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Art. XX.—*A Study of the Batesford Limestone.*

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(With Plates LII.–LV.).

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Contents.

General Description.

The limestones of the Batesford area are of a twofold character. The basal portion of the series, formerly referred to as "Orbitoidal Limestone," is a true *Lepidocyclina*-rock. This rock, in its consolidated form, may be seen in the Upper Quarry, near Batesford, situated on the left bank of the Moorabool River, near the Dog Rocks, and $4\frac{3}{4}$ miles N.E. of Geelong Railway Station. The stone of this Upper Quarry is almost entirely composed of the tests of *Lepidocyclina tournoueri*, *L. marginata*, and *L. martini*. As will be shown in the sequel, the genus *Lepidocyclina* differs fundamentally from the Eocene genus *Orbitoides*, and is, elsewhere, typically Miocene, although occasionally found in the Oligocene.

The limestone of the Upper Quarry is technically known as "Moorabool Stone," and is occasionally used for building purposes. It passes upwards into a friable limestone, comparable to the polyzoal limestone of the Filter Quarries, which is overlain by a marly bed, and lastly covered by a great thickness of basalt. Dr. T. S. Hall and Mr. G. B. Pritchard[1] who have written a comprehensive account of the Tertiaries of the

1 "Notes on the Lower Tertiaries of the Southern Portion of the Moorabool Valley." Proc. Roy. Soc. Vict., vol. iv., pt. i., n.s., 1891, pp. 9-26.

Moorabool Valley, give the details of the hill-section in this locality as follows:—

"Basalt	75	feet.
Incoherent sandy material with calcareous concretions	50	,,
Yellow clay with calcareous concretions	5	,,
Polyzoal limestone	25	,,
Orbitoidal limestone	20	,,
Total	175	feet."

The Dryden or Filter Quarries are situated on the right bank of the Moorabool River, lower down than, and about three-quarters of a mile in a direct line from, the stone quarry. They are of much greater extent than the Moorabool Stone Quarry, the deposit being worked on a large scale by P. McCann and Sons, of Fyansford, for lime-burning, in the manufacture of cement, and for filter blocks. The Filter Quarries extend along the hill-side skirting the Moorabool, and present a section of tolerably uniform appearance. The Dripstone, for filters, is taken from the compact layers at the base of the quarries; the beds vary from 12 inches to 3 feet in thickness. The lower portion measured at one place gave 22 vertical feet of pure white to cream-coloured friable limestone, composed largely of the same foraminifera (*Lepidocyclinae*) as in the Moorabool stone, and gradually passing upwards into polyzoal rock with fewer *Lepidocyclinae*. Over this were seen 14 feet of fine-textured pale bluish clay, which closely resembles the clay of the Waurn Ponds Quarry, both as to lithological characters and microzoic contents. The deepest part of the quarry, measured by the aneroid, was 80 feet to the river.

The Moorabool Limestone is of a yellow or ochreous colour, varying to a reddish brown. The rock of this, the Upper Quarry, is fairly compact, and some portions could be selected which would take a tolerably high polish, the included foraminiferal shells adding to its ornamental appearance. More often, however, the rock is slightly cavernous, but could still be used for building purposes, for which it is eminently suitable, being an even-textured freestone. Mr. W. B. McCann, to whom I

am indebted for some valuable data regarding these quarries, informs me that the stone of the Upper Moorabool Quarry has been used in the erection (facing) of the Malvern Post Office, and the Bendigo Roman Catholic Cathedral. The crushing strength of a 3-inch cube of this stone, as ascertained by Mr. McCann, is 25 tons. The following analyses of the limestone from both quarries were made by Mr. P. G. Bayley, Assoc. S.A.S.M., and for these I am indebted to the Secretary for Mines and Mr. E. J. Dunn, F.G.S., Director of the Geological Survey.

No. 735. "Moorabool Stone." Upper Quarry. Yellowish brown, dense, tough limestone.

No. 736. Filter Quarries. White, soft, friable limestone with slight ferruginous stain.

	735.	736.
SiO_2 - - - -	0.85	1.13
Al_2O_3 - - - -	0.13	0.02
Fe_2O_3 - - - -	1.59	0.58
FeO - - - -	0.18	0.11
MgO - - - -	0.81	1.12
CaO - - - -	53.83	54.13
CO_2 - - - -	42.64	43.05
Na_2O - - - -	trace	trace
K_2O - - - -	0.06	0.05
H_2O+ (above 110° C.) -	0.08	0.11
H_2O- (100° C.) - -	0.20	0.21
TiO_2 - - - -	trace	trace
MnO - - - -	p.n.d.*	trace
CO_2 - - - -	trace	trace
SO_3 - - - -	nil	nil
P_2O_5 - - - -	0.05	0.04
	100.42	100.55

* Under 0.10/°.
Trace indicates under 0.01/°.

The *Lepidocyclina* limestone of the Upper Quarry contains those little discoid foraminifera in great abundance, associated with a small proportion of polyzoa. When a fractured surface is examined by the aid of a lens, the tests are seen scattered

through the mass, generally with no definite arrangement, but occasionally rudely parallel. These conditions were probably induced by the ever-varying minor currents which would naturally occur in the littoral or shallow-water surroundings, most likely existing during the deposition of this rock. In the friable rock of the Filter Quarries may be frequently noticed a rough but unmistakable structure of cross-bedding, especially where the larger *Lepidocyclinae* are unusually abundant.

The microscopic structure of the compact Batesford limestone or "Moorabool Stone," as seen in thin sections, consists of a dense mass of calcareous organisms, chiefly referable to foraminifera and polyzoa. There is usually very little interstitial cement present, and what there is appears as a fine mosaic of calcite crystals. These crystals are also found lining the cavities of the small shells. Along with the encrustation of these calcareous and other grains by carbonate of lime, there has occurred an infiltration of iron oxide, with the result that the interior of the cellular bodies is often coated with it; and the structure of the fossils thereby differentiated by a thin brown deposit, which in some parts definitely crystallizes out as a mass of tiny rhombs, probably of the composition of chalybite. In this way the chambered structure of the foraminifera is, even to the naked eye, rendered distinct, upon the fractured surface of the limestone. The organisms forming the bulk of the limestone, in the order of their relative abundance, are *Lepidocyclinae*, polyzoa, *Amphisteginae*, *Rotalia calcar*, echinoid spines, calcareous algae, *Gypsinae* and *Carpenteriae;* and after these only occasional examples of the rarer foraminifera, and some ostracoda.

The fossil contents of both the friable and the compact limestones are much the same; the comparative paucity in the fossil lists from the Upper Quarry being accounted for by the unfavourable condition of the rock for the extraction of the fossils. It is probable that in some manner this consolidation of the limestone by a deposit of secondary cement is due to the proximity of the granite of the Dog Rocks. Its tenacity of structure and rough grain almost merits the English quarryman's term "ragstone."

Messrs. Hall and Pritchard, in the paper previously referred to, state that the limestone beds show a slight dip to the S.E.

From its proximity to the granite of the Dog Rocks, it is probable that this series immediately overlies it. Indeed, the evidence given me by Mr. McCann strongly points in that direction, for he says that the basal portion of the limestone is rendered so impure and "clinkery" by the included fragments of granite as to be useless for calcining.

As Messrs. Hall and Pritchard imply by their observations, the polyzoal rock forms a continuous series with the lower, *Lepidocyclina* limestone, since "similar foraminifera" occur "freely scattered through it, though its great bulk consists of polyzoa and spines and plates of echinoderms, together with a few lamellibranch shells." Evidence of a sudden change of the local conditions is seen in the sharp transition from polyzoal limestone to yellow clay; yet, as the above authors point out, the fossils of the former rock persist in the clay deposit for the first few feet, when they appear to be extinguished by turbid water conditions.

The only other known locality in Victoria which affords a similar instance of the occurrence of a *Lepidocyclina* limestone is Green Gully, Keilor, noticed by Messrs. Hall and Pritchard in their paper, "A Contribution to Our Knowledge of the Tertiaries in the Neighbourhood of Melbourne."[1] This limestone is of a pale yellow colour, and contains one of the two species of *Lepidocyclina* found in the Batesford limestone, as well as the characteristic *Gypsina howchini* found in that rock. The Keilor rock shows a great lithological variability, since, in close proximity, this limestone is replaced by a calcareous grit, still, however, containing the tests of *Lepidocyclina*, intermingled with echinoid spines and polyzoa. The beds at this exposure are 20 feet in thickness, and rest on the older volcanic series.

The Foraminifera and Ostracoda; Description of New Species and Notes on the more Important Forms.

The groups of the foraminifera and ostracoda have not been systematically worked out for the Batesford Limestone series; hence they are dealt with here in some detail. The list of identifications of foraminifera from these beds by Mr. Howchin

1 Proc. Roy. Soc. Vict., vol. ix., n.s., 1897, p. 211.

is included in Messrs Hall and Pritchard's paper.[1] The forms enumerated are, *Orbitoides*[2] *mantelli*, *Amphistegina* sp., *Operculina* sp., and *Gypsina* sp.

The shallow-water nature of this part of the fauna of the limestone is shown by the occurrence of the minuter forms of foraminifera usually inhabiting areas close to the shore-line, as *Polystomella crispa*, *Truncatulina lobatula*, *Nonionina boueana*, *Rotalia calcar*, and lastly and most important, by the comparatively large discoidal forms, *Cyclocypeus* and *Lepidocyclina*. In connection with this same group of organisms, it is of additional interest to note that several species first described by Dr. H. B. Brady from the "Challenger" collections, dredged in and peculiar to Australian waters, occur in these beds of comparatively remote age; so that these particular species have been persistently local from at least Miocene times, whilst some are also present in homotaxial beds in Europe, as the Miocene of the Vienna Basin.

Through the detailed results of Mr. Howchin's work on the foraminifera found elsewhere, we are enabled to make a general comparison with other tertiary foraminiferal faunas of southern Australia. Thus many of the smaller and commoner species recorded for the first time from these beds have previously occurred in the Balcombian series of the Lower Muddy Creek beds, and in strata of similar age in the neighbourhood of Port Phillip.

The ostracoda are nearly all of living species, and two are even now found in the Southern Ocean, off the Australian coast, viz., *Bairdia foveolata* and *B. amygdaloides*. These and other forms indicate a moderately shallow-water habitat.

FORAMINIFERA.

Fam. Miliolidae.

Miliolina oblonga, Montagu sp.

Vermiculum oblongum, Montagu, 1803, Test. Brit., p. 522, pl. XIV., Fig. 9. *Miliolina oblonga*, Mont. sp., Brady, 1884, Rep. Chall. vol. IX., p. 160, pl. V. Figs. 4*a*, *b*, Chap-

1 Proc. Roy. Soc. Vict., vol. iv., pt. i., 1891, p. 18.

2 Referable to *Lepidocyclina* on account of the spatulate form of the median chamberlets.

man, 1907, Journ. Linn. Soc. London. Zool., vol. XXX., p. 17, pl. II., Fig. 26.

This species has been recorded from the Australian tertiaries, from the lower (Balcombian) and upper (Kalimnan) beds of Muddy Creek, by Mr. Howchin; and from Balcombe's Bay and the Altona Bay Coal-shaft (Balcombian) by the writer.

The present example, from the Filter Quarries, is a fully developed and typical form, and as such denotes a shallow-water habitat. The deeper water blue clays of the Balcombian localities noted above furnish small examples.

Miliolina vulgaris, d'Orbigny, sp.

Quinqueloculina vulgaris, d'Orbigny, 1826, Ann. Sci. Nat., vol. VII., p. 302, No. 33; *Miliolina auberiana*, d'Orb. sp., Brady, 1884, Rep. Chall. vol. IX., p. 162, pl. V., Figs. 8, 9; *M. vulgaris*, d'Orb. sp., Chapman, 1907, Journ. Linn. Soc. Lond. Zool., vol. XXX., p. 18, pl. II., Fig. 32.

The specimens are small, indicating less favourable conditions for growth than those from the blue Balcombian clays. Filter Quarries.

Miliolina polygona, d'Orbigny, sp.

Quinqueloculina polygona, d'Orbigny, 1839, Foram. Cuba, p. 198, pl. XII., Figs. 21-23; *Miliolina polygona*, d'Orb. sp., Chapman, 1907, Journ. Linn. Soc. London. Zool., vol. XXX., p. 18, pl. II. Fig. 29.

