

# THE FORAMINIFERA OF THE OLDER TERTIARY OF AUSTRALIA (NO. 1, MUDDY CREEK, VICTORIA).

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[Read October 4, 1888.]

## Plate I.

The Older Tertiary beds exposed on Muddy Creek consist of two main divisions, sharply distinguished in their palæontological as well as their stratigraphical features.\* In the following list those species which only occur in the Lower Bed are indicated by an asterisk (\*). Those peculiar to the Upper Bed are marked with a dagger (†).

### FAMILY MILIOLIDÆ.

#### Genus—BILOCULINA, *d'Orbigny*.

1. *B. ringens*, Lamk. Not common in Lower Bed, but include some very large examples. Upper Bed, rather scarce.

2. *B. depressa*, d'Orb. Most of the specimens possess flaps at the aboral extremity, as shown by Mr. Brady in "Challenger" Report, but those from Muddy Creek have these appendages much larger than the one figured by Mr. Brady. Lower Bed, rather scarce, as also in Upper Bed.

3. \**B. irregularis*, d'Orb. These exhibit great diversity of form, some being much depressed laterally, whilst others in their sub-globular outline approach very near to *B. sphaera*. The aperture is generally a curved gaping slit without tongue. Lower Bed, rather scarce.

4. *B. elongata*, d'Orb. Lower Bed and Upper Bed, rare.

5. †*B. bulloides*, d'Orb. The examples of this species are few in number, but of large size, and are distinguished by very large stelate apertures. Mr. Brady ("Challenger" Report) has shown that *B. sphaera*, d'Orb., sometimes possesses a labyrinthic aperture, especially in the case of deep water examples. In the present instance the aperture is not labyrinthic, but exhibits strong bars of shell substance radiating from the centre to the outer margin of the oral aperture. Upper Bed, rare.

6. †*B. sp.* A large species of *Biloculina*, possessing thick longitudinal costæ which are rendered still more conspicuous by a slight weathering of the test, was obtained from the Upper Bed;

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\*Dennant, Roy. Soc. S. Aust., vol. xi., p. 30, et seq.; Tate, Roy. Soc., N.S.W., 1888, p. 242.

but the specimens, which were few in number, have been unfortunately mislaid.

Genus—MILIOLINA, *Williamson*.

7. *M. seminulum*, Linn. Of the short and thick variety, mostly fine examples, measuring up to one-tenth of an inch. Lower Bed, moderately common. Upper Bed, very common.

8. \**M. Cuvieriana*, d'Orb. Lower Bed, rather scarce.

9. *M. trigonula*, Lamk. In Lower and Upper Beds, rather scarce.

10. *M. tricarinata*, d'Orb. Lower Bed, rather scarce. Upper Bed, rare.

11. \**M. valvularis*, Rss. A single example of robust build has, with some hesitation, been referred to this species. Lower Bed.

12. \**M. prisca*, Terq. One of the pitted *Miliolice*. In weathered specimens the pitted depressions become coarse perforations of the test. Lower Bed, moderately common.

13. *M. oblonga*, Montag. Not very characteristic, the specimens being mainly passage forms approaching the elongated varieties of *M. seminulum*. Lower Bed, moderately common. Upper Bed, common.

14. \**M. pygmaea*, Rss. Lower Bed, moderately common.

15. *M. Linneana*, d'Orb. Several examples of this fine species were observed in both formations, but it is not very common.

16. \**M. Brongniartii*, d'Orb. Lower Bed, rare.

17. \**M. Ferussacii*, d'Orb. Lower Bed, moderately common.

18. \**M. undosa*, Kar. Many of the specimens show intermediate characters approaching *M. Ferussacii*. Lower Bed, common. The most characteristic examples of this species in the Challenger collection were from Bass Straits.

19. \**M. scrobiculata*, Brady. One or two specimens were obtained in Lower Bed which agree very closely with Mr. Brady's descriptions and figures. This form must be distinguished from *Articulina sulcata*, which it somewhat resembles.

20. *M. agglutinans*, d'Orb. Specimens vary from a broad oval outline to a much elongated test with produced neck. Lower Bed, very common. In Upper Bed the examples are fewer in number, and for the most part very coarse in test structure.

21. \**M. angularis*, sp. nov. Pl. i., figs. 1—3.

Test free, elongate, fusiform; composed of numerous (about 18 or 20) chambers, arranged lengthways, and more or less spirally around the longer axis. Segments narrow and much compressed, investing, only the final whorl being visible externally. Early chambers oval in transverse section; the later chambers increase in size mainly in a lateral direction. The final whorl consists of from five to six chambers arranged at obtuse angles to each other,

and exhibit in peripheral outline as many facets and angles as there are segments in outer whorl. External surface smooth. Aperture small, terminal, obscure. Length,  $\frac{1}{15}$  in.

