, ..	0·06	0·16 ,,	Died 120 hours
29	23.11.36	,, ,, ,, ..	0·06	0·16 ,,	Lived
30	23.11.36	,, ,, ,, ..	0·06	0·125 ,,	Died 24–40 hours
31	23.11.36	,, ,, ,, ..	0·06	0·125 ,,	Died 24–40 hours
32	23.11.36	,, ,, ,, ..	0·06	0·1 ,,	Died in less than 16 hours
33	23.11.36	,, ,, ,, ..	0·06	0·1 ,,	Died in less than 16 hours
34	23.11.36	,, ,, ,, ..	0·006	..	Lived
35	23.11.36	,, ,, ,, ..	0·0075	..	Lived
36	25.11.36	,, ,, ,, ..	0·006	..	Died in less than 22 hours
37	25.11.36	,, ,, ,, ..	0·0075	..	Died in less than 22 hours
38	25.11.36	,, ,, ,, ..	0·0094	..	Died in less than 2? hours
39	25.11.36	,, ,, ,, ..	0·012	..	Died in less than 22 hours

It can be assumed that in pigs 20 and 21 there was barely one fatal dose left unneutralized; therefore 0.2 c.c. of antivenene saved against 22 fatal doses, or a weight of 0.06 minus 0.0026 mg. of Reevesby Island venom. 1 c.c. of antivenene is therefore calculated to neutralize 0.287 mg. of this venom.

By the same method of calculation the same antivenene in a dose of 0.16 c.c. neutralizes nine fatal doses of venom, or 0.06 minus 0.006 mg. of Mainland venom. 1 c.c. of antivenene thus neutralizes 0.3375 mg. of Mainland venom.

If we consider these results from the viewpoint of the amount of dried venom of each species which the antivenene is capable of neutralizing, then it would appear that the Mainland tiger antivenene is slightly more potent against the homologous Mainland tiger venom, but the difference is small and within the limits of spacing of doses.

If we consider the effectiveness of neutralization by the antivenene in terms of certainly fatal doses of each venom, then a difference is apparent in favour of neutralization of Reevesby Island venom. In other words, 1 c.c. of antivenene is capable of neutralizing 110.4 certainly fatal doses of Reevesby Island venom, whereas it will neutralize 56.25 certainly fatal doses of Mainland tiger venom.

In treating a case of snakebite it is always very difficult to assess the probable amount of venom which the snake injected into the tissues, owing to the possibility of variation in the size of the snake, the locality bitten, the presence of clothing and several other circumstances which may hamper the effectiveness of the bite. We can assume safely that it is very seldom, if ever, that a snake will inject at one bite the whole of the venom available in its glands. Data obtained by Fairley and Splatt(3) for repeated spontaneous bites upon rubber diaphragms show that such is the case, the amount of venom ejected diminishing with each successive bite. If we take into consideration the amount of venom available in the glands of each variety of snake, and allow an ample excess of antivenene to neutralize the average yield obtained at each "milking" under laboratory conditions, then the practical result will, in the great majority of cases, be favorable. Thus, 34.3 mg. of dried venom was the average obtained from the first "milking" of three Reevesby Island tiger snakes (Table I.) and 50 mg. was the average per snake from a representative collection of Mainland tiger snakes. One hundred and twenty c.c. of the Mainland tiger antivenene, Batch No. 2624, would be required to neutralize 34.3 mg. of dried venom of the Reevesby Island variety. One hundred and forty-eight c.c. of the same serum would be required to neutralize 50 mg. of Mainland tiger venom.

It can be seen that the use of Mainland tiger monovalent antivenene is strongly indicated, following a bite by the Reevesby Island snake. Similar dosage should be employed. Owing to the smaller amount of venom which, in all probability, would be injected on the average by the latter snake, the outcome of treatment by the antivenene may be, on the average, more favorable to the patient.

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2. ————, C. H., and D. F. Thomson, 1932, *Aust. Jour. Exp. Biol. & Med. Sci.*, x., p. 41.
3. Fairley, N. H., and B. Splatt, 1929, *Med. J. of Aust.*, i., p. 336.

13. *Aves.*

Compiled from the field notes of FREDERIC WOOD JONES, H. CONDON, G. MACK, J. F. RUTTER, and J. A. TUBB.

1. Eudyptula minor novaehollandiae (Stephens)—Little Penguin.

Spheniscus novaehollandiae Stephens, Shaw's Gen. Zool., xiii., 1826, p. 68.

The Little Penguin was present on all the islands of the group. The breeding season was over; but young birds of the year were still present in breeding burrows on Reevesby and probably on other islands. The nesting sites varied greatly on the different islands. On Little English Island the birds were all living in deep crevices between the granite boulders. It is possible that this choice of nesting sites was dictated by the presence of the colony of seals on the island; since during their breeding season the seals live largely on penguins. On the more sand-covered islands, such as Blyth, deep nesting burrows were excavated among the tangle of *Nitraria* bushes; and on the islands that carry a travertine capping they breed in the deep recesses weathered beneath the ledges of travertine along the coastline.

(Skin ♂ Reevesby, Nat. Mus., Melbourne.)

2. Coturnix pectoralis Gould—Stubble Quail.

Coturnix pectoralis Gould, Syn. Birds Aust., pt. 2, 1837, pl. 29, fig. 1.

Quail were seen in small numbers on Reevesby, Winceby, Hareby, Spilsby, and Duffield Islands. A clutch of four eggs was found on Winceby.

(Skins ♂ ♀ Reevesby, Nat. Mus. Melbourne.)

3. Rallus philippensis australis (Pelzeln)—Banded Landrail.

Hypotaenidia australis Pelzeln. Ibis, 1873, p. 42.