This species has been found only once previously in Australian tertiary deposits, in the Balcombian clays of Grice's Creek. Rare; Filter Quarries.

Miliolina ferussacii, d'Orbigny, sp.

Quinqueloculina ferussacii, d'Orbigny, 1826, Ann. Sci. Nat., vol. VII., p. 301, No. 18, Modèle No. 32; *Miliolina ferussacci*, d'Orb. sp., Brady, 1884, Rep. Chall., vol. IX., p. 175, pl. CXIII., Figs. 17, *a*, *b*; Chapman, 1907, Journ. Linn. Soc. Lond. Zool., vol. XXX., p. 19, pl. II., Fig 39.

A minute example of this species was found in the Filter Quarries. It has already been noted by Howchin from the Balcombian of Muddy Creek, and it is not uncommon in beds of similar age at Grice's Creek.

Fam. Lituolidae.

Cyclammina complanata, Chapman.

C. complanata, Chapman, 1904, Rec. Geol. Surv. Vict., vol. I., pt. 3, p. 228, pl. XXII., Fig. 7.

This *Trochammina*-like species is a form apparently restricted to beds of Janjukian age; having been previously described from the Bird Rock Cliffs, and Brown's Creek, between the Aire and Joanna Rivers. The writer had it also from beds of similar age at Waurn Ponds. Filter Quarries; very rare.

Fam. Textulariidae.

Textularia gibbosa, d'Orbigny.

T. gibbosa, d' Orbigny, 1826, Ann. Sci. Nat., vol. p. 262, No. 6. Modèle, No. 28; Howchin, 1889, Trans. R. Soc. S. Aust., vol. XII., p. 6; Chapman, 1907, Journ. Linn. Soc. Lond. Zool., vol. XXX., p. 25, pl. III., Fig. 54.

This is a frequent form in Balcombian and Janjukian beds alike. Filter Quarries.

Textularia gibbosa, var. *tuberosa*, d'Orbigny.

T. tuberosa, d'Orbigny, 1826, Ann. Sci. Nat., vol. VII., p. 263, No. 26; Fornasini, 1889, Boll. Soc. Geol. Ital., vol. VI., p. 161, pl. II., Figs. 2*a*, *b*; *T. gibbosa*, var. *tuberosa*, d'Orb., Chapman, 1907, Journ. Linn. Soc. Lond. Zool., vol. XXX., p. 26, pl. IV., Fig. 76.

This variety is also common to the Balcombian and Janjukian beds of Victoria. It is restricted to tertiary strata, and is typical of the Neogene of Italy. In the recent condition it was found by Dr. H. B. Brady in the N. and S. Atlantic and the S. Pacific; at the latter locality it occurred at depths of 175 and 210 fathoms. Filter Quarries.

Textularia gramen, d'Orbigny.

T. gramen, d'Orbigny, 1846, Foram. Foss. Vienne, p. 248, pl. XV., Figs. 4-6; Howchin, 1889, Trans. R. Soc. S. Aust., vol. XII., p. 7; Chapman, 1907, Journ. Linn. Soc. Lond. Zool., vol. XXX., p. 25, pl. III., Fig. 53.

Well developed examples of this form occur in the Filter Quarries. The species has already been recorded from the Balcombian of Port Phillip and Muddy Creek.

Verneuilina ensiformis, sp. nov. (Plate II., Figs. 1*a*, *b*).

Test triangular, elongate, very slightly tapering; septa nearly flush with the surface, or slightly depressed. Surface of test slightly rough, granulate near the aboral end, but not spinous, as in *V. spinulosa*, Reuss., to which this form bears some resemblance.

Length, .517 mm.; greatest breadth, .224 mm.

Remarks.—This species is probably that referred to by Mr. Howchin[1] as *Verneuilina* sp., and he remarks (loc. cit.) that it resembles *V. spinulosa*, but for the elongate contour, the plane surfaces and absence of spines. Filter Quarries.

Bigenerina (*Siphogenerina*) *conica*, Heron-Allen and Earland.

Bigenerina conica, Heron-Allen and Earland, 1909, Journ. R. Micr. Soc., p. 329, pl. XVI.

This interesting little hyaline species has quite recently been described by the above-named authors, who give some excellent figures of the shell, and good diagrammatic drawings showing the internal structure. The species was previously described from the Paris tertiaries under Gümbel's name of *Clavulina eocaena;* and Heron-Allen and Earland have shown that it is distinct from that species and identical with their Selsey specimens. One of the chief points of interest is their discovery of the same species in washings from the polyzoal rock of the Filter Quarries, near Batesford. So far as I have found, the species is not common. I am indebted to Mr. Earland

1 Trans. Roy. Soc. S. Aust., 1889, vol. xii., p. 7.

for some beautifully preserved specimens from the Filter Quarries, found in material collected by Mr. E. J. Bradley, of South Australia.

Spiroplecta siphonifera, Brady sp. Pl. III. Fig 1.

Textularia siphonifera, Brady, 1881, Quart. Journ. Micr. Sci., vol. XXI., N.S. p. 53. Id., 1884, Rep. Chall., vol. IX., p. 362, pl. XLII., Figs. 25-29. Chapman, 1907, Journ. Linn. Soc. Lond. Zool., vol. XXX., p. 26, pl. III., Fig. 56.

In his description of the above form Dr. Brady mentions that it is "tapering and pointed at the aboral end." A close examination of the Batesford specimens shows the pointed end to be invariably flattened. Upon cutting vertical sections through the test in the plane of compression, it was seen that each commenced with a megalospheric chamber, followed by a short spiral, and that this was immediately succeeded by the normal textularian series. In a specimen examined in this section, the megalosphere has a diameter of 62u. Although formerly referred to the genus *Textularia*, this species, on account of the evidence now brought forward, should be relegated to the genus *Spiroplecta*.

As a recent form Dr. Brady records it from a few localities in the S. Pacific, and in the Gulf of Suez, at depths from 15-40 fathoms. The writer found it at Funafuti at various depths down to 150 fathoms, where it was most abundant. It appears to be confined to coral-reef areas, and consequently only found in tropical or sub-tropical waters, It has occurred in the fossil condition in the Balcombian of Port Phillip.

Common in both Quarries.

Spiroplecta sagittula, Defrance, sp.

Textularia sagittula, Defrance, 1824, Dict. Sci. Nat. vol. XXXII., p. 177; vol. LIII., p. 344; Atlas Conch., p. XIII., Fig. 5. *Spiroplecta sagittula*, Defr. sp., Wright, 1902, Irish Naturalist, vol. XI, p. 211, pl. III., Figs. *a-e*. Chapman, 1907, Journ. Linn. Soc. Lond. Zool., vol. XXX., p. 27, pl. III., Figs. 58, 59.

Typical specimens are not uncommon. They show the spiral commencement very clearly. *S. sagittula* is a common form in the Balcombian, the Janjukian and the Kalimnan series of Victoria. In the Janjukian it has been recorded from Waurn Ponds, near Geelong. In both Upper and Filter Quarries.

Spiroplecta sagittula, Defr. sp., var. *fistulosa*, Brady.

Textularia sagittula, Defr. var. *fistulosa*, Brady, 1884, Rep. Chall., vol. IX., p. 362, pl. XLII., Figs. 19-22. *Spiroplecta sagittula*, Defr. sp. var. *fistulosa*, Brady, Chapman, 1907, Journ. Linn. Soc. Lond. Zool., vol. XXX., p. 27, pl. III., Fig. 60.

Howchin records this form as rare in the Balcombian of Muddy Creek. In the Port Phillip tertiaries it was found to be nearly as common as the specific form. Very rare at Batesford, in the Filter Quarries.

Spiroplecta carinata, d'Orbigny, sp.

Textularia carinata, d'Orbigny, 1826, Ann. Sci. Nat., vol. VII., p. 263, No. 13. *Spiroplecta carinata* d'Orbigny, sp., Chapman, 1907, Journ. Linn. Soc. Lond. Zool., vol. XXX., p. 27, pl. III., Fig. 61.

This species has previously occurred in the Balcombian of Muddy Creek, and the Port Phillip tertiaries.

Very rare in the Filter Quarries.

Gaudryina rugosa, d'Orbigny.

G. rugosa, d'Orbigny, 1840, Mém. Soc. Géol. France, ser. I., vol. IV., p. 44, pl. IV., Figs. 20, 21. Chapman, 1907, Journ. Linn. Soc. Lond. Zool., vol. XXX., p. 28, pl. III. Fig. 64.

Typical, stoutly built tests rather common. It frequently occurs arrested at the triserial stage, and shows a tendency for the salient edges of the test to become slightly serrated, thus approaching *Verneuilina spinulosa*, from which it is separated, however, by the arenaceous structure of the shell.

It has occurred in the Balcombian of Muddy Creek, and the Port Phillip tertiaries. Filter Quarries.

Bulimina elegantissima, d'Orbigny.

B. elegantissima, d'Orbigny, 1839, Foram. Amér. Mérid., p. 51, pl. VII., Figs. 13, 14, Howchin, 1889, Trans. R. Soc. S. Aust., vol. XII., p. 18.

This moderately shallow-water form is also a well-known tertiary fossil. Recorded from both beds at Muddy Creek (Balcombian and Kalimnan) by Howchin. In the Filter Quarries; not uncommon.

Bulimina elegantissima, d'Orb. var. *apiculata*, Chapman.

B. elegantissima, var. *apiculata*, Chapman, 1907, Journ. Linn. Soc. Lond. Zool., vol. XXX., p. 31, pl. IV., Fig. 77.

This variety was originally described from the Balcombian clays of the Port Phillip tertiary beds.

In the Filter Quarries; equally common with the specific form.

Bolivina textilarioides, Reuss.

B. textilarioides, Reuss, 1862, Sitz. d. k. Ak. Wiss. Wien, vol. XLVI., p. 81, pl. X., Fig. 1. Chapman, 1907, Journ. Linn. Soc. Lond. Zool., vol. XXX., p. 31, pl. IV., Fig. 79.

A moderately deep-water form. It has occurred in the Port Phillip tertiaries (Balcombian). Very rare; in the Filter Quarries.

Bolivina punctata, d'Obigny.

B. punctata, d'Orbigny, 1839, Foram. Amér. Mérid., p. 61, pl. VIII., Figs. 10-12. Chapman, 1907, Journ. Linn. Soc. Lond. Zool., vol. XXX., p. 32, pl. IV., Fig. 80.

Common in the Balcombian clays of Muddy Creek, Grice's Creek, and of the Altona Bay Coal-shaft.

Very rare; in the Filter Quarries.

Bolivina limbata, Brady.

B. limbata, Brady, 1884, Rep. Chall. vol. IX., p. 419, pl. LII., Figs. 26-28. Chapman, 1907, Journ. Linn. Soc. Lond. Zool., vol. XXX., p. 32, pl. IV., Fig. 83.

This species has been found in the Victorian tertiaries in the Balcombian of Muddy Creek and Balcombe's Bay.

Occasional specimens met with ; Filter Quarries.

Cassidulina laevigata, d'Orbigny (dentate var.).

C. laevigata, d'Orbigny, 1826, Ann. Sci. Nat., vol. VII., p. 282, pl. XV., Figs. 4, 5 ; Modèle, No. 41. Howchin, 1889, Trans. R. Soc. S. Aust., vol. XII. p. 8.

Previously recorded in the Victorian tertiaries from the Balcombian of Muddy Creek.

A single example of this cosmopolitan species was met with in the Filter Quarries, having the dentate periphery occasionally observed in this form.

Cassidulina calabra, Seguenza sp.

Burseolina calabra, Seguenza, 1879, Formaz. Terz. Reggio, p. 138, pl. XIII., Figs. 7*a*, *b*. *Cassidulina calabra*, Seg. sp., Brady, 1884, Rep. Chall. vol. IX., p. 431, pl. CXIII., Figs. 8*a-c*.

The original specimens were described from the Miocene of Calabria. As a recent form it has occurred at Raine's Islet, Torres Strait, and off Kandavu, Fiji Ids. This is its first occurrence as a tertiary fossil in Australia.

A typical specimen was found at Batesford, in the Filter Quarries.

Cassidulina subglobosa, Brady.

C. subglobosa, Brady, 1884, Rep. Chall. vol. IX., p. 430, pl. LIV., Figs. 17*a-c*. Chapman, 1907, Journ. Linn. Soc. Lond. Zool., vol. XXX., p. 33, pl. IV., Fig. 84.