The species now described is distinguished from its congeners by the great number of its chambers, their shallowness in comparison with their length, and the completeness of their investing character. Its nearest analogue in the Milioline series appears to be *M. alveoliniformis*, Br. The latter species can be easily distinguished by its arenaceous test, tubular chambers, and deeply depressed sutures, whilst *M. angularis* is always porcellaneous in its testaceous investment, the chambers are compressed transversely to little more than narrow slits, and the sutures are flush or marked by prominent angles in peripheral outline. Lower Bed, moderately common.

22. †*M. secans*, d'Orb. Upper Bed, rather scarce.

23. †*M. bicornis*, W. and J. Upper Bed, very rare.

24. †*M. insignis*, Brady. Upper Bed, very rare.

#### Genus—SPIROLOCULINA, *d'Orbigny*.

25. \**S. asperula*, Kar. Rather coarsely arenaceous, with a thin outspread test. In the Muddy Creek specimens none but the marginal segments are distinctly visible on the exterior. Lower Bed, rare.

26. *S. grata*, Terq. Lower Bed, rather scarce. Upper Bed, very rare.

27. \**S. affixa*, Terq. Lower Bed, rather scarce.

28. †*S. limbata*, d'Orb. Upper Bed, rather scarce.

29. \**S. Tateana*, sp. nov. Pl. i., figs. 4, 5.

Test oblong or nearly circular, much compressed; primordial region biconvex and fusiform, consisting of numerous elongated segments arranged in an acervuline manner. Later chambers (varying from three to six on either side) flattened, outspread, and arranged concentrically. Segments narrow, smooth, nearly flush, much attenuated near the raised centre, increasing gradually in diameter towards the outer margin. Periphery rounded. Average size,  $\frac{1}{40}$  in. diameter.

This shell is constructed on a double plan of growth, the earlier portions being Milioline, or investing, and the latter segments outspread or Spiroloculine. The acervuline chambers often exhibit a close resemblance to small examples of *Miliolina pygmaea*, and when the outspread portion of the test is reduced to a single segment on either side, as is the case with some specimens, the analogy is very close. The outer chambers form a fringe around the thickened centre very much like the alæ of certain seeds. It is a small and delicate shell, the outspread portion being sufficiently translucent to show by transmitted light

the septation with great distinctness. Mr. Brady, to whom specimens were submitted, informs me that he has occasionally met with examples similar to the present in recent material associated with *S. crenata*, Kar., and at the time regarded it as a weak thin-shelled modification of that species. *S. crenata* does not occur in the Muddy Creek material, but the form now described is comparatively common, and in no instance have I seen the slightest tendency to crenulation of the test as in *S. crenata*. There is therefore no alternative but to assign it a specific position. I have great pleasure in associating the name of my friend Prof. Ralph Tate, F.G.S., with this shell, as one who has devoted much time and conspicuous ability in working out the mollusca of the beds from which the species now described has been obtained. Lower Bed, moderately common.

Genus—*CORNUSPIRA*, *Schultze*.

30. \**C. involvens*, Rss. The larger examples exhibit an ornamentation of fine wavy disconnected striæ, running in a line with the convolutions. Lower Bed, rather scarce.

31. \**C. foliacea*, Phil. It is worthy of note that all the specimens, which are more or less weathered, show a fine surface ornamentation resembling *C. striolata*, Brady; but they undoubtedly belong to the above species, and the ornamentation seems to have been brought out as an effect of weathering. Lower Bed, rather scarce.

32. \**C. crassisepta*, Brady. Lower Bed, rare.

Genus—*HAUERINA*, *d'Orbigny*.

33. †*H. intermedia*, spec. nov. Pl. i., fig. 6.

Test free, compressed, consisting of two or three convolutions, which increase in size towards the oral extremity. Segments compressed laterally, arcuate, inflated, from six to ten visible externally and from three to five in final convolution; segmentation marked externally by lines of sutural constrictions. Surface of test, smooth; colour an opaque-white. Peripheral margin carinate, sub-carinate, or rounded. Aperture never compound, but Milioline in character, formed by a slight constriction of the chamber cavity, and furnished with a long straight tooth rising from the inferior portion of the peripheral margin of the final chamber, and extends to about half the diameter of the aperture in a line with the medial plane. Adult specimens,  $\frac{1}{20}$  in.