An adult bird was first seen on Winceby Island, but the identity of the species was not fully established until a dead and partly decomposed immature specimen was found in a well on Reevesby. Subsequently an adult was frequently seen searching for the remains of food thrown out on the camp dump. The species was unknown to the tenant of the Reevesby homestead, and it has evidently not taken to eating the eggs of the domestic poultry as it has on some other islands (e.g. Maetsuyker) on which it has gained a footing.

(No specimen procured.)

4. Pelagodroma marina dulciae Mathews—White-faced Storm Petrel.

Pelagodroma marina dulciae Mathews, Birds of Aust., ii., 1912, p. 21.

Upon every island of the group, with the exception of the rocky Little English Island and Spilsby, the storm petrels were breeding in thousands. Spilsby is a large island, and it is possible that some small breeding area upon it may have been overlooked, but the prolonged occupation with the consequent effects of cultivation and the introduction of sheep and rabbits have evidently combined to render the island unsuitable as a petrel rookery.

On 6th December, the large rookery on the southern end of Reevesby was examined and eggs, ranging from new-laid to those containing large embryos, were found. All the birds incubating the eggs on that date proved to be males. No female bird was found incubating until a single female was discovered on 11th December, and several were observed on 23rd December, when the first newly-hatched young was met with. On Reevesby the breeding area is confined to the red-soil, salt-bush area at the southern end of the island; on the very similar area at the northern end there was not a single burrow. The colony is a large one. The burrows are all made around the clumps of vegetation, and are usually long and extremely tortuous. It is a remarkable thing that so feeble-looking a bird can manage to drive its tunnels into the rather hard red soil on Reevesby. The tunnels twist about in all directions, for when the bird encounters a hard piece of travertine it attempts to go round it and, if that is impossible strikes off in another direction. In this way many of the burrows become forked and complicated by side tunnels and loops. One burrow that was carefully excavated had three entrances and two nesting chambers; one was occupied by a bird and the other contained one egg.

In one complicated burrow excavated on 8th December, a male bird was found sitting on two eggs—the only instance in which two eggs were found in one nest. It is probable that these complicated burrows are caused by an excavating bird striking a burrow originally made by another bird and finally taking possession of the whole system; but two birds were never found in the same burrow, however complicated. Upon the islands, such as Blyth, where the soil consists entirely of loose sand, the burrows are made amidst the roots of the *Nitraria* bushes. So large are the holes and so much sand is piled about the entrances that, without opening a burrow, it is difficult to believe that they are the work of so small a bird. The first impression is that some much larger petrel, or even a Mutton Bird, must be responsible for the burrows. On certain islands of the group, such as Langton, the surface is so extensively mined by the birds that it is almost impossible to walk even a few yards without breaking into the burrow of some unfortunate bird. For the most part the birds are silent during the daytime, but, on occasions, large areas of a rookery will become vocal with the little grunting coos of the sitting birds.

The chief enemies of the petrels on Reevesby are the numerous black tiger snakes, which at the time of our visit were living on the adult birds. Snakes killed as they lay outside the burrows early in the morning almost invariably contained an adult petrel only partly digested. Two snakes killed on one small area each contained a petrel; in the one the bird lay in the stomach with its head lowest, and in the other the position was reversed. Judging from the numbers of the snakes and their extreme fatness, they must take heavy toll of the birds during their stay on the islands. On all the islands upon which colonies of breeding birds are established the Pacific Gulls, most murderous of birds, secure their victims; and on certain islands they are preyed on by hawks. It is much to be regretted that goats have been turned down on Sibsey, for their trampling of the burrows is endangering the petrel colony. Besides the rock parrots, which seem to use the petrel's burrows before their rightful owners occupy them, a cricket (*Neomobius* sp.) was almost invariably present in the burrows. The cricket is an insect that lives in dark places, and so probably only uses the petrels' burrows as safe retreat; but the birds appeared in no way to resent their presence, even when half a dozen crickets occupied the nesting chamber.

The breeding season would seem to be prolonged and somewhat irregular. Fresh eggs have been found from 19th November to 31st December; newly-hatched young from 23rd December to 20th February, and the earliest date on which young were noted as having left the nest was 24th February. The newly-hatched chick is covered with a fine grey down, with the exception of the region round the eye, the base of the bill and the throat, which are bare. The first plumage is identical with that of the adult, the down being gradually shed until only a few stray down feathers adhere to the tail coverts when the bird is ready to leave the nest. The parents leave the young by day from the moment of its hatching.

The average measurements of sixteen eggs from Reevesby Island are 35.8 x 25.7 mm. The maximum measurements are 38 x 26, and 37 x 26.5. The minimum measurements 34.5 x 26, and 36.5 x 24.5. Of these sixteen eggs, six are without any trace of markings, nine show a very few and almost microscopic brown specks at the larger end, and one shows fairly large brown dots instead of the minute specks. Only on one occasion was a bird found sitting on two eggs, and these eggs were identical in measurements (36 x 26), and were similarly speckled.

The average measurements of incubating males from Reevesby, taken during December, 1936, are as follows:—Wing, 155.3 mm.; Tarsus, 42.3; bill, 16.6 x 7.

For young ♂ birds in adult plumage, but with down still adhering to the tail coverts, from Reevesby, taken in February, 1936:—Wing, 133.7 mm.; tarsus, 38.7; bill, 16.5 x 6.5.

(Skins ♂ ♂ ♀ Reevesby, Nat. Mus. Melb. ♂ ♂ ♂ ♂ ♀ Reevesby, S.A. Mus.)

5. PUFFINUS CARNEIPES Gould—Fleshy-footed Shearwater.

Puffinus carneipes Gould, Ann. Mag. Nat. Hist., xiii., 1844, p. 365.