This form is distinguished from the preceding by the inflated character of the segments and the open-pyriform shape of the aperture.

Very rare in the Filter Quarries.

Ehrenbergina serrata, Reuss.

E. serrata, Reuss, 1849, Denkschr, d. k. Ak, Wiss. Wien, vol. I., p. 377, pl. XLVIII., Figs, 7 *a-c*. Chapman, 1907, Journ. Linn. Soc. Lond. Zool., vol. XXX., p. 33, pl. IV., Figs. 85-87.

Recorded previously from the Balcombian series of Muddy Creek and the Port Phillip tertiaries.

Rare in the Filter Quarries.

Fam. Lagenidae.

Lagena globosa, Montagu sp.

Vermiculum globosum, Montagu, 1803, Test. Brit. p. 523, *Lagena globosa*, Montagu sp., Brady, 1884, Rep. Chall., vol. IX., p. 452, pl. LVI., Figs. 1-3.

Previously recorded from the Balcombian beds of Muddy Creek by Howchin. A single example with a subglobular test and asperous aperture was found in the limestone of the Filter Quarries.

Lagena favosopunctata, Brady.

L. favosopunctata, Brady, 1881, Quart. Journ. Micr. Sci., vol. XXI., N.S. p. 62. Idem, 1884, Rep. Chall., vol. IX., p. 473, pl. LVIII., Fig. 35 ; pl. LIX., Fig. 4 ; pl. LXI., Fig. 2.

This ornate species is extremely rare. In the recent condition it was recorded by Brady from two localities only—viz., Torres Strait, at 155 fathoms, and from the north coast of New Guinea at 17 fathoms. This appears to be its first occurrence in the fossil state.

One specimen, of a globose form, from the Filter Quarries.

Lagena orbignyana, Seguenza sp., var. *clathrata*, Brady.

Lagena clathrata, Brady, 1884, Rep. Chall., vol. IX, p. 485, pl. LX., Fig. 4. *L. orbignyana*, Seg. sp., var. *clathrata*, Brady, Millett, 1901, Journ. R. Micr. Soc., p. 628, pl. XIV., Fig. 23.

As a fossil this species is new to the Australian region. In the recent condition it has been recorded from Galway (Balkwill and Millett); from New Guinea, off the Ki Ids., and off Aru Id. (Brady); from the Malay Archipelago (Millett); and from the S. of New Zealand (Chapman Ms.).

A single specimen occurred in the Filter Quarries.

Nodosaria (Dentalina) pauperata, d'Orbigny sp.

Dentalina pauperata, d'Orbigny, 1846, Foram. Foss. Vienne, p. 46, pl. I., Figs. 57, 58.

Recorded by Howchin from both Balcombian and Kalimnan beds at Muddy Creek. One example from the Filter Quarries.

Nodosaria (Dentalina) consobrina, d'Orbigny sp.

Dentalina consobrina, d'Orbigny, 1846, Foram, Foss. Vienne, p. 46, pl. II., Figs. 1-3.

This species has been recorded previously only from the Kalimnan beds of Victoria, at Muddy Creek, by Mr. Howchin.

Not uncommon in the Filter Quarries.

Nodosaria (Dentalina) soluta, Reuss sp.

Dentalina soluta, Reuss, 1851, Zeitschr, d. deutsch, Gellsch., vol. III., p. 60, pl. III., Figs. 4*a*, *b*.

A fragmentary specimen found. This species is noted by Howchin from the Balcombian of Muddy Creek. It is a common form in the Port Phillip tertiaries of the same age, and I have also found it less frequently in Janjukian beds at Torquay, and in the Kalimnan at Jemmy's Point (T. S. Hall coll.). Filter Quarries.

Nodosaria (Dentalina) obliqua, Linné sp.

Nautilus obliquus, Linné, 1767, Syst. Nat., 12th. ed., p. 1163, 281;-1788, Ibid. 13th. (Gmelin's) ed., p. 3372, No. 14.

This species is not at all rare at Batesford. The specimens are shorter and stouter than those dredged off the coast of New Zealand, near Gt. Barrier Id. Filter Quarries.

Nodosaria scalaris, Batsch sp.

Nautilus (Orthoceras) scalaris, Batsch, 1791, Conchyl. des Seesandes, No. 4, pl. II. Figs. 4*a*, *b*. *Nodosaria scalaris*, Batsch sp., Brady, 1884, Rep. Chall., vol. IX., p. 510, pl. LXIII. Figs. 28-31.

As a recent form this species is usually found in shallow water. It is also well known as a tertiary fossil.

One example from the Filter Quarries.

Nodosaria badenensis, d'Orbigny.

N. badenensis, d'Orbigny, 1846, Foram. Foss. Vienne, p. 38, pl. I., Figs. 34, 35.

This is a short, stout form allied to the better known *N. raphanus*. It is typical of the Vienna Basin fauna, and occurs throughout the greater part of our Victorian tertiary strata.

One typical specimen from the Lepidocyclina rock of the Filter Quarries.

Cristellaria crepidula, Fitchtel and Moll sp.

Nautilus crepidulus, Fichtel and Moll, 1798, Test. Micr., p. 107, pl. XIX. Figs. G-I.

Good typical examples of this variable form were found in the *Lepidocyclina* rock of the Filter Quarries.

Cristellaria crepidula, F. and M. sp., var. *arcuata*, d'Orbigny.

Cristellaria arcuata, d'Orbigny, 1846, Foram. Foss. Vienne, p. 87, pl. III. Figs. 34-36.

A specimen was found in the limestone of the Filter Quarries, which closely matches the above variety described by d'Orbigny from the Miocene of the Vienna Basin. It represents the broad curved form which centres round *C. crepidula* as the type, and which is more elongate.

Cristellaria crepidula, F. and M. sp., var. *gladius*, Philippi var.

Marginulina gladius, Philippi, 1843, Tertiär nordwest. Deutsch., p. 40, pl. I. Fig. 37. *Cristellaria crepidula*, F. and M. sp., var. *gladius*, Philippi, Burrows and Holland, 1897, Proc. Geol. Assoc., vol. XV. p. 40, pl. I., Figs. 6, 9, 16.

This is another of the many varieties of *C. crepidula*, and is distinguished by the extraordinary elongation of the test. It somewhat resembles *C. schloenbachi* of Reuss, but is more regular in outline and evenly curved.

Found in the Filter Quarries.

Cristellaria articulata, Reuss sp.

Robulina articulata, Reuss, 1863, Sitz. d. k. Ak. Wiss. Wien. vol. XLVIII. p. 53, pl. V., Fig. 62.

Typical specimens occur in the limestone of the Filter Quarries. This species was met with by Howchin in the Balcombian of Muddy Creek. It is rather rare as a fossil form, but is abundant in certain dredgings in New Zealand waters and elsewhere.

Cristellaria rotulata, Lamarck sp.

Lenticulites rotulata, Lamarck, 1804, Annales du Muséum. vol. V., p. 188, No. 3. Tableau Encycl. et. Méth. pl. CCCCLXVI., Fig. 5. *Cristellaria rotulata*, Lam. sp., Brady, 1884, Rep. Chall., vol. IX., p. 547, pl. LXIX. Figs. 13*a*, *b*.

A few examples of this common species were found in the limestone of the Filter Quarries. Howchin records it from the Balcombian of Muddy Creek.

Polymorphina gibba, d'Orbigny.

P. (Globulina) gibba, d'Orbigny, 1826, Ann. Sci. Nat., vol. VII., p. 266, No. 20; Modèle, No. 63. *Globulina gibba*, d'Orb., 1846, Foram. Foss. Vienne, p. 227, pl. XIII., Figs. 13, 14.

Recorded by Howchin from the Kalimnan and Balcombian of Muddy Creek; and from the Kent Town Bore, Adelaide (Barwonian).

Rare in the limestone of the Filter Quarries.

Polymorphina compressa, d'Orbigny.

P. compressa, d'Orbigny, 1846, Foram. Foss. Vienna, p. 233, pl. XII., Figs, 32-34. *P. lactea*, var. *oblonga*, Williamson, 1858, Rec. Foram. Gt. Brit., p. 71, pl. VI., Fig. 149, 149*a*.

A variety with a granulose surface occurs in the limestone of the Filter Quarries. Howchin records this species from the upper beds of Muddy Creek (Kalimnan).

Polymorphina oblonga, d'Orbigny.

P. oblonga, d'Orbigny, 1846, Foram. Foss. Vienne, p. 232, pl. XII., Figs, 29-31.

Recorded by Howchin from both series at Muddy Creek. Not uncommon in the Filter Quarries.

Polymorphina elegantissima, Parker and Jones.

P. elegantissima, Parker and Jones, 1864, Phil. Trans., vol. CLV., Table X., p. 438, Brady and Jones, 1870, Linn. Soc. Lond., vol. XXVII., p. 231, pl. XL., Fig. 15. H. B. Brady, 1884, Rep. Chall., vol. IX., p. 566, pl. LXII., Figs. 12-15. Chapman, 1907, Journ. Quekett Micr. Club, p. 132, pl. X., Fig. 3.

This species is a common form in the Victorian tertiaries, and has been recorded by Howchin from both series of strata at Muddy Creek. The examples from the *Lepidocyclina* rock of the Filter Quarries at Batesford show a wide range of variation, from the broad, triangular form to the slender, elongate variety ; and all showing the vertically elongated and sickle-ended segments typical of this species. As a living form it is remarkable for its peculiarly Australian distribution, the only exceptional localities being Raine Islet and Hong Kong Harbour. A closely related, if not identical form, is *P. problema*, var. *deltoidea*, Reuss, which occurs in the Septarian Clays (Oligocene) of Germany.

Polymorphina regina, Brady, Parker and Jones.

P. regina, B.P. and J., 1870, Trans. Linn. Soc. Lond., vol. XXVII., p. 241, pl. XII., Fig. 32.

A small, thin-shelled form of this beautiful species occurred in the Lepidocyclina rock of the Filter Quarries. Howchin records it from the Balcombian of Muddy Creek, and from the Kent Town Bore, Adelaide (Barwonian). In the recent condition Brady found it limited to shallow water in the Pacific. Egger records it from Kerguelen Id. at 57 fathoms; and Millett from comparatively shallow water in the Malay Archipelago. From Victorian waters the writer obtained it in some abundance from Altona Bay.

Uvigerina angulosa, Williamson.

U. angulosa, Williamson, 1858, Rec. Foram. Gt. Brit., p. 67, pl. V., Fig. 140. Flint, 1899, Rep. U.S. Nat. Mus., for 1897, p. 320, pl. LXVIII., Fig. 3.

A small but otherwise typical specimen found in the Filter Quarries. Howchin records it from the Barwonian of the Kent Town Bore, Adelaide.

Fam. Globigerinidae.

Globigerina triloba, Reuss.

G. triloba, Reuss, 1849, Denkschr, Akad. Wiss. Wien, vol. I., p. 374, pl. XLVII., Fig. 11. *G. bulloides*, d'Orbigny, var. *triloba*, Reuss, Howchin, 1889, Trans. R. Soc.. S. Aust., col. XII., p. 11. *G. triloba*, Reuss, Chapman, 1907, Journ. Quekett Micr. Club, ser. 2, vol. X., p. 133.

As a tertiary form this is met with in the Balcombian beds of Muddy Creek and elsewhere in Victoria. It was found by the writer as a recent form, at Beaumaris and Torquay. It is not uncommon in the Filter Quarries, and a related shell occurs in thin sections of the *Lepidocyclina* rock of the Upper Quarry.

Sphaeroidina bulloides, d'Orbigny.

S. bulloides, d'Orbigny, 1826, Ann. Sci. Nat., vol. VII., p. 267, No. 1; Modèle, No. 65, Flint, 1899, Rep. U.S. Nat. Mus., for 1897, p. 325, pl. LXXI., Fig. 1.

This interesting little form, doubtfully pelagic, is moderately common in washings from the *Lepidocyclina* rock of the Filter Quarries. It has been recorded from the Balcombian of Muddy Creek by Mr. Howchin.

Fam. Rotaliidae.

Spirillina cf. *inaequalis*, Brady.

S. inaequalis, Brady, 1884, Rep. Chall. vol. IX., p. 631, pl. LXXXV. Figs. 8-11.

A single example was found in the rock from the Filter Quarries. It is concave on one face, and slightly convex on the other. The periphery is rounded rather than flat, as in Brady's figured examples. Otherwise it agrees in general characters with the above species. Howchin found *S. inaequalis* in the Balcombian of Muddy Creek. As a living form it seems confined to the southern hemisphere, in the region round Australia and the S. Pacific.