The most striking feature of the form now described is the divergence which it exhibits from the generic type in relation to the aperture. *Hauerina*, as a rule, carries a very distinctive cribiform or compound orifice, whilst the present species is conspicuously and (so far as my observation has gone) invariably

Milioline in its oral features. This variation establishes another point of resemblance between *Hauerina* and *Miliolina*, in addition to that which is exhibited by the Milioline arrangement of its earlier segments. Upper Bed, moderately common.

Genus—VERTEBRALINA, *d'Orbigny*.

34. *V. insignis*, Brady. A feeble variety of this rare form occurs in the material, the triangular and carinate periphery, the ornamentation in regular parallel lines, and the absence of rectilinear growth are sufficient to mark the species. This is the first record of it in a fossil state, and it is only known as an existing species from three localities, one of which is Torres Straits. Lower and Upper Beds, rare.

Genus—ARTICULINA, *d'Orbigny*.

35. *\*A. sulcata*, Rss. Reuss figures a minute and somewhat dubious form under this name from the Tertiaries of Germany. It is known as a recent shell from four "Challenger" stations, one being off Raine Island, Torres Straits. Lower Bed, rare.

36. *\*A. sagra*, d'Orb. A complete example and the final segment of another were the only indications of this species observed. Lower Bed.

Genus—ORBITOLITES, *Lamarck*.

37. *\*O. complanata*, Lamk. Several fragments of fairly large shells were noted, but in each case these were broken and worn by attrition. They are most likely to be derived fossils not proper to the bed. Lower Bed.

Genus—PLANISPIRINA, *Sequenza*.

38. *P. sigmoidea*, Brady. This is one of the "Challenger" species, but only noted at five stations. Lower Bed, moderately common. Upper Bed, rare.

39. *\*P. exigua*, Brady. Two specimens occurred of this minute but interesting little shell. Like the preceding, this is the first record of its occurrence in the fossil condition. Lower Bed, rare.

FAMILY LITUOLIDÆ.

Genus—LITUOLA, *Lamarck*.

40. †*L. nautiloidea*, Lamk. A single example, showing labyrinthic structure, from Upper Bed.

Genus—PLACOPSILINA, *d'Orbigny*.

41. †*P. Cenomana*, d'Orb. Single specimen from Upper Bed.

Genus—REOPHAX, *de Montfort*.

42. \**R. fusiformis*, Will. The examples of *Reophax* from Muddy Creek are remarkable for the very coarse structure of their tests, being built up of the exuviae of *M. pygmaea*, *Discorbinae*, and other foraminiferal shells, and shelly sand. A few single-chambered specimens have been referred to this species, but they are not common. Lower Bed.

43. \**R. scorpiurus*, Montfort. One or two tapering and segmented examples may be referred to this species, but it is rarer than the preceding. Lower Bed.

Genus—HAPLOPHRAGMIUM, *Reuss*.

44. \**H. pseudospirale*, Will. Several relatively large examples, coarsely built, compressed, obscurely segmented, one with subspiral commencement. Lower Bed, rather scarce.

45. \**H. agglutinans*, d'Orb. A single specimen has been referred to this species, although it is far from characteristic, being subglobular and without rectilinear segments, but this seems the best classification that can be made at present. Lower Bed.

46. \**H. sphaeroidiniformis*, Br. MS. Mr. Brady has favoured me with the following notes on this, at present, undescribed species:—"I have this in my cabinet (from Mr. Robertson, I think). I believe it to be the Sphaeroidine isomorph in the *Haplophragmium* series, just as *H. globigeriniformis* is the Globigerine form of the genus. I have given it the MSS. name of *Haplophragmium sphaeroidiniformis*. The aperture resembles *Sphaeroidina* more than *Textularia*, and some specimens which I have seen are very like *Sphaeroidina*—indeed, in all but texture." Lower Bed, common.

Genus—BDELLOIDINA, *Carter*.

47. \**D. aggregata*, Carter. Three examples of this very rare species were met with. Mr. Brady ("Challenger" Report) states that the known distribution of the species was limited to the north coast of New Guinea for recent specimens, and a single Cretaceous specimen in the fossil condition. The forms from Muddy Creek are detached, and show clearly on the underside the peculiar labyrinthic structure of the test. Lower Bed, rare.

Genus—TEXTULARIA, *DeFrance*.

48. \**T. aspera*, Brady. Very fine examples, and in considerable numbers. Lower Bed.

49. \**T. gibbosa*, d'Orb. Moderately common, Lower Bed.

50. \**T. agglutinans*, d'Orb. Typical specimens of this species are rare in the material, and at best can only be reckoned as passage forms with allied species. Lower Bed.