Two decomposed birds were found on the beaches. The condition of the soft parts was sufficiently good to make the specific diagnosis quite certain. It is a remarkable fact that two of these unfamiliar shearwaters should be found on islands in Spencer Gulf in the entire absence of any remains of *P. tenuirostris* whose breeding grounds (on the Althorps and Neptunes) are so near at hand.

6. PHALACROCORAX SULCIROSTRIS SULCIROSTRIS (Brandt)—Little Black Cormorant.

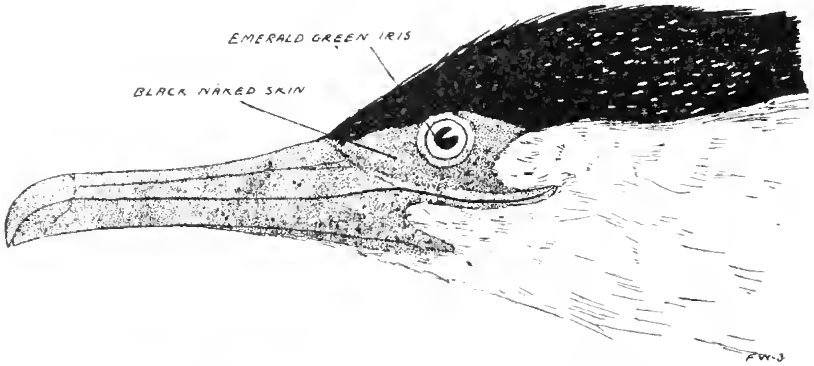
Carbo sulcirostris Brandt, Bull. Sci. Imp. Acad. Sci. St. Petersb., iii., 1837, col. 56.

Seen only on the rocks lying off Marum Island. Some half dozen birds were present (13th December) among a much larger number of *P. fuscescens.*

7. PHALACROCORAX FUSCESCENS (Vieillot)—Black-faced Cormorant.

Hydrocorax fuscescens Vieillot, Nouv. Dict. Hist. Nat., viii., 1817, p. 86.

Common on the shores of all the islands. The birds had not begun to lay in their rookery on Winceby by the time the party



P. FUSCESCENS. ADULT ♂ BREEDING SEASON.

FIG. 1

left the islands. (On Winceby fresh eggs, and newly-hatched young were present in the nests on 20th February, 1936). All the nests of *P. fuscescens* were placed upon the ground, often raised to some little height by masses of fish bones, and debris of all sorts. No trace of purple was present on the faces of birds either during the breeding period or in the months immediately preceding it.

The average measurements of fifteen eggs from Winceby is 56.6 x 35.9. The maximum measurements being 61 x 36 and 55 x 38, and the minimum 49 x 34 and 55 x 33.

(Skins ♂♂♂♂♀♀ Reevesby, Nat. Mus. Melb. ♀♀♀ S.A. Mus.)

8. Phalacrocorax varius (Gmelin)—Yellow-faced Cormorant.

Pelecanus varius Gmelin, Syst. Nat. i., pt. 2, 1789, p. 576.

In the early days of December *P. varius* was present in very small numbers, probably being in a proportion of less than one to fifty *P. fuscescens;* but in January their numbers increased, and on Winceby, on which is situated their largest rookery, they were present in perhaps the ratio of one to ten *P. fuscescens.* *P. varius* is easily recognized in a mixed company of *P. varius* and *P. fuscescens* by its being a larger bird, and by its habit of sitting considerably more erect. On Winceby Island all the nests of this species are elevated on the tops of the low nitraria bushes which are scattered over the general area in which *P. fuscescens* is nesting on the ground.

Average measurements of nineteen eggs from Winceby is 59.9 x 38.8. The maximum measurements being 65 x 37 and 62 x 41, and the minimum 57 x 38 and 58 x 37.

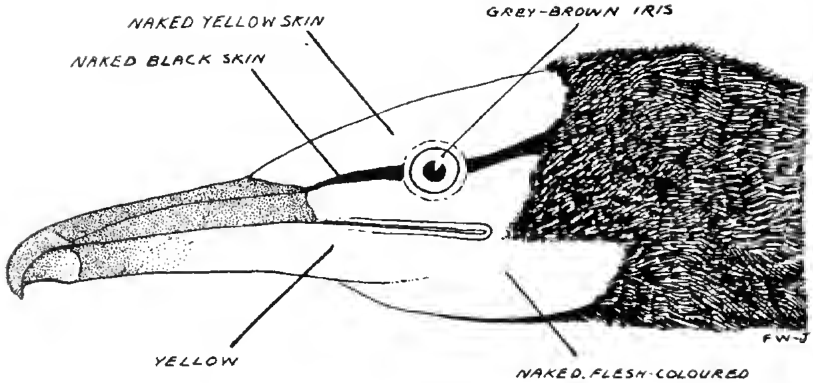
9. Microcarbo melanoleucus melanoleucus (Vieillot)—Little Pied Cormorant.

Hydrocorax melanoleucos Vieillot, Nouv. Dict. Hist. Nat., viii., 1817, p. 86.

This bird was seen only on Roxby Island, where there was a small rookery containing five nests. The little breeding colony had taken up its position on a small rocky peninsular only some 20 yards across at its widest part. One young bird was not quite able to fly, one young bird was secured flying at sea, and the other nests contained fresh eggs. The number of eggs in each nest varied from two to four.