Discorbina orbicularis, Terquem sp.

Rosalina orbicularis, Terquem, 1876, Anim, sur la Plage de Dunkerque,, p. 75, pl. IX. Figs. 4*a*, *b*. *Discorbina orbicularis*, Terq. sp. Egger, 1893, Abhand, k. bayer, Akad. Wiss., Cl. II., vol. XVIII., p. 389, pl. XV. Figs. 16-18, 76-78.

An example of this little shallow-water form was found in the *Lepidocyclina* rock of the Filter Quarries. It is more convex on the superior face than usual. *D. orbicularis* is a well-known species in Miocene and Pliocene strata, and has also occurred in beds as old as the Lower Cretaceous in England. Howchin records it from the Balcombian of Muddy Creek.

Discorbina pileolus, d'Orbigny sp.

Valvulina pileolus, d'Orbigny, 1839, Foram. Amér. Mérid., p. 47, pl. I., Figs. 15-17. *Discorbina pileolus*, d'Orb. sp., Brady, 1884, Rep. Chall., vol. IX.,. p. 649, pl. LXXXIX., Figs. 2-4.

An Eocene and Miocene species in Europe. Howchin found it in only the Kalimnan beds of Muddy Creek. As a living foraminifer it affects quite shallow water.

Two specimens from the Filter Quarries; one being a double form, in plastogamic union.

Discorbina dimidiata, Parker and Jones.

D. dimidiata, Parker and Jones, 1862, in Carpenter, Parker and Jones' Introd. Study Foram., p. 201, Fig. XXXIIB. Parker and Jones, 1865, Phil. Trans., vol. CLV., pp. 385, 422, pl. XIX., Figs. 9*a-c*. Chapman, 1907, Journ. Quekett Micr. Club, ser. 2, vol. X., p. 136, pl. X., Figs. 8*a*, *b*.

It is of much interest to record this living Australian species from our older tertiary strata. The specimens are quite typical. Rare in the rock at the Filter Quarries.

Discorbina valvulata, d'Orbigny sp.

Rosalina valvulata, d'Orbigny, 1826, Ann. Sci. Nat., vol. VII., p. 271, No. 4. *Discorbina valvulata*, d'Orb., Brady, 1884, Rep. Chall., vol. IX., p. 644, pl. LXXXVII., Figs. 5-7.

As a living form this species is typical of the shallow waters of the Australian coast. The writer found it in shore sand at Torquay. Howchin records it from Post-tertiary beds at Port Adelaide. Moderately common in the limestone of the Filter Quarries.

Discorbina biconcava, Parker and Jones.

D. biconcava, Parker and Jones, 1865, Phil. Trans., vol. CLV., p. 422, pl. XIA., Figs. 10*a-c*. Brady, 1884, Rep. Chall. vol. IX., p. 653, pl. XCI., Figs. 2, 3.

The test of one of the Filter Quarry specimens is slightly hispid. Another found here is of exceptionally large size. This species is found still living on the Victorian coast.

Discorbina polystomelloides, Parker and Jones.

D. polystomelloides, P. and J., 1865, Phil. Trans. vol. CLV., p. 421, pl. XIX., Figs. 8*a-c*. Brady, 1884, Rep. Chall., vol. IX., p. 652, pl. XCI., Figs. 1*a-c*.

At the present time this species lives amongst the islands S. of New Guinea. Howchin records it from the Kalimnan and Balcombian of Muddy Creek. One specimen in the rock of the Filter Quarries.

Planorbulina larvata, Parker and Jones.

P. larvata, Parker and Jones, 1865, Phil. Trans. vol. CLV., p. 380, pl. XIX., Figs. 3*a*, *b*. Brady, 1884, Rep. Chall. vol. IX., p. 658, pl. XCII., Figs. 5, 6.

It is of interest to note that as a living species this form is only found in tropical areas, and especially in the sands of coral islands. In the fossil condition Howchin records it from the Balcombian of Muddy Creek, where it is moderately common.

This species is also fairly common at Batesford. The specimens from the limestone of the Filter Quarries are diminutive, with thin tests. Those from the *Lepidocyclina* limestone of the Upper Quarry are, as a rule, stouter, and with very conspicuous peripheral chambers.

Truncatulina refulgens, Montfort sp.

Cibicides refulgens, Montfort, 1808, Conchyl. System., vol. I., p. 122, 31^{e} genre. *Truncatulina refulgens*, Montf., sp., Brady, 1884, Rep. Chall. vol. IX., p. 659, pl. XCII., Figs. 7-9.

Somewhat rare in the foraminiferal rock of the Filter Quarries. Not previously recorded as a fossil from the Australian tertiary beds.

Truncatulina lobatula, Walker and Jacob sp.

Nautilus lobatulus, Walker and Jacob, 1798, Adams' Essays, Kanmacher's Ed., p. 642, pl. XIV., Fig. 36.

Typical specimens are not uncommon in the foraminiferal rock of the Filter Quarries. Howchin records this species from the Kalimnan, near Adelaide, and the Balcombian of Muddy Creek.

Truncatulina variabilis, d'Orbigny.

T. variabilis, d'Orbigny, 1826, Ann. Sci. Nat., vol. VII., p. 279, No. 8. Brady, 1884, Rep. Chall., vol. IX., p. 661, pl. XCIII., Figs. 6, 7.

This wild-growing modification of the preceding species is also moderately frequent in the limestone of the Filter Quarries. Howchin records it from the Balcombian of Muddy Creek.

Truncatulina tenuimargo, Brady.

T. tenuimargo, Brady, 1884, Rep. Chall. vol. IX., p. 662, pl. XCIII., Figs. 2, 3.

As a recent species this is frequently met with in Australian seas. It does not appear to have been previously noticed as a fossil form. A fine example from the Filter Quarries.

Truncatulina wuellerstorfi, Schwager sp.

Anomalina wuellerstorfi, Schwager, 1864, Novara-Exped., Geol. Theil, vol. II., p. 258, pl. VII., Figs. 105, 107.

Rare in the limestone of the Filter Quarries. In the living condition it is usually found in deep-water ooze. The original specimens of Schwager's came from the Pliocene of Kar Nikobar.

Truncatulina ungeriana, d'Orbigny sp.

Rotalina ungeriana, d'Orbigny, 1846, Foram. Foss. Vienne, p. 157, pl. VIII., Figs. 16-18. *Truncatulina ungeriana*, d'Orb. sp., Brady, 1884, Rep. Chall., vol. IX., p. 664, pl. XCIV., Figs. 9*a-c*.

A moderately common form in the limestone of the Filter Quarries. It is well distributed throughout the Victorian ter-

tiaries. It has been recorded from the Balcombian of Muddy Creek and the Barwonian of Mount Gambier, the Murray Flats and Adelaide. Also from the Kalimnan of Muddy Creek.

Truncatulina reticulata, Czjzek sp.

Rotalina reticulata, Czjzek, 1848, Haidinger's Naturw. Abhandl., vol. II., p. 145, pl. XIII., Figs, 7-9.

Occasional examples found in the Filter Quarries. Recorded from the Balcombian of Muddy Creek, the Barwonian of Mount Gambier and the Murray Flats. Also from the Kalimnan of Muddy Creek.

Anomalina ammonoides, Reuss sp.

Rotalina ammonoides, Reuss, 1845, Verstein, böhm. Kreidef., pt. 1, p. 36, pl. XIII., Fig. 66; pl. VIII., Fig. 53. *Anomalina ammonoides*, Reuss sp., Brady, 1884, Rep. Chall. vol. IX., p. 672, pl. XCIV., Fig. 2, 3.

Recorded by Howchin from both Kalimnan and Balcombian beds at Muddy Creek, and from the Adelaide Bore (Kent Town). One specimen from the Filter Quarries.

Anomalina grosserugosa, Gümbel sp.

Truncatulina grosserugosa, Gümbel, 1870, Abhandl. k. bayer, Ak. Wiss., vol. IX., p. 660, pl. II., Figs. 104*a*, *b*. *Anomalina grosserugosa*, Gümbel sp., Sherborn and Chapman, 1889, Journ. R. Micr. Soc., p. 487, pl. XI., Fig. 34.

In the living condition this form inhabits moderately deep water. A few typical examples from the Filter Quarries.

Carpenteria proteiformis, Goës,

C. balaniformis, Gray, var. *proteiformis*, Goës, 1882, K. Svenska, Vet.-Akad. Handl., vol. XIX., No. 4, p. 94, pl. VI., Figs. 208-214; Pl. VII., Figs. 215-219. *C. proteiformis*, Goës, Brady, 1884, Rep. Chall., vol. IX., p. 679, pl. XCVII., Figs. 8-14.

As a recent form this species shows a restricted range, and is apparently confined to coral seas. It occurs in the W. Indies,

and at a few localities in the Eastern Archipelago. *C. proteiformis* has been previously recorded as a fossil from the Balcombian of Muddy Creek by Mr. Howchin.

It is not uncommon both in the Filter Quarries and the Upper Quarry; the specimens met with show a wide range of variation.

Pulvinulina punctulata, d'Orb. sp.

P. punctulata, d'Orb. sp., Brady, 1884, Rep. Chall., vol. IX., p. 685, pl. CIV., Figs, 17*a-c*.

The peripheral edge of our specimen is more evenly rounded than usual. The surface is coarsely pitted, the sutures deeply marked, and the inferior surface tends to become granulate at the umbilicus, as in *Discorbina*, to which this form bears some affinity. *P. punctulata* does not seem to have been previously noticed in the Australian tertiaries, but it is known from tertiary strata in other parts of the world.

One specimen from the Filter Quarries.

Pulvinulina concentrica, Parker and Jones.

P. concentrica, Parker and Jones, 1864 (in Brady), Trans. Linn. Soc. Lond., vol. XXIV., p. 470, pl. XLVIII., Fig. 14. Parker and Jones, 1865, Phil. Trans., vol. CLV., p. 393, Brady, 1884, Rep. Chall., vol. IX., p. 686, pl. CV., Figs. 1*a-c*.

P. concentrica occurs as a fossil in the Miocene of Southern Italy. It was figured by Seguenza under the name of *Discorbina vestita*. As a recent form it was found, among other localities, off Kandavu, Fiji Ids., and off Raine Islet, Torres Strait.

Rare in the Filter Quarries.

Pulvinulina partschiana, d'Orbigny sp.

Rotalina partschiana, d'Orbigny, 1846, Foram. Foss. Vienne, p. 153, pl. VII., Figs. 28-30; pl. VIII., Figs. 1-3. *Pulvinulina partschiana*, d'Orbigny, sp., Brady, 1884, Rep. Chall., vol. IX., p. 699, pl. CV., Fig. 3.

In the living condition this form is usually found in deep water. Recorded by Howchin from the Balcombian of Muddy Creek.

Typical specimens, of fair size, are moderately common in the foraminiferal rock of the Filter Quarries.

Pulvinulina elegans, d'Orbigny sp.

Rotalia (Turbinulina) elegans, d'Orbigny, 1826, Ann. Sci. Nat., vol. VII., p. 276, No. 54.

The specimens found in the Batesford Limestone have a sharp periphery, but are otherwise typical. This form has been recorded from the Australian tertiaries, but only from the Murray Flats.

Very rare; Filter Quarries.

Pulvinulina scabricula, sp. nov. Pl. II., Figs. 2*a*, *b*.

Description.—Test trochoid; superior face moderately convex to tumid; whorls numerous; inferior face slightly convex, with sutures of last whorl well-marked; umbilicus with a callosity. Both surfaces of test finely and densely pitted; peripheral edges granulate to hispid. Greatest breadth of figured specimen, .414mm.; thickness at umbilical axis, .267mm.

Moderately common in the foraminiferal rock of the Filter Quarries.

Pulvinulina pulchella, d'Orbigny sp.

Rotalia pulchella, d'Orbigny, 1826, Ann. Sci. Nat., vol. VII., p. 274, No. 32. *Pulvinulina pulchella*, d'Orb. sp., Jones, Parker and Brady, 1866, Foram. Crag, Pal. Soc. Mon., vol. XIX. pl. II., Figs. 25-27.

This is a form like *P. elegans*, but with thickened sutures to the chambers. It has been recorded by Tenison Woods and Howchin from the Balcombian beds at Muddy Creek.

Frequent in the Filter Quarries.