51. *T. agglutinans*, var. *porrecta*, Brady. Differs from the type

mainly by the chambers being less inflated, the septal lines more nearly flush, the shell elongated, and has a neater and more symmetrical form than *T. agglutinans*. It is in the main a coral-reef form in the recent condition. Lower and Upper Beds, rather scarce.

52. \**T. rugosa*, Rss. This is also a characteristic coral-reef species. Lower Bed, rare.

53. *T. sagittula*, Def. One of the commonest forms in this very rich material, many of the specimens attaining a large size. Lower and Upper Beds.

54. \**T. sagittula* var. *fistulosa*, Br. A few examples of this variety with fistulose growths on the lateral edges occur, but they are relatively rare. Lower Bed.

55. \**T. carinata*, d'Orb. This is a somewhat variable species. A single specimen was noted, which I think must be referred to it, although the septal lines are non-limbate and slightly depressed. The lateral margins are sharply carinate, and give indications of having possessed dentate appendages, although most of these are broken, probably from attrition. Lower Bed.

56. \**T. gramen*, d'Orb. A species of the *T. sagittula* type, but much broader in relation to its length, and with greater inflation of the later segments. Lower Bed, rather scarce.

#### Genus—PAVONINA, d'Orbigny.

57. \**P. flabelliformis*, d'Orb. The only species of the genus founded by d'Orbigny as far back as 1826, and unverified by subsequent researches until recent years. Mr. Brady records it from nine or ten localities, one of which is Torres Straits. It is a compressed, fan-shaped, dimorphous foraminifer; textularian in its earlier segments, the later segments being arranged in single series. This is the first record of its occurrence in a fossil condition. Lower Bed, very rare.

#### Genus—VERNEUILINA, d'Orbigny.

58. *V. triquetra*, Münst. The specimens show a considerable range as to size and contour, but are always distinctly triangular in shape, with rough exterior. Lower Bed, common. Upper Bed, rare.

59. \**V. tricarinata*, d'Orb. More regular in shape than the preceding, and less rugose. Lower Bed, rare.

60. \**V. polystropha*. Lower Bed, rare.

61. \**V.* sp. A form closely allied to *V. spinulosa*, Reuss, from which it differs chiefly in its more elongated contour, absence of spines, and nearly flush septation. Specimens were submitted to Mr. Brady, who writes that he is "convinced it has been figured,"

although at the time he could not find the description. Lower Bed, rather scarce.

62 † *V. pygmaea*, Egger. Upper Bed, very rare.

Genus—GAUDRYINA, *d'Orbigny*.

63. \**G. rugosa*, d'Orb. Closely resembles *V. triquetra*, from which it differs only in the biserial arrangement of its later chambers. Lower Bed, rather scarce.

Genus—CLAVULINA, *d'Orbigny*.

64. *C. communis*, d'Orb. Lower and Upper Beds, very rare.

65. *C. angularis*, d'Orb. Lower and Upper Beds, very rare.

Genus—BULIMINA, *d'Orbigny*.

66. *B. elegantissima*, d'Orb. A single example was obtained of this beautiful little shell from each of the beds of the Muddy Creek section.

67. \**B. obtusa*, d'Orb. A sub-cylindrical variety with obtuse aboral extremity. Occurs as a Cretaceous form in European strata. Lower Bed, very rare.

Genus—BOLIVINA, *d'Orbigny*.

68. \**B. punctata*, d'Orb. Lower Bed, rather scarce.

69. \**B. limbata*, Br. In the recent condition this is a common form on the New Guinea coasts and the Australian coral-reef. Lower Bed, rare.

70. \**B. dilatata*, Rss. Two specimens, which are not altogether characteristic, have been assigned to this species. They are apparently intermediate forms uniting *B. dilatata* with *B. pygmaea*, Br. Lower Bed.

Genus—CASSIDULINA, *d'Orbigny*.

71. *C. subglobosa*, Br. In the recent condition it has a deep water habitat. Common in Lower Bed, but of small size. Upper Bed, very rare.

72. \**C. laevigata*, d'Orb. Lower Bed, rare.

Genus—EHRENBERGINA, *Reuss*.

73. \**E. serrata*, Rss. Lower Bed, rather scarce.

FAMILY LAGENIDÆ.

Genus—LAGENA, *Walker & Jacob*.

74. \**L. hexagona*, Will. A single specimen. Lower Bed.

75. *L. sulcata*, W. & J. Lower Bed, rare. Upper Bed, very rare.

76. \**L. globosa*, Montag. Lower Bed, rare.

77. \**L. lineata*, Will. A single specimen. Lower