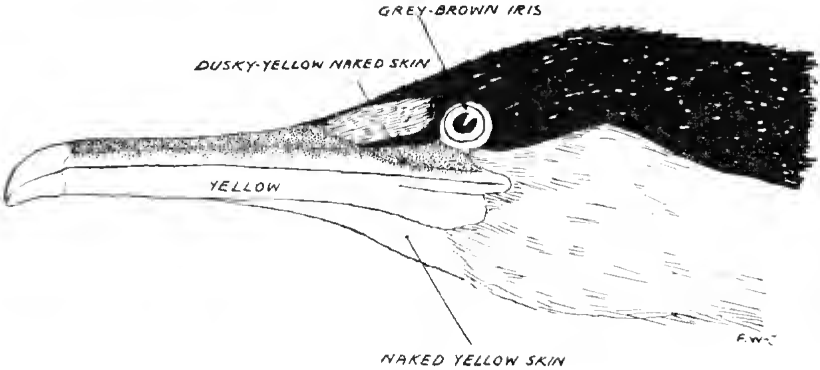
The average measurements of six eggs from Roxby is 45.8 x 28.8. The maximum being 48 x 31 and the minimum 44 x 27.

(Skins ♀ ad. ♂ young adult. ♂ inv. Roxby, Nat. Mus. Melb.).



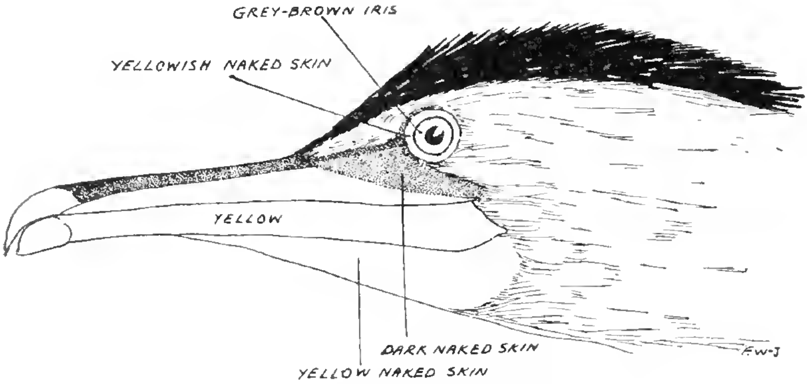
M. MELANOLEUCUS. YOUNG ♂ IN ALL-BLACK DOWN

Fig. 2.



M. MELANOLEUCUS. IMMATURE ♂.

Fig. 3.



M. MELANOLEUCUS. ADULT BREEDING ♀

Fig. 4.

10. Hydroprogne caspia strenua (Gould).—Caspian Tern.

Sylochelidon strenua Gould, Proc. Zool. Soc. 1846, p. 21.

Caspian Terns were found breeding on Winceby, Bligh, Kirkby, Lusby, Roxby, and Partney. Unlike the other breeding terns, the Caspians breed in isolation and, at the most, three pairs were found breeding on one island (Kirkby). Fresh eggs were found on Winceby and Partney, downy young on Lusby, and young birds nearly able to fly on Bligh and Kirkby.

(Skins ♂ ♀ Winceby. Nat. Mus., Melb.)

11. Thalasseus bergii cristatus (Stephens).—Crested Tern.

Sterna cristata Stephens, Shaw's Gen. Zool., xiii., 1826, p. 146.

Two nesting colonies were watched and photographed, the larger colony being on Kirkby and the smaller on Winceby. On Hareby a number of birds were observed courting and mating, but no breeding colony was established on the island at the time of our visit (20th December). On Winceby the eggs had only recently been laid (10th December), and on Kirkby (26th December) the young birds were just hatching. The whole process of the nesting operations up to the time of the parent birds conducting the young to the sea was observed and recorded by cinematograph. It is a remarkable thing that the newly hatched birds swim as readily as gulls and that, on occasion during the initiation of the young birds, the parents will alight on the water and swim. The curious drooping ("elbowing") of the wings, which has been described as an antic of courtship in some species, is maintained by the parent birds all through the breeding season, and is especially pronounced during the time of initiation of the young.

(Skins ♂ ♂ Five eggs. Winceby. Nat. Mus., Melb. ♂ Three eggs. S.A. Mus.)

12. Sterna nereis nereis (Gould).—Fairy Tern.

Sternula nereis Gould, Proc. Zool. Soc., 1842 (1843), p. 140.

Fairy terns were observed fishing around all the islands and large breeding colonies were present on Kirkby, Langton, and Stickney. The eggs were mostly fresh on Christmas Day, but the young were hatched before the camp was abandoned. The clutch consisted, as a rule, of two eggs, but in a few instances three were present in one nest.

(Skins ♂ ♀ Reevesby. Nat. Mus., Melb. ♂ Reevesby. S.A Mus.)

13. LARUS NOVAE-HOLLANDIAE NOVAE-HOLLANDIAE Stephens.—Silver Gull.

Larus novae-hollandiae Stephens, Shaw's Gen. Zool., xiii., 1826, p. 196.

Silver gulls were not numerous about the islands until the end of December. Apparently they have no breeding station in the group, and their added numbers in January—especially on Winceby Island—is almost certainly in anticipation of the commencing incubation of the shags, since during the second week of February, when the breeding season of the shags is at its height, the gulls are present in large numbers. The moment an incubating shag is disturbed and leaves its eggs unprotected the silver gulls crowd round and eat the eggs, or if they happen to be hatched, the young birds.

(Skins ♀ Reevesby. Nat. Mus., Melb. ♂ S.A. Mus.)

14. GABIANUS PACIFICUS (Latham).—Pacific Gull.

Larus pacificus Latham, Ind. Orn. Suppl., 1801, p. 68.

The black-backed gull was to be observed on the shores of all the islands, and evidently they breed, as is their habit, as isolated pairs on many of the islands. An abandoned egg was found on Reevesby, and two were present in a deserted nest on Marum. Several immature birds in the brown phase were present. The adult bird, during life, has the breast feathers and the under wing covets suffused with a very beautiful delicate pinkish-yellow colour: this colour is, however, evanescent and fades in the dried preserved skin.