Pulvinulina schreibersii, d'Obigny sp.

Rotalina schreibersii, d'Orbigny, 1846, Foram. Foss. Vienne, p. 154, pl. VIII., Figs 4-6. *Pulvinulina schreibersii*, d'Orb. sp., Brady, 1884, Rep. Chall., vol. IX., p. 697, pl. CXV., Figs 1*a-c*.

The more depressed varieties have a sharp peripheral keel. *P. schreibersii* was recorded by Howchin from the Balcombian of Muddy Creek.

Frequent in the foraminiferal rock of the Filter Quarries.

Rotalia clathrata, Brady.

Rotalia clathrata, Brady, 1884, Rep. Chall., vol. IX., p. 709, pl. CVII., Figs. 8, 9. Howchin, 1889, Trans. R. Soc. S. Aust., vol. XII., p. 15.

It interesting to note the occurrence of this species as a fossil in the Balcombian series in Victoria. At Muddy Creek Mr. Howchin found it to be moderately common; and it has also occurred in the Janjukian at several localities examined by the writer; whilst in the Kalimnan it is an exceptionally abundant form. The species seems to be restricted to a very limited area at the present day, for Brady records it only from four localities between Bass Strait (at Moncoeur Id.) and Cook Strait, New Zealand; and from two stations on the West Coast of Patagonia. These localities are practically co-extensive with the Middle Tertiary shore-line, which had so many species of mollusca in common, embracing the Santa Cruz series of Patagonia, the Oamaru series of New Zealand, and the Barwonian of Victoria. The tests of *R. clathrata* from the Janjukian are more heavily built than those from the Kalimnan and Recent deposits.

Very common in the Batesford Limestone at both Quarries.

Rotalina calcar, d'Orbigny, sp. Pl. III. Fig. 2.

Calcarina calcar, d'Orbigny, 1826, Ann. Sci. Nat., vol. VII., p. 276, No. 1; Modèle, No. 34. Id., 1839, Foram. Cuba, p. 93, pl. V., Figs. 22-24. *Rotalia calcar*, d'Orbigny sp., Brady, 1884, Rep. Chall., vol. IX., p. 709, pl. CVIII., Fig. 3.

A very striking species, and, next to the *Lepidocyclinae* and the *Amphisteginae*, the most abundant form in the Batesford Limestone. The ornament consists of numerous papillae of supplemental shell-growth, a thickened umbilicus, ridged and papillate intersutural areas on the superior face, and angular or bluntly pointed peripheral spines. The distribution of *Rotalia calcar* at the present day is wide, but confined chiefly to the coral seas.

As a fossil it is known from beds as old as the Middle Eocene. It has already been recorded, as a rare form, from the Balcombian of Muddy Creek, by Howchin.

Very abundant in the *Lepidocyclina* limestone of the Filter Quarries and the Upper Quarry.

Gypsina globulus, Reuss sp.

Ceriopora globulus, Reuss, 1847, Haidinger's Naturw. Abhandl., vol. II., p. 33, pl. V., Fig. 7. *Gypsina globulus*, Reuss sp., Brady, 1884, Rep. Chall., vol. IX., p. 717, pl. CI., Fig. 8.

Howchin records this species as a fossil from both beds at Muddy Creek; in the Balcombian it is common, and in the Kalimnan rather scarce. *G. globulus* is moderately common in the foraminiferal rock of the Filter Quarries, and the specimens are generally less than the average size.

Gypsina vesicularis, Parker and Jones sp.

Orbitolina vesicularis, Parker and Jones, 1860, Ann. and Mag. Nat. Hist., ser. 3, vol. VI., p. 31, No. 5. *Gypsina vesicularis*, Brady, 1884, Rep. Chall., vol. IX., p. 718, pl. CI., Figs. 9-12.

This and the foregoing species date their first appearance as fossils from the Miocene; being found in beds of that age in Austria, Hungary, the S. of France and the W. Indies. At the present day they are almost confined to coral seas, although

the two species are occasionally met with on the Atlantic seaboard of the British Ids.

G. vesicularis is recorded by Howchin from Muddy Creek; as being common in the Balcombian and rare in the Kalimnan. It is interesting thus to note the certain influence of climatic changes.

In the Filter Quarries, not common. Specimens rather small.

Gypsina howchini, sp. nov. Pl. II., Figs. 4*a*, *b*; pl. III., Figs. 3-5.

Description.—Test discoidal; opposite faces more or less slightly convex, rarely flat, or more rarely slightly concave. Surface granulate to pustular, as in *G. vesicularis*. Chamberlets numerous, with a sub-concentric arrangement. Shell-wall coarsely perforate. Central series of chambers globigeriniform and surrounded by a series of small chamberlets, which in turn is succeeded by the larger, normal chamberlets. No marked differentiation of the chamberlets along the median plane when examined in vertical section, except in their being more spacious in occasional specimens.

Diameter of test, 1.5 to 2.4mm.

Observations.—A reference to the genus *Gypsina* as occurring in the Upper Quarry at Batesford is made by Messrs. T. S. Hall and G. B. Pritchard in their paper on the Lower Tertiaries of the Moorabool Valley, which in all probability is the form above described. I have much pleasure in naming this species after Mr. W. Howchin, who determined the genus for the above-named authors.

G. howchini is a very distinct form in the Batesford limestone. It has the coarsely perforate structure of the chamberlets seen in *G. vesicularis*, P. and J. sp., but is invariably discoidal. Dr. Goës figured a recent variation of the latter type, from the Carribean Sea,[1] which he named *G. vesicularis*, var. *discus:* that form, however, has a differentiated median layer of chamberlets as in the Miocene genus *Miogypsina*, but without the vertical pillars, and the shell-wall is usually thinner. It is probable that the species now described is a climatal modifi-

1 Bull. Mus. Comp. Zool., Harvard Coll., vol. xxix., No. i., 1891, pl. vii., figs. 5, 4-6.

cation of the Miocene form, since both types occur in beds of the same age, characterised by the same species of Lepidocyclines, that is to say, the Miocene beds in the E. Indies contain *Lepidocyclina marginata* and *Miogypsina*,[1] whilst at Batesford the *L. marginata* is accompanied by *Gypsina howchini*. The *Miogypsinae* of the Miocene and the related *Gypsina vesicularis* var. *discus* are both typical of coral seas.

Common in the *Lepidocyclina* limestone of both Quarries.

Polytrema minutum, sp. nov. Pl. II., Figs. 3*a*, *b*.

Description.—Test very small; conical, with a spreading base. Body of test slender, and with minute branches. Chamberlets minute.

Width of base, .93 mm.; height, .517 mm.

Observations.—This is an exceeding small and neat modification of *P. miniaceum*, and may be distinguished from that form by the almost perfectly circular base, short habit and slender branches.

Two specimens from the foraminiferal rock of the Filter Quarries.

Family Nummulinidae.

Nonionina umbilicatula, Montagu sp.

Nautilus umbilicatulus, Montagu, 1803, Test. Brit., p. 191; Suppl., p. 78, pl. XVIII., Fig. 1.

Previously recorded from the Balcombian of Muddy Creek by Howchin.

One specimen in the foraminiferal rock of the Filter Quarries.

Nonionina boueana, d'Orbigny.

Nonionina boueana, d'Orbigny, 1846, Foram. Foss. Vienne, p. 108, pl. V., Figs. 11, 12.

The nearest locality where this species now lives appears to be the West Coast of Patagonia. It is a common Upper Oligocene and Miocene form. The species is new to the Australian Tertiary fauna.

A typical specimen from the Filter Quarries.

1 Miogypsina, according to Vraldenberg, has not yet been met with in India.

Polystomella subnodosa, Münster sp.

Robulina subnodosa, Münster, 1838 (fide Roemer), Neues Jahrb, für, Min., etc., p. 391, pl. III., Fig. 61. *Polystomella subnodosa*, Münster sp., Brady, 1884, Rep. Chall. vol. IX., p. 734, pl. CX., Figs. 1*a*, *b*.

Howchin has noted this species from Muddy Creek, but only from the Upper Beds. One specimen from the Filter Quarries.

Polystomella antonina, d'Orbigny. Pl. II., Figs 5*a*, *b*.

P. antonina, d'Orbigny, 1846, Foram. Foss. Vienne, p. 128, pl. VI., Fig. 17, 18.

This species somewhat resembles *P. subnodosa*, Münst. sp., but differs in its much greater umbilical diameter, in the fewer exposed chambers, and in its coarse septal bars. It has been previously recorded only from the Miocene of the Vienna Basin.

Three examples from the Filter Quarries.

Polystomella crispa, Linné sp.

P. crispa, Linné sp., Brady, 1884, Rep. Chall. vol. IX., p. 736, pl. CX., Figs. 6, 7.

Recorded only from the later Tertiary beds by Howchin, viz., from N.W. Bend, Adelaide, and Muddy Creek (Kalimnan).

A few examples met with in the limestone of the Filter Quarries.

Polystomella verriculata, Brady.

P. verriculata, Brady, 1884, Rep. Chall., vol. IX., p. 738, pl. CX., Figs. 12*a*, *b*.

As a living form this species is practically restricted to its early Tertiary geographical position, it having been found off E. Moncoeur Id., Bass Strait, and in Curtis Strait, Queensland, by the "Challenger."

Howchin records this species as rare at Muddy Creek (Balcombian).

A few examples found in the Filter Quarries.

Amphistegina lessonii, d'Orbigny, Pl. III., Fig. 6.

A. lessonii, d'Orbigny, 1826, Ann. Sci. Nat., vol. VII., p. 304, No. 3, pl. XVII., Figs. 1-4 *A. hauerina*, Id., 1846, Foram. Foss. Vienne, p. 267, pl. XII., Figs. 3-5. *A. campbelli*, Karrer, 1864, Novara Exped., Geol. Theil, vol. I., p. 84, pl. XVI., Fig. 18. *A. aucklandica*, Id., 1864, ibid., p. 85, pl. XVI., Fig. 19. *A. lessonii*, d'Orb., Brady, 1884, Rep. Chall., vol. IX., p. 740, pl. CXI., Figs. 1-7.

The majority of specimens found in the Batesford limestone are of the compressed lenticular variety, as typified in *A. hauerina* of the Vienna Miocene, and some examples attain a fair size, often as much as 2.5mm. in diameter. They are frequently so nearly equilateral as to closely resemble the small species of Nummulites like *N. variolaria*. The resemblance, however, is only external, since a cross-section reveals the unequal umbilical cones and the one-sided alar overlap of the septal margin.

A. lessonii is very common in the upper portion of the beds, the polyzoal rock, taking the place of the *Lepidocyclinae* of the lower beds. Both Quarries.

Operculina complanata, Defrance sp.

Lenticulites complanata, Defrance, 1822, Dic. Sci. Nat., vol. XXV. p. 453. Operculina complanata, Defr. sp., Brady, 1884, Rep. Chall., vol. IX., p. 743, pl. CXII., Figs. 3, 4, 5, 8.

Occasional ; in the limestone of the Filter Quarries and in the Upper Quarry.

Operculina complanata, Defr. sp., var. *granulosa*, Leymerie.

Operculina granulosa, Leymerie, 1846, Mém. Soc. Géol. France, sér. 2, vol. I., p. 359, pl. XIII., Figs. 12*a*, *b*.

Tests very finely granulate. The septa occasionally evince a tendency to bifurcate near the peripheral border, after the manner of *Heterostegina*. Frequent. In the Filter Quarries and the Upper Quarry.

Heterostegina depressa, d'Orbigny.

H. depressa, d'Orbigny, 1826, Ann. Sci. Nat., vol. VII., p. 305, pl. XVII., Figs. 5-7 ; Modéle, No. 99. Brady, 1884, Rep. Chall., vol. IX., p. 746, pl. CXII., Figs. 14-20.

Some of the specimens found here are papillate, and closely approach Schlumberger's *H. margaritata*,[1] from the Miocene of the Dutch E. Indies, with which species they may eventually be identified.

Rare. Found in the Filter Quarries and also in the Upper Quarry at Batesford limestone.

Cycloclypeus pustulosus, Chapman, Pl. II., Fig. 6 ; pl. V., Fig. 4.

C. pustulosus, Chapman, 1905, Journ. Linn. Soc. N.S.W., vol. XXX., p. 271, pl. V., Fig. 1 ; pl. VI., Fig. 2 ; pl. VII., Fig. 2.

This is a very distinct species, having the papillae of the test-surface distributed over the whole of the shell. Both the megalospheric and the microspheric forms are found here, as they are at Santo, New Hebrides, from the Miocene of which locality they were first described.

Not uncommon at Batesford, in both Quarries, in the *Lepidocyclina* rock.

Lepidocyclina tournoueri, Lemoine and Douvillé, Pl. IV. Figs. 1, 2 (part) and 6.

L. tournoueri, Lemoine and Douvillé, 1904, Mém. Soc. Géol. France, vol. XII. fasc. II., p. 19, pl. I., Fig. 5 ; pl. II., Figs. 2-14, Pl. III., Fig. 1. R. Douvillé, 1907, Bull. Soc. Geol. France, p. 52 et seq. and Figs. 5, 7, 13, 16, 17, 37.

This is the commonest species of the genus in the Batesford *Lepidocyclina* limestone, and the tests often compose the greater part of the rock. Found in both Quarries.

The characters of this species are as follows :—Umbilical axis salient or apiculate on each face ; peripheral edge sharp ; granulations coarse in centre, smaller and more numerous in the

1 Samml. Geol. Reichs.-Mus. Leiden., ser. i., vol. vi., pt. iii., 1902, p. 252, pl. vii., fig. 4.

outer area and extending to the periphery. Internally the pillars, in vertical section, are seen to be numerous and slender ; in median section the megasphere is subcircular and immersed in the semi-lunar secondary chamber. Equatorial chamberlets spatuliform, rarely hexagonal. The megasphere in a Batesford specimen has a diameter of .195mm. The megasphere of the E. Indian examples of this species is exactly similar in shape to the Victorian examples, and would consequently, according to R. Douvillé, belong to the same geographical race.

L. tournoueri was first described from Mediterranean examples by MM. P. Lemoine and R. Douvillé, and it has since been recorded from Borneo by H. Douvillé in beds referred to the Burdigalian.

In the original description, the diameter of the test of this species is given as about 2mm., and our Batesford specimens have the same dimensions.

Lepidocyclina marginata, Michelotti sp. Pl. IV. Fig. 5 ; pl. V., Figs. 1-3.

Nummulites marginata, Michelotti, 1841, Mem. Soc. ital. del Scienze, vol. XXII., p. 45, pl. III., Fig. 4. *Orbitoides marginata*, Michelotti, 1847, Naturk. Verh. Holl. Maatsch-Wetensch, Haarlem, vol. III., p. 16, pl. I., Fig. 10. *Orbitoides mantelli*, Howchin (non Morton), 1891, in Hall and Pritchard, Proc. Roy. Soc. Vict., p. 10, et seq. *Lepidocyclina marginata*, Michelotti sp., P. Lemoine and R. Douvillé, 1904, Mém. Soc. Géol. France, vol. XII., fasc. II., p. 16, pl. I., Fig. 7 ; pl. II., Figs. 7, 9, 11, 20 ; pl. III., Figs. 3, 8, 9, 13.

The test of this species is usually comparatively large and thin ; the diameter of some Batesford specimens measuring as much as 15mm. The swollen central area is distinctly granulate, whilst the thin peripheral portion has the granules much finer. In vertical section the pillars are seen to be numerous and very slender in the peripheral flange-like portion, and gradually thicken towards the region of the umbilical boss, where they protrude from the surface as distinct papillae. The equatorial chambers of this species are distinguished from those

of *L. mantelli*, to which it bears some external resemblance, by the longer sides and cuspid, not broadly arched, ends. Both megalospheric and microspheric forms (forms A and B) occur at Batesford, the former being common, the latter very rare. A megasphere in a Batesford specimen measures .319mm. in diameter. The equatorial chambers of *L. marginata* are spatuliform, and as R. Douvillé has pointed out,[1] this type is characteristic of the E. Indian race of Leptocyclines, as distinct from the American race with the hexagonal outline, including forms like *L. dilatata* and *L. canellei*.

H. Douvillé,[2] in "Les Foraminiferes dans le Tertiaire de Borneo," places the beds H (sand and clay), containing *Lepidocyclina tournoueri*, *L. sumatrensis*, *Miogypsina*, and *Operculina niasi*, in the Burdigalian stage (Middle Miocene).

E. W. Vredenburg[3] remarks that the Lepidocyclines found in the Gaj beds of India are often of large dimensions, and belong exclusively to the group of *L. marginata*, with large pillars and a megasphere only partly enveloped by the second chamber. The Gaj beds contain no large Nummulites, and Vredenburg refers to them as probably Uppermost Aquitanian (Lower Miocene).

Found in both Quarries.

Lepidocyclina martini, Schlumberger. Pl. IV., Figs. 2 (part), 3 and 4.

Orbitoides stellata, Howchin (non d'Archiac), 1889, Trans. R. Soc. S. Aust., vol. XII., p. 17; id. ibib, 1891, vol. XIV., p. 356. *Lepidocyclina martini*, Schlumberger, 1900, Samml. Geol. Reichs-Mus. Leiden, ser. I., vol. VI., pt. 3, p. 131, pl. VI., Figs. 5, 8. L. martini, Schl., Chapman, 1905, Journ. Linn. Soc. N.S.W., vol. XXX., p. 272, pl. V., Fig. 2.

This form out of the Batesford limestone is a true *Lepidocyclina*, and is clearly referable to Schlumberger's *L. martini*, which that author described from the Miocene beds of Java,

1 Bull. Soc. Geol. France, 1907, ser. iv., vol. vii., p. 57.

2 Ibid, 1905, ser. iv., vol. v., p. 454.

3 Records Geol. Surv. India, vol. xxxv., 1907, p. 67.

D'Archiac's species *stellata* has the same outline, but the chambers of the median plane are rectangular, and it is now referred to the Eocene genus *Orthophragmina*. I have already recorded *L. martini*, from the Miocene limestone of the West Coast of Santo, New Hebrides.

The test of the above species is distinguished externally by its roughly stellate form, with prominent ridges passing from the central area into the peripheral processes ; the latter tend to flatten out at the extremities. A megasphere of this species from Batesford measures .172mm. in diameter. The test sometimes attains a diameter of 5mm.

Moderately common in the basal limestones of both Quarries.

OSTRACODA.

Fam. Cypridae.

Pontocypris attenuata, Reuss.

P. attenuata, Reuss, G. S. Brady, 1868, Ann. Mag. Nat. Hist., ser. 4, vol. II., p. 179, pl. IV., Figs. 11-14. Id., 1880, Rep. Chall. Zool., pt. III. p. 38, pl. XV., Figs. 2*a-d*.

This species is now living in the Indian Ocean, around New Guinea, and in the China Seas.

A small but characteristic valve from the Filter Quarries.

Bythocypris reniformis, G. S. Brady.

B. reniformis, G. S. Brady, 1880, Rep. Chall. Zool., pt. III., p. 46, pl. V., Figs. 1*a-l*.

This species, as a living form, has a wide distribution. Amongst other localities it has been recorded off E. Moncoeur Id., Bass Strait, 38-40 fathoms.

A single carapace found in the limestone of the Filter Quarries.

Bairdia amygdaloides, G. S. Brady.

B. amygdaloides, G. S. Brady, 1865, Trans. Zool. Soc. Lond., vol. V., p. 364, pl. LVII., Figs. 6*a-c*. Id., 1880, Rep. Chall. Zool., pt. III., p. 54, pl. IX., Figs. 5*a-f* ; pl. X. Figs. 2*a-c*.

A distinguishing feature of this species is its evenly arched carapace, as seen from above. It is found living in Bass Strait,

and in Port Jackson ; and its range extends into the coral seas of the Pacific.

Abundant in the limestone of the Filter Quarries, also from the Upper Quarry.

Bairdia foveolata, G. S. Brady.

B. foveolata, G. S. Brady, 1867, les Fonds de la Mer, vol. I., p. 56, pl. VII., Figs. 4-6. Idem, 1880, Rep. Chall. Zool. pt. III., p. 55, pl. VIII., Figs 1*a-f* ; Figs. 2*a-f*. Chapman, 1902, Journ. Linn. Soc. Lond. Zool., vol. XXVIII. p. 423. *B.* cf. *foveolata*, G.S.B., Id., 1905, Journ. Linn. Soc. N.S. Wales, vol. XXX., p. 272, pl. XII. Fig. 1.

This species is found living in the Atlantic and Pacific Oceans, and its range extends as far south as Bass Strait. There is not much doubt that it was this species which occurred in the Miocene limestones of Santo, New Hebrides.

The carapace of *B. foveolata*, as seen from above, is tumid in the centre, and the surface is generally distinctly pitted.

A few carapaces and detached valves were found in the limestone of the Filter Quarries.

Fam. Cytheridae.

Cythere wyville-thomsoni, G. S. Brady.

C. wyville-thomsoni, G. S. Brady, 1880, Rep. Chall. Zool., pt. III., p. 82, pl. XX., Figs. 4*a-f*.

This species is now living in the Southern Ocean and in Torres Strait. A carapace and two separate valves from the Filter Quarries ; and one carapace from the *Lepidocyclina*-limestone of the Upper Quarry.

Loxoconcha alata, G. S. Brady.

L. alata, G. S. Brady, 1868, Ann. Mag. Nat. Hist., ser. 4, vol. II., p. 223, pl. XIV., Figs. 8-13.

This species is found living at Honolulu and Mauritius, and is therefore confined to coral seas at the present day.

Two carapaces and a single valve from the Filter Quarries.

Xestoleberis curta, G. S. Brady sp.

Cytheridea (?) curta, G. S. Brady, 1865, Trans. Zool. Soc. Lond., vol. V., p. 370, pl. LVIII., Figs. 7*a*, *b*. *Xestoleberis curta*, G. S. Brady, 1880, Rep. Chall. Zool., vol. I., pt. III., p. 126, pl. XXXI., Figs. 6*a-d*.

The distribution of this species at the present day is the W. Indies, the S. Pacific and the Southern Ocean. At Port Jackson it is found at 2-10 fathoms. Our specimen is narrower than usual in side view, but it has the characteristic, truncated posterior margin.

One example from the Filter Quarries.

(?) Cytheropteron angustatum, G. S. Brady.

(?) Cytheropteron angustatum, G. S. Brady, 1880, Rep. Chall. Zool., vol. I., pt. III., p. 137, pl. XXXIV., Figs. 5*a*, *b*.

Recent examples of this form have been dredged at Balfour Bay, Kerguelen Id., at 20-50 fathoms; and at Torres Strait, 155 fathoms.

One valve from the Filter Quarries.

Cytheropteron batesfordiense, sp. nov. Plate II., Figs. 7*a-c*.

Description.—Carapace seen from the side, elongate ovate; anterior truncately rounded at the dorsal angle, posterior produced at the ventral angle, the extremity sub-spinose; anterior and ventral margins keeled; dorsal line broadly arched, ventral, sinuous. Lateral alae pronounced, long and gently curved. Carapace thickest at the middle of the ventral margin, rapidly sloping to the extremities and the dorsal border. Surface of carapace finely pitted. Edge view, ovate, compressed at the extremities. End view, sub-triangular. Height of carapace equal to about half the length; thickness of carapace more than half the length.

Length, 1mm.; height, .62mm.; thickness of, carapace, .655mm.

Affinities.—This species is quite distinct from *C. wellingtoniense*,[1] G. S. Brady, although showing some relationship in

1 Rep. Chall. Zool., vol. i., pt. iii., 1880, p. 136, pl. xxxiv., figs. 4*a-d*.

having a sub-triangular carapace, as seen from the end, and in the surface pittings. The shape in side view differs materially in that our species is broader anteriorly and narrower posteriorly, the reverse of that seen in *C. wellingtoniense.*

A carapace and two separate valves from the *Lepidocyclina*-rock of the Filter Quarries.

THE FAUNA OF THE BATESFORD LIMESTONE.