(Skins ♂♂ ad Reevesby. ♂ imat. Winceby. Nat. Mus., Melb. ♂ ♀ S.A. Mus.)

15. ARENARIA INTERPRES INTERPRES (Linnaeus).—Turnstone.

Tringa interpres Linnaeus, Syst. Nat., i., 1758, p. 148.

Present in little flocks of from two or three up to ten or so on the shores of most of the islands. As a rule they were in common flocks composed of little stints and red-capped dotterels, but they differ from these small waders in usually feeding further from the shore, on rocky promontories, or at the end of sand spits. When flushed with a common flock of waders, the turnstones as a rule dissociate themselves from the dotterels and other species by flying further out to sea. The dotterels and stints usually fly parallel to the water's edge, and settle on the sand not very far from the spot whence they were flushed; but turnstones fly to sea and, coming round in a wide arc, land far from their point of departure. Though not easy to recognize in a mixed feeding flock at any great distance they are easily identified when on the wing.

(Skins ♂ ♀ ♀ Reevesby. ♂ Spilsby, Nat. Mus., Melb.)

16. Haematopus ostralegus longirostris Vieillot.—Pied Oyster-catcher.

Haematopus longirostris Vieillot, Nouv. Dict. Hist. Nat., xv., 1817, p. 410.

Usually seen singly or in pairs and present on the shores of most of the islands, these birds were far less numerous than the sooty oyster-catchers. They were also far more wary, and usually took fright from the beach if they were approached within from 80 to 100 yards. Again, unlike the all black birds, they were frequently seen among the sand hills at the top of the beach as though in the neighbourhood of their eggs, but no nest was found.

(Skin ♂ Reevesby. Nat. Mus., Melb.)

17. Haematopus fuliginosus Gould.—Sooty Oyster-catcher.

Haematopus fuliginosus Gould. Birds of Aust., iv., 1845, pl. 8.

Common on all the islands, and usually seen in small parties or pairs on the more rocky parts of the coast. Two adult birds captured by dazzling them with electric torches at night, showed a curious difference in the length of their bills: for whilst the bill of one was 90 mm., that of the other was only 74 mm. Moreover, the longer bill was distinctly paler and more yellow than the shorter bill. These birds were kept for some days, and fed readily on crushed winkles. They were liberated before the camp broke up, and their sex was not determined. One abandoned egg was found on Reevesby—measurements, 65 x 42 mm.

(Skins ♂ ♂ Reevesby, Nat. Mus., Melb. ♂ S.A. Mus.)

18. Lobibyx novae-hollandiae (Stephens).—Spur-winged Plover.

Vanellus novae-hollandiae Stephens, Shaw's Gen. Zool., xi., 1819, p. 516.

Small parties were present on most of the islands. In the early morning they were mostly to be seen along the sand flats, but they were usually to be found in the stubble on Reevesby, and on the higher parts of most of the islands. As is usual, they were readily alarmed and difficult to approach.

(Skin ♂ Winceby, Nat. Mus., Melb.)

19. Zonifer tricolor (Vieillot).—Banded Plover.

Charadrius tricolor Vieillot, Nouv. Dict. Hist. Nat., xxvii., 1818, p. 147.

Only a few were seen, usually in company with the Spur-winged Plover in the stubble near the homestead on Reevesby. No specimens were obtained, but an abandoned egg (measurements 43 x 32 mm.) was picked up on Reevesby.

20. Pluvialis dominica fulva (Gmelin).—Golden Plover.

Charadrius fulvus Gmelin, Syst. Nat., i., 1789, p. 687.

A specimen was secured on Partney Island, and other birds believed to be of this species were seen singly or in pairs feeding far out on rocky flats on other islands, but they were excessively wary and difficult to observe at anything like close range.

(Skin ♂ Partney, Nat. Mus., Melb.)

21. Charadrius rubricollis Gmelin.—Hooded Dotterel.

Charadrius rubricollis Gmelin, Syst. Nat., i., 1789, p. 687.

Mostly seen in pairs running on the sandy beaches of Reevesby, but also observed on Lusby and some other islands in the group.

(Skin ♂ Reevesby, Nat. Mus., Melb.)

22. Charadrius alexandrinus ruficapillus Temminck.—Red-capped Dotterel.

Charadrius ruficapillus Temminck, Pl. Col. d'Ois, i., 1821, pl. 47.

Far more abundant than the hooded dotterel, little parties were observed on the sandy beaches of practically all the islands. Adult and young birds were captured by dazzling them with electric torches on the beach at night. The young were still in the down during December.

(Skins ♂ ♂ ♀ ♀ Reevesby, Nat. Mus., Melb. ♂ S.A. Mus.)

23. Numenius madagascariensis (Linnaeus).—Curlew.

Scolopax madagascariensis Linnaeus, Syst. Nat., ed. 12, i., 1766, p. 242.

Of these birds solitary individuals were seen on most of the islands. As a rule they fed far out at the extremity of rocky flats, and were exceptionally wary and difficult to approach. Only on Reevesby were two birds ever observed to be feeding in company.

(No specimen was procured.)

24. Tringa nebularia (Gunnerus).—Greenshank.

Scolopax nebularia Gunnerus, in Leem, Beskr. Finm. Lapper, 1767, p. 251.

On Reevesby two of these birds were watched feeding in a mixed flock of dotterels and stints. It was noticed that they usually took up a station seaward of the smaller waders and that their movements were much less brisk during their feeding operations. For long intervals they would remain immobile while the dotterels and stints showed their usual little fits and starts of activity. Others were observed on a sand spit on Hareby, also in a flock of mixed waders. Solitary individuals were seen on most of the islands.