Preliminary Remarks.—The several records of species from the Batesford limestone, comprising the foraminiferal and polyzoal rocks, are here collected in systematic form for facility of reference. The corals, mollusca and some other groups of the fauna have already been recorded by Dr. T. S. Hall, M.A., and Mr. G. B. Pritchard, B.Sc., F.G.S.;[1] whilst a new echinoid *Echinoneus*[2] and also *Pentagonaster*[3] have lately been added by the former. Mr. Pritchard has described a new species of *Linthia*, which until recently had been confused with McCoy's "*Pericosmus gigas*" of the Murray River Cliffs.[4] I myself am responsible for the Foraminifera and the Ostracoda, which groups are now described in detail for the first time; one species of the former group, however, had already been figured and described in England by Messrs. Heron-Allen and Earland[5] under the name of *Bigenerina conica*, and Mr. W. Howchin gave generic names to several forms recorded in Messrs. Hall and Pritchard's paper referred to above. In the Spongida I record spicules of calcisponges and identify the species of *Isis* as the N. Zealand Tertiary form *I. hamiltoni*, which is, in Victoria, a typical Janjukian fossil. Arm ossicles of *(?) Antedon* have occurred in some of the washings of the disintegrated limestone. The Cheilostomatous Polyzoa have been revised and catalogued by Mr. C. M. Maplestone in his list of Fossil Cheilostomatous Polyzoa,[6] and some new species of the Cyclostomatous section have been described by the same author in a later

1 Proc. Roy. Soc. Vict., vol. iv., pt. i., n.s., 1891, p. 18; also a revised and extended list. Idem, ibid, vol. viii., n.s., 1896, p. 159.

2 Ibid, vol. xix., pt. ii., n.s., 1907, p. 47.

3 Ibid, vol. xv., pt. i., n.s., 1902, p. 81.

4 Ibid, vol. xxi., pt. i., n.s., 1908, p. 394.

5 Jour. R. Micr. Soc., 1909, p. 329.

6 Proc. Roy. Soc. Victoria, vol. xvii., pt. i., n.s., 1904, pp. 186-217.

paper.[1] The tooth of a shark, *Odontaspis contortidens*, Ag., was recorded with some reservation as from Batesford by Mr. Pritchard and myself in our paper on the "Fossil Fish Remains of the Tertiary of Australia, Pt. I."[2] I have since found this locality to be correct.

U. = Upper Quarry ; F. = Filter Quarries ; B. = Batesford, probably Filter Quarries.

FORAMINIFERA.

Miliolina oblonga, Mont., sp.	F.	
,, *vulgaris*, d'Orb., sp.	F.	
,, *polygona*, d'Orb., sp.	F.	
,, *ferussacii*, d'Orb., sp.	F.	
Cyclammina complanata, Chapm.	F.	
Textularia gibbosa, d'Orb.	F.	
,, ,, ,, ,, var. *tuberosa*, d'Orb.	F.	
,, *gramen*, d'Orb.		
Verneuilina ensiformis, sp. nov.	F.	
Bigenerina (*Siphogenerina*) *conica*, H. A. and E.	F.	
Spiroplecta siphonifera, Brady, sp.	U.	F.
,, *sagittula*, Defr., sp.	U.	F.
,, ,, ,, ,, var. *fistulosa*, Br.		F.
,, *carinata*, d'Orb., sp.		F.
Gaudryina rugosa, d'Orb.		F.
Bulimina elegantissima, d'Orb.		F.
,, ,, ,, ,, ,, var. *apiculata*, Chapm.		F.
Bolivina textilarioides, Rss.		F.
,, *punctata*, d'Orb.		F.
,, *limbata*, Brady.		F.
Cassidulina laevigata, d'Orb.		F.
,, *calabra*, Seg., sp.		F.
,, *subglobosa*, Brady.		F.
Ehrenbergina serrata, Rss.		F.
Lagena globosa, Mont., sp.		F.
,, *favosopunctata*, Brady		F.
,, *orbignyana*, Seg., var. *clathrata*, Brady		F.

1 Proc. Roy. Soc. Victoria, vol. xxi., pt. i., n.s., 1908, p. 233.

2 Ibid., vol. xvii., pt. i., n.s., 1904, p. 275.

Nodosaria (*Dentalina*) *pauperata*, d'Orb., sp. F.
„ „ „ *consobrina*, d'Orb., sp. F.
„ „ „ *soluta*, Rss., sp F.
„ „ „ *obliqua*, L., sp. F.
„ *scalaris*, Batsch, sp. F.
„ *badenensis*, d'Orb. F.
Cristellaria crepidula, F. and M., sp. F.
„ „ „ „ „ var. *arcuata*, d'Orb. F.
„ „ „ „ „ „ *gladius*. Phil., var. F.
„ „ *articulata*, Rss., sp. F.
„ „ *rotulata*, Lam., sp. F.
Polymorphina gibba, d'Orb. F.
„ „ *compressa*, d'Orb. F.
„ „ *oblonga*, d'Orb. F.
„ „ *elegantissima*, P. and J. F.
„ „ *regina*, P. B. and J. F.
Uvigerina angulosa, Will. F.
Globigerina triloba, Rss. F.
Sphaeroidina bulloides, d'Orb. F.
Spirillina cf. *inaequalis*, Brady F.
Discorbina orbicularis, Terq., sp. F.
„ *pileolus*, d'Orb., sp. F.
„ *dimidiata*, P. and J. F.
„ *valvulata*, d'Orb., sp. F.
„ *biconcava*, P. and J. F.
„ *polystomelloides*, P. and J F.
Planorbulina larvata, P. and J. U. F.
Truncatulina refulgens, Montf.. sp. F.
„ „ *lobatula*, W. and J., sp. F.
„ „ *variabilis*, d'Orb. F.
„ „ *tenuimargo*, Brady F.
„ „ *wuellerstorfi*, Schw., sp. F.
„ „ *ungeriana*, d'Orb., sp. F.
„ „ *reticulata*, Cz., sp. F.
Anomalina ammonoides, Rss., sp. F.
„ *grosserugosa*, Gümbel, sp. F.
Carpenteria proteiformis, Goës. U. F.

Pulvinulina punctulata, d'Orb., sp.		F.
,, *concentrica*, P. and J.		F.
,, *partschiana*, d'Orb., sp.		F.
,, *elegans*, d'Orb., sp.		F.
,, *scabricula*, sp. nov.		F.
,, *pulchella*, d'Orb., sp.		F.
,, *schreibersii*, d'Orb., sp.		F.
Rotalia clathrata, Brady	U.	F.
,, *calcar*, d'Orb., sp.	U.	F.
Gypsina globulus, Rss., sp.		F.
,, *vesicularis*, P. and J., sp.		F.
,, *howchini*, sp. nov.	U.	F.
Polytrema minutum, sp. nov.		F.
Nonionina umbilicatula, Mont., sp.		F.
,, *boueana*, d'Orb.		F.
Polystomella subnodosa, Münster, sp.		F.
,, ,, *antonina*, d'Orb.		F.
,, ,, *crispa*, L., sp.		F.
,, ,, *verriculata*, Brady		F.
Amphistegina lessonii, d'Orb.	U.	F.
Operculina complanata, Defr., sp.	U.	F.
,, ,, ,, ,, var. *granulosa*, Ley.	U.	F.
Heterostegina depressa, d'Orb.	U.	F.
Cycloclypeus pustulosus, Chapm.	U.	F.
Lepidocyclina tournoueri, Lem. and Douv.	U.	F.
,, ,, *marginata*, Mich., sp.	U.	F.
,, ,, *martini*, Schlumberger	U.	F.

Spongida.

Spicules of calcisponges (indet.)	F.

Anthozoa.

Placotrochus deltoideus, Dunc.	F.
,, ,, *elongatus*, Dunc.	F.
Flabellum gambierense, Dunc.	F.
Isis hamiltoni, Thomson	F.

ECHINODERMATA.

(?) Antedon sp. (Arm ossicles). Pl. ii., figs. 8*a*, *b*.

The arm ossicles in *Antedon* and *Pentacrinus* are closely similar. The balance of evidence seems here to be in favour of *Antedon*, since the basal portions of the crowns of this genus are known from Australian Barwonian strata, and it is well-distributed in the seas of the Southern Hemisphere at the present day ; while *Pentacrinus* appears to be now nearly restricted to the W. Indian seas. U. F.

Pentagonaster sp. F.

Cidaris (? Leiocidaris), sp. F.

Spines of a cidaroid, indet. F.

Psammechinus woodsi, Laube, sp. B.

Echinocyamus (Scutellina) patella, Tate, sp. B.

Clypeaster gippslandicus, McCoy U. F.

Arachnoides (Monostychia) australis, Laube, sp. F.

Linthia mooraboolensis, Pritchard U. F.

,, sp., near *gigas*, McCoy F.

POLYZOA (CYCLOSTOMATA).

Berenicea nitida, Maplest. F.

Idmonea concinna, Maplest. F.

,, *angustata*, Maplest. F.

Entalophora sparsa, Maplest. F.

,, *quadrata*, Maplest. F.

(CHEILOSTOMATA).

Canda fossilis, Lamz. F.

Cellaria contigua, McGill. F.

Amphiblestrum crassissimum, Maplest. F.

,, ,, *robustum*, Maplest. F.

Lunulites parvicella, T. Woods, sp. F.

Selenaria concinna, T. Woods F.

,, *marginata*, T. Woods F.

Thalamoporella patula, Waters, sp. F.

Steganoporella magnilabris, Busk		F.	
Cribrilina terminata, Waters		F.	
Tessaradoma elevata, Waters, sp.		F.	
Adeona obliqua, McGill.		F.	
Smittia macgillivrayi, Maplest., sp.		F.	
,, *tatei*, T. Woods, sp.		F.	
Mucronella conica, Maplest.		F.	
,, *lata*, McGill		F.	
Porina gracilis, Milne Edw., sp.		F.	
Retepora rimata, Waters		F.	

Brachiopoda.

Crania quadrangularis, Tate			B.
Rhynchonella squamosa, Hutton		F.	
Terebratulina catinuliformis, Tate	U.		
,, ,, *scoulari*, Tate			B.
Magasella compta, Sow., sp.		F.	
,, *(?) woodsiana*, Tate		F.	
(?) Magellania garibaldiana, Dav., sp.	U	F.	
,, ,, *divaricata*, Tate, sp.			B.
Magellania macleani, Tate, sp.			B.
,, *furcata*, Tate, sp.			B.
Terebratula vitreoides, T. W.			B.

Pelecypoda.

Nucula sp.	U.		
Glycimeris cainozoicus, T. W., sp.			B.
Ostrea sp.	U.	F.	
Pecten murrayanus, Tate	U.	F.	
,, *polymorphoides*, Zittel		F.	
,, *consobrinus*, Tate, var.	U.		
,, sp.			B.
Spondylus pseudoradula, McCoy.	U.		
Lima (Limatula) jeffreysiana, Tate			B.
Septifer fenestratus, Tate			B.
Dosinea densilineata, Pritchard			B.
Mactra howchiniana, Tate			B.

GASTEROPODA.

Patella sp. B.
Pleurotomaria, sp. (cast) B.
Tenagodes sp. B.
Also casts of other spp., indet. U.

OSTRACODA.

Pontocypris attenuata, Rss. F.
Bythocypris reniformis, G.S.B. F.
Bairdia amygdaloides, G.S.B. U. F.
,, *foveolata*, G.S.B. F.
Cythere wyville-thomsoni, G.S.B. U. F.
Loxoconcha alata, G.S.B. F.
Xestoleberis curta, G.S.B., sp. F.
(?) Cytheropteron angustatum, G.S.B. F.
Cytheropteron batesfordiense, sp. nov. F.
Chelæ of Crustacea, indet. B.

PISCES.

Odontaspis contortidens, Ag. U.

(This specimen was recorded in the paper on Australian Tertiary Sharks' teeth by Mr. G. B Pritchard and myself, with a query as to the locality. I am now able to recognise the characteristic *Lepidocyclinae* in the hard, dark coloured matrix of the specimen, and this confirms the locality as Batesford, Upper Quarry).

Oxyrhina retroflexa, Ag. F.

(About 24 teeth, originally many more, in a block of *Lepidocyclina* limestone measuring 45 cm. × 35 cm. × 14 cm., associated with shells of *Pecten* spp. and a tooth of *Carcharodon megalodon*, presented to the National Museum by Mr. W. B. McCann).

Carcharodon megalodon, Ag. F.

CETACEA.

Vertebral epiphyses, probably of a whale B.

CALCAREOUS ALGAE.

Lithothamnium, 2 spp. One form is small and has knobby or tufty branches; the other is explanate, thin and encrusting U. F.

A large portion of the present paper is devoted to the description of two groups of fossils from the Batesford Limestone which have been somewhat neglected—viz., the Foraminifera and the Ostracoda. Of the first group, the sub-family of *Orbitoidinae* affords direct and convincing evidence as to the homotaxial equivalents of the beds in question; and this evidence, taken in conjunction with the occurrence of other fossil forms which are restricted to more or less definite palaeontological horizons, points to the correlation of the Batesford series of the Victorian tertiaries with the Middle Miocene of Europe, Asia and the East Indies.