(Skins ♂ Reevesby. ♂ Spilsby. Nat. Mus., Melb.)

25. Erolia ruficollis (Pallas).—Little Stint.

Trynga ruficollis Pallas, Reise versch. Prov. Russ. Reichs, iii., 1776, p. 700.

The little stint was observed on practically every island. At times it was in little flocks of from a dozen to twenty individuals, and at times it formed part of mixed flocks, one or two being present with dotterels and turnstones in a common feeding party. When flushed with a mixed flock, the stints usually manoeuvre with the dotterels, and fly down the beach parallel with the tide line.

(Skins ♂ ♂ ♀ ♀ Reevesby, ♂ ♀ ♀ Hareby, Nat. Mus., Melb. ♂ ♂ S. A. Mus.)

26. Erolia acuminata (Horsfield).—Sharp-tailed Sandpiper.

Totanus acuminatus Horsfield, Trans. Linn. Soc. Lond., xiii., 1821, p. 192.

A single specimen, one of a pair flushed from the beach, was obtained on Hareby Island.

(Skin ♂ Hareby, Nat. Mus., Melb.)

27. Burhinus magnirostris (Latham).—Stone Curlew.

Charadrius magnirostris Latham, Ind. Orn. Suppl, 1801, p. 66.

As usual this bird was more often heard than seen. Every night they were heard passing over the camp, but by day time they were only seen when by chance a squatting bird was flushed in the sand hills. One bird was captured by dazzling it with an electric torch and, after being photographed, was released. A deserted clutch of two eggs was found on Reevesby.

(Skins ♂ Reevesby, ♂ Marum; Nat. Mus. Melb. ♀ S.A. Mus.)

28. Plegadis falcinellus peregrinus (Bonaparte).—Glossy Ibis.

Ibis peregrina Bonaparte, Consp. Av., ii., 1855, p. 159.

A pair of these birds was seen flying low over the party camped on the beach of Spilsby (21st December, 1936), and next day, on landing on Little Spilsby, three birds were observed standing on the highest point of the island. On being disturbed they flew towards Spilsby Island, and appeared to land on its southern end.

29. Notophoyx novae-hollandie (Latham).—White-faced Heron.

Ardea novae-hollandiae Latham, Ind. Orn., ii., 1790, p. 701.

Solitary birds or pairs were seen on the majority of the islands, usually standing at the seaward end of reefs. They were, however, excessively shy.

30. Cereopsis novae-hollandiae Latham.—Cape Barren Goose.

Cereopsis novae-hollandiae Latham, Ind. Orn. Suppl., 1801, p. 67.

It is not so long ago that the Banks Group was the most important breeding station of Cape Barren Geese in South Australia. The South Australian Pilot calls attention to the abundance of geese in the group, and within the memory of people living in the neighbourhood geese have swarmed on the islands. To-day their numbers are sadly diminished. A party of from eight to ten was generally to be seen in the stubble near the Reevesby homestead, and birds were seen in twos and threes on several other islands; but it was impossible to arrive at any precise estimate of the total numbers since the birds fly freely from island to island. The islands were very dry during the visit of the members of the Society, and the geese appeared to be subsisting mostly on the pigface and the sprouts of oats appearing among the stubble. It would seem that, unless a vigorous protection policy is undertaken, the raids carried out by parties from the mainland will, in a very short while, exterminate the Cape Barren geese of the Banks Group. One young bird was captured and presented to the Flora and Fauna Board of South Australia for liberation on the reserve of Flinders Chase; and one young adult, after having been cinematographed, was secured as a specimen.

(Skin ♂ juv. Kirkby, Nat. Mus., Melb.)

31. Chenopis atrata (Latham).—Black Swan.

Anas atrata Latham, Ind. Orn. ii., 1790, p. 834.

Four birds were observed (by H.T.C.) passing eastwards over Reevesby Island on 10th December.

32. Anas superciliosa rogersi Mathews.—Grey Duck.

Anas superciliosa rogersi Mathews, Aust. Av. Rec., i., 1912, p. 33.

A pair seen on the dam on Spilsby and a party of four on the shore of Roxby Island.

33. Haliaeëtus leucogaster (Gmelin).—White-breasted Sea Eagle.

Falco leucogaster Gmelin, Syst. Nat., i., 1788, p. 257.

It is rather remarkable that only one example of the Sea Eagle was observed in the group. The solitary bird was first seen on a rocky cliff in Spilsby, and when alarmed it flew towards the centre of the island. Unfortunately no information about the birds breeding on the island was obtained from the occupants of the homestead.

34. Falco cenchroides Vigors and Horsfield.—Kestrel.

Falco cenchroides Vigors and Horsfield, Trans. Linn. Soc. Lond., xv., 1827, p. 183.

Only one pair of birds, with, in some instances, the grown young of the year, was present on each island. Reevesby, Winceby, Marum, and Partney, each had a pair of birds, and on Reevesby the full grown young of the year were accompanying their parents. On Winceby the birds make a nest on the ground in a corner of the lighthouse enclosure.

(Skin ♂ Partney, Nat. Mus., Melb.)

35. Kakatoë roseicapilla (Vieillot).—Galah.

Cacatua roseicapilla Vieillot, Nouv. Dict. Hist. Nat., xvii., 1817, p. 12.

A large flock visited Reevesby Island and settled in the stubble fields near the homestead; later in the same day (24th December) scattered birds were seen in various parts of the island, but all seemed to have left before nightfall.

36. Neophema petrophila (Gould).—Rock Parrot.

Euphema petrophila Gould, Proc. Zool. Soc., 1840, p. 148.