The great abundance of the nummulinoid genus *Amphistegina* in our tertiary strata is additional proof of their homotaxial relationship with the Miocene elsewhere. As my revered friend, Prof. Rupert Jones, has pointed out to me, the result of a unique experience of European microzoic tertiary faunas, the genus *Amphistegina*, with its inequilateral test, took the place of the equilateral Nummulite towards the close of the great Nummulitic period, and flourished in prodigious abundance in Miocene times.[1] The Miocene forms of *Amphistegina* are, moreover, curiously simulant of the nummuline test, as they are often of large size, and flattened lenticular in contour, as distinguished from the living forms, which are typically smaller, stouter and more dome-shaped. Hence the confusion of *Amphistegina* in Australian rocks with the smaller species of *Nummulites* as *N. variolaria*.

1 The genus *Nummulites* attained its maximum development in middle Eocene times, as shown by its abundant species and large size (e.g., *N. complanata*, with a test often exceeding 2½ inches in diameter). It occurs more sparingly in Oligocene strata, and is occasionally found as high in the series as the middle Miocene and represented by *N. niasi*. The recent species of the genus show some affinity with *Operculina* and *Amphistegina*.

Among the Batesford echinoids the genus *Linthia* calls for a few remarks. Its distribution is from the Cretaceous to Recent, but it is typically Miocene, and its maximum development was attained at that period. In conformity with the recognised law of increase of size in phyletic branches, the genus *Linthia* affords an interesting case in point. It probably attained its largest dimensions in *L. gigas*, McCoy sp., from the Murray Cliffs, the type specimen having a length of seven and a-half inches.[1] The stratum in which it occurs is of Barwonian age (i.e., Balcombian or Janjukian), but presumably Janjukian.

Of the twenty-three spp. of polyzoa recorded from Batesford by Mr. C. M. Maplestone, four species are found living—viz., *Selenaria concinna* (S. Australia), *S. marginata* (S. Australia), *Steganoporella magnilabris* (Australia, N. Zealand and Japan), and *Porina gracilis* (Australia). Thus the ratio of living to fossil forms is 17 per cent.

The brachiopod, *Rhynchonella squamosa*, Hutton, is still living S. of Kerguelen Island.[2]

The comparatively modern aspect of the Janjukian strata is shown by the group of the ostracoda. Of the nine species here recorded, one is new, whilst eight are living at the present day. The distribution of these living species ranges from Kerguelen Id. to Torres Strait, the Indian Ocean and the China Seas; whilst one species is found in the Atlantic. Three have been recorded from Bass Strait and two from Port Jackson.

Although the species of sharks, represented in the Batesford Limestone by teeth, are not numerous, they possess a special interest. Perhaps the most important is *Oxyrhina retroflexa*, by far the commonest form. This species is found in several other localities where beds of similar age are exposed, and it also occurs in the remanié or nodule beds of the Grange Burn and Beaumaris, whose material was probably derived from an underlying Janjukian stratum. This same species, *O. retroflexa*, occurs in the Oamaru Stone of the S. Island of N. Zealand, and described under the name of *Oxyrhina vonhaasti* by

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1 This species was recorded also from Corio Bay in error for Batesford (Prod. Pal. Vict., dec. vii., 1882, p. 16). The specimen has the test badly crushed, but shows some characters intermediate between *L. gigas* and *L. mooraboolensis*, Pritch.

2 See Hutton, Trans. and Proc. N.Z. Institute, vol. xxxvii., 1905, p. 481.

J. W. Davis.[1] Certain other typical fossils of the Oamaru Series are also common to the Janjukian of southern Australia, and the Oamaru Stone horizon in particular appears to be homotaxial with the Batesford Limestone. A recent writer on this subject, Prof. J. Park,[2] has summarised the latest evidence, both stratigraphical and palaeontological, and he places the Oamaru Stone in the Miocene, at about the middle of that series. This opinion independently supports my own conclusion as to the age of the Batesford beds. Besides the species of shark just mentioned, both the Mount Brown Beds and the underlying Oamaru Stone contain the remarkable cetacean type, *Kekenodon onomata*, Hector, which, from the structure of the fangs and the rounded contour of the crowns of the molars are undoubtedly of the squalodont form, although the species has always been referred to as a zeuglodont. In his description of this fossil, Hector, however, does state that the New Zealand teeth resemble, amongst other genera, those of *Squalodon*.[3] The Janjukian of Waurn Ponds, and Castle Cove, Cape Otway, occasionally yield the teeth of *Squalodon wilkinsoni;* and these show a close relationship with the New Zealand fossils, with the exception that the latter are much larger, and the canines more trenchant and strongly curved. Moreover, from the Oamaru Series at White Rock River Quarry, N.Z., Davis has described a denticulated tooth of a true squalodont, which he refers to a new species, *Squalodon serratus*,[4] at the same time remarking that it shows great relationship with McCoy's *S. wilkinsoni*. The molar tooth from the polyzoal rock of Mt. Gambier, named *Zeuglodon harwoodi* by Mr. E. B. Sanger, is also closely related, if not identical with the Victorian *Squalodon*.[5] In its bearing on the age of the Janjukian it is interesting to note that the genus is typical of the Miocene series of France and Bavaria, and remains have also been found in European Pliocene strata. The pennatulid *Graphularia*, is another guide-fossil common to the Middle Oamaru Series and the

1 Trans. R. Dubl. Soc., ser. ii., vol. iv., 1888, p. 26, pl. iv., figs. 1-3.
2 Trans. and Proc. N.Z. Institute, vol. xxxvii. (1904), 1905, pp. 489-551.
3 Ibid, vol. xxx. (1880), 1881, p. 435.
4 Trans. R. Dubl. Soc., ser. ii., vol. iv., 1888, p. 4, pl. vii., fig. 9.
5 Proc. Linn. Soc. N.S. Wales, vol. v., 1881, p. 298.

Victorian Janjukian Beds. Other closely allied fossils are a species of *Linthia* from the Oamaru Series of the Geraldine District, N.Z., and *L. mooraboolensis*, Pritch., from Batesford; and the "*Celleporina*" (*Cellepora*) *papalosa* from the Oamaru Series and a similar, but undescribed form in the polyzoal rock of Victoria and S. Australia.

Summary, and Conclusions as to the Age of the Beds.

1.—The Batesford Limestone Series includes a *Lepidocyclina* and a polyzoal, facies, there being a gradual transition from one to the other. They were evidently formed at one continuous period of sedimentation, the palaeontological differences being due to the deepening of the water during the formation of the polyzoal banks in this area. In other localities, however, the polyzoa, by the abundance of the more massive forms, show evidence of shallower conditions.

2.—This series is of Janjukian age, as shown by Messrs. Hall and Pritchard; and corresponds to the widespread stage of the polyzoal rock which represents a comparatively distinct phase in the Tertiary history of Victoria.

3.—By the presence of *Lepidocyclinae* of the *L. marginata* type, accompanied by *L. tournoueri* and *L. martini*, as well as by *Cycloclypeus pustulosus*, the limestones are shown to be the homotaxial equivalents of the Burdigalian beds as developed in Southern Europe (Faluns de Saint-Paul, near Dax), and in Java, Sumatra, Borneo and the New Hebrides.

4.—The modern character of the beds is indicated by the Ostracoda, which are all, with the exception of one new species, of living types.

5.—By comparison, the Keilor *Lepidocyclina* Limestone appears to be on a slightly lower horizon of the Janjukian series than that of Batesford, as shown by the addition to the Batesford *Lepidocyclina* fauna, of *L. verbeeki*, a form also occurring in a still lower stage at Clifton Bank, Muddy Creek, near Hamilton. The Gaj Beds of India I would refer to this, Keilor, horizon, which in the case of the Indian beds, is regarded by Vredenburg as probably Upper Aquitanian. The *L. insulae-natalis* beds of Christmas Id., in all probability, also belong here.

6.—The Batesford beds, in common with other Janjukian strata, occupy a middle position in our Tertiary series, and are younger than the richly fossiliferous Balcombian clays and sands of Mornington and Muddy Creek (Lower Beds).

In conclusion, I desire to express my sincere thanks to Dr. T. S. Hall, M.A., for many specimens and samples of foraminiferal material with which I began the examination of the microzoa of these quarries. I am also indebted to Mr. G. W. Cortous, of Geelong, for kindly supplying me with further fossiliferous material; as well as Mr. W. B. McCann, as before mentioned.

The types of the new species and representative specimens have been presented to the National Museum collection.

EXPLANATION OF PLATES.

Plate LII.

Fig. 1—*Verneuilina ensiformis*, sp. nov. 1*a*, lateral aspect; 1*b*, oral aspect. Filter Quarry. × 58

2—*Pulvinulina scabricula*, sp. nov. 2*a*, superior face; 2*b*, peripheral view. Filter Quarry. × 58.

3—*Polytrema minutum*, sp. nov. 3*a*, superior aspect; 3*b*, side view. Filter quarry. × 29.

4—*Gypsina howchini*, sp. nov. 4*a*, lateral aspect; 4*b*, peripheral aspect. Filter quarry. × 29.

5—*Polystomella antonina*, d'Orbigny. 5*a*, lateral aspect; 5*b*, oral aspect. Filter quarry. × 58.

6—*Cycloclypeus pustulosus*, Chapm. Lateral aspect. Filter Quarry. × 29.

7—*Cytheropteron batesfordiense*, sp. nov. 7*a*, lateral aspect of left valve; 7*b*, ventral aspect; 7*c*, end view. Filter Quarry. × 29.

8—*(?) Antedon*, sp. Arm ossicle. 8*a*, distal face of the epizygal; 8*b*, edge view, showing crenulated edge of the radially marked proximal face. Filter Quarry. × 14.

Plate LIII.

Fig. 1—*Spiroplecta siphonifera*, Brady, sp. Median vertical section passing through the megasphere, and showing the spiroplectoid commencement. Filter Quarry. × 40.

2—*Rotalia calcar*, d'Orb., sp. Four examples showing the redundant papillose shell-growth and the calcarine periphery. Filter Quarry. × 18.

3—*Gypsina howchini*, sp. nov. Median section of test, showing the crowded initial series of chambers. Upper Quarry, near Batesford. × 40.

4—*G. howchini*, sp. nov. Median section of test vertical to the disc, shewing megasphere. Upper Quarry, near Batesford. × 40.

5—*G. howchini*, sp. nov. Another specimen in vertical section, showing a tendency to develop a median line of chambers as in *Miogypsina*. Upper Quarry, near Batesford. × 40.

6—*Amphistegina lessonii*, d'Orb. Section in limestone parallel with the umbilical axis; showing the asymmetry of the test as distinct from *Nummulites*. Upper Quarry, near Batesford. × 40.

Plate LIV.

Fig. 1—*Lepidocyclina tournoueri*, Lemoine and R. Douvillé. Lateral aspect. Filter Quarry. × 18.

2—Vertical sections of *Lepidocyclina martini*, Schlumberger (left hand figure), and *L. tournoueri*, Lem. and Douv.; in limestone from the Upper Quarry, near Batesford. × 18.

3—*Lepidocyclina martini*, Schl. Lateral aspect. Filter Quarry. × 18.

4—*L. martini*, Schl. Median transverse section of test, showing chamberlets of both superficial and median layers. Filter Quarry. × 18.

5—*Lepidocyclina marginata*, Michelotti, sp. Median section, passing through the megasphere. Filter quarry. × 20.

6—*L. tournoueri*, Lem. and Douv. Vertical section, passing through the megasphere. From limestone of the Upper Quarry, Batesford. × 20.

7—Typical microscope section of the Batesford Limestone (Upper Quarry), showing the relative abundance of the *Lepidocyclinae*. × 9.

Plate LV.

Fig. 1—*Lepidocyclina marginata*, Michelotti, sp. Lateral aspect. Filter Quarry. × 6.

2—*L. marginata*, Mich., sp. Portion of a section through the median layer of chamberlets; showing the spatulate ends of the same. Filter Quarry. × 18.

3—*L. marginata*, Mich., sp. Vertical section of test, showing the thin pillars and crowded chamberlets. Filter Quarry. × 18.

4—*Cycloclypeus pustulosus*, Chapman. A transverse median section, passing through the megasphere. Filter Quarry. × 18.