The beautiful little Rock Parrot is abundant in all the islands. At the time of the visit of the Society the breeding season was evidently over as birds of the year were indistinguishable from their parents, and the genital glands of all specimens procured were in the resting phase. Although at times it was thought that birds were seen to disappear into a petrel's burrow only one parrot was actually dug out (Winceby), and this bird had no egg or young one in the nesting chamber. On a previous visit (20th February, 1936) a parrot was found with a fresh egg in the nesting chamber of a petrel's burrow, and it would seem probable that they normally use the petrels' burrows before the rightful owners' usual breeding season. This point could only be determined by examining a series of burrows in September. It is usually said that the eggs are deposited under ledges of travertine; but though numerous travertine caves and ledges were examined no trace of former occupancy was detected. A single abandoned egg lying out in the open (26 x 20) was picked up on Reevesby.

The birds feed on the seeds of *Mesembryanthemum*, and upon the berries of *Myoporum insulare*.

The plumage about the face is frequently stained magenta red from the juices of the berries on which they feed. Upon the plumage of one bird a dipterous parasite (Hippobuscidae) was present.

(Skins ♂ ♂ ♀ Reevesby, Nat. Mus., Melb. ♀ ♀ S.A. Mus.)

37. Hirundo tahitica neoxena Gould.—Welcome Swallow.

Hirundo neoxena Gould, Birds of Aust., ii., 1842, pl. 13.

Swallows were seen about most of the islands, and were often to be observed sitting on the rocks or actually on the seashore at low tide. A pair was usually hawking over the bush in the neighbourhood of the camp.

(Skin ♀ Reevesby, Nat. Mus., Melb. ♂ S.A. Mus.)

38. Grallina cyanoleuca (Latham).—Magpie Lark.

Corvus cyanoleucus Latham, Ind. Orn. Suppl., 1801, p. 25.

A female bird was seen around the camp for a few days in January. It was not observed after 8th January.

39. Epthianura albifrons (Jardine and Selby).—White-fronted Chat.

Acanthiza albifrons Jardine and Selby, Illus. Orn., ii., 1828, pl. 56.

Abundant on all the islands. Usually to be seen in the early morning on saltbush along the shore, or even on beds of seaweed still washed by the waves. Little parties were frequently seen among the rocks at low tide, and at all times it was to be found in the more open parts of the islands.

(Skins ♂ ♀ Reevesby, Nat. Mus. Melb.)

40. Megalurus gramineus gramineus (Gould).—Little Grassbird.

Sphenoeacus gramineus Gould, Proc. Zool. Soc., 1845, p. 19.

The note of this bird was heard daily in the neighbourhood of the camp on Reevesby for more than a month before any member of the party actually saw an individual. The quiet observation of bush birds was rendered difficult by the constant irritation of flies, since it was impossible to remain still for any prolonged interval; nevertheless hours were spent in attempting to localize the birds producing the constantly repeated notes. Some disused nests, possibly of this species were found on Reevesby and Winceby.

(Skin ♂ Winceby; Spirit specimen, Reevesby, Nat. Mus., Melb.)

41. Artamus cyanopterus (Latham).—Dusky Wood Swallow.

Loxia cyanoptera Latham, Ind. Orn. Suppl., 1801, p. 46.

Seen only on Spilsby Island, where it was by no means uncommon among the casurinas. It was even noticed sitting on the fence posts around the homestead.

(Skin ♀ Spilsby, Nat. Mus., Melb.)

42. Xosterops lateralis (Latham).—Grey-backed Silvereye.
Sylvia lateralis Latham, Ind. Orn. Suppl., 1801, p. 55.

By far the most abundant birds on all the islands. Seen everywhere in little parties hunting among the bush. The early morning song is a rather elaborate affair, and differs entirely from the twittering notes uttered by the birds as they pass from bush to bush feeding during the day time. Nests containing young and eggs in all stages of incubation were numerous, and nest-building and laying were going on actively throughout the whole of December.

(Skins ♂ ♂ ♀ Reevesby, Nat. Mus. Melb. ♂ ♂ ♂ ♀ S.A. Mus.)

43. Anthus australis australis Vieillot.—Pipit.
Anthus australis Vieillot, Nouv. Dict. Hist. Nat., xxvi., 1818, p. 501.

Present in small numbers on most islands. Particularly abundant on Marum, Partney, and Hareby.

(Skins ♂ ♀ Reevesby, ♂ Winceby, Nat. Mus., Melb. ♂ ♂ S.A. Mus.)

Introduced Species.

44. Sturnus vulgaris Linnaeus.—Starling.
Sturnus vulgaris Linnaeus, Syst. Nat., 1758, p. 167.

45. Passer domesticus (Linnaeus).—House Sparrow.
Fringilla domestica Linnaeus, Syst. Nat., 1758, p. 183.

Sparrows and starlings are naturally most abundant on Reevesby and Spilsby, where homesteads are situated and farming is carried on; but sparrows were breeding freely in the boxthorn bushes on Lusby.

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Gordon, Alan, B.Sc., c/o Forestry Commission, Public Offices, C.2 .. 1938
Grieve, Brian J., B.Sc., Ph.D., 194 Osborne-street, Williamstown, W.16 1929
Hanks, W., 10 Holroyd-street, Coburg, N.13 1930
Hardy, A. D., 24 Studley-avenue, Kew, E.4 1903
Hauser, H. B., M.Sc., Geology School, University, Carlton, N.3 .. 1919
Head, W. C. E., Harcourt-street, Nathalia 1931
Hoette, Miss Shirley, M.Sc., 23 Moorhouse-street, Armadale, S.E.3 1934
Holland, R. A., 126 Kooyong-road, Caulfield, S.E.7 1931
Holmes, Mrs. S. C. A., M.Sc., Ph.D., "Oakbank," Hampton-grove, Ewell, Surrey 1930
Holmes, W. M., M.A., B.Sc., Observatory, South Yarra, S.E.1 .. 1913
Honman, C. S., B.M.E., Melbourne Technical College, 134 Latrobe-street, C.1. 1934

Jack, A. K., M.Sc., 49 Aroona-road, Caulfield, S.E.7 1913
Jacobson, R., M.Sc., Woodbine-grove, Chelsea 1937
Jessep, A. W., B.Sc., M.Ag.Sc., Dip. Ed., Horticultural Gardens, Burnley, E.1 1927
Jona, J. Leon, M.D., M.S., D.Sc., Lister House, 61 Collins-street, Melbourne, C.1 1914
Keartland, Miss B., M.Sc., 56 Canberra-street, Brunswick, N.10 .. 1919
Lambert, C. A., Carlyon's Hotel, Spencer-street, Melbourne, C.1 .. 1919
Lennox, Mrs. Gordon, M.Sc., c/o C.S.I.R., Box 109, Canberra City, Canberra, F.C.T. 1934
Lindsay, Miss Eder A., B.Agr.Sc., Agriculture School, University, N.3 1936
McCance, D., M.Sc., 144 Gatehouse-street, Parkville, N.2 1931
MacDonald, B. E., "The Heights," 127 Banksia-street, Heidelberg, N.22 1920
McIver, Miss Euphemia, M.Sc., Higher Elementary School, Rochester 1936
McLennan, Assoc. Prof. Ethel, D.Sc., University, Carlton, N.3 .. 1915
Melhuish, T. D'A., M.Sc., Flat 9, Karori, 47 Elizabeth-street, Elizabeth Bay, Sydney 1919
Moore, F. E., O.B.E., Chief Electrical Engineer's Branch, P.M.G.'s Department, Treasury Gardens, East Melbourne, C.2 1920
Morris, P. F., National Herbarium, South Yarra, S.E.1 1922
Newman, B. W., B.Sc., Meteorological Bureau, Sydney 1927
Nicholls, Miss A., B.Sc., 633 Inkerman-road, Caulfield, S.E.7 .. 1929
Nye, E. E., College of Pharmacy, 360 Swanston-street, Melbourne, C.1 1932
Nye, Rev. Edward, B.A., Wesley College, St. Kilda-road, Prahran, S.1 1934
Oke, C., 34 Bourke-street, Melbourne, C.1 1922
Osborne, N., c/o Island Exploration Co., Daru, Papua 1930
Paterson, Miss Helen T., 7 Glan Avon-road, Hawthorn, E.2 .. 1933
Petersen, Miss K., B.Sc., 56 Berkeley-street, Hawthorn, E.2 .. 1919
Prentice, H. J., B.Sc., 218 Esplanade West, Port Melbourne, S.C.1 .. 1936
Pretty, R. B., M.Sc., Technical School, Wonthaggi, Vic. 1922
Raff, Miss J. W., M.Sc., F.R.E.S., University, Carlton, N.3 .. 1910
Rayment, Tarlton, Bath-street, Sandringham, S.8 1929
Refshauge, Miss Lyly D., M.Sc., c/o Forests Commission 1935
Richardson, Sidney C., 2 Geelong-road, Footscray, W.11 1923
Rosenthal, Newman H., B.A., B.Sc., 10 Oulton-street, Caulfield, S.E.7 1921
Rothberg, M., B.Agr.Sc., 1094 Lygon-street, N.4 1937
Sayce, E. L., B.Sc., A.Inst.P., Research Laboratories, Maribyrnong, W.3 1924
Scott, T. R., M.Sc., 7 Garden-street, Hawthorn, E.3 1934
Shaw, Dr. C. Gordon, 75 Clendon-road, Toorak, S.E.2 1931
Sherrard, Mrs. H. M., M.Sc., 43 Robertson-road, Centennial Park, N.S.W. 1918
Smith, J. A., 25 Collins-place, Melbourne, C.1 1905
Stach, L. W., M.Sc., 78 Herbert-street, Albert Park, S.C.6 1932
Sutherland, Miss Jean L., M.Sc., Presbyterian Girls School, Glen Osmond, Adelaide, S.A. 1934

Thomas, L. A., B.Sc., c/o Council for Scientific and Industrial Research, Stanthorpe, Queensland 1930

Traill, J. C., B.A., B.C.E., 630 St. Kilda-road, Melbourne, S.C.3 .. 1903

Trüdinger, W., 27 Gerald-street, Murrumbeena, S.E.9 1918

Tubb, J. A., M.Sc., Fisheries Section, C.S.I.R., Cronulla, N.S.W. .. 1936

Turner, A. W., D.Sc., D.V.Sc., Animal Health Research Laboratory, cr, Flemington-road and Park-street, Parkville, N.2 1925

Vasey, A. J., B.Agr.Sc., "Westaways," Werribee 1937

Wilcock, A. A., B Sc., Dip.Ed., 294 The Avenue, Parkville, N.2 .. 1934

Wilson, F. E., F.E.S., 22 Ferncroft-avenue, E. Malvern, S.E.5 .. 1921

Wilson, Major H. W., O.B.E., M.C., C. de G., B.Sc., 630 Inkerman-road, Caulfield S.E.7 1923

Withers, R. B., B.Sc., Dip. Ed., University High School, Parkville, N.2 1935

Wood, E. J. F., M.Sc., B.A., Fisheries Section, C.S.I.R., Cronulla, N.S.W. 1935

Wood, Assoc. Prof. G. L., M.A., Litt. D., University, Carlton, N.3 .. 1933

Woodburn, Mrs. Fenton, 21 Bayview-crescent, Black Rock, S.9 .. 1930

Wunderly, J., D.D.Sc. (Melb.), 2 Collins-street, Melbourne, C.1 .. 1937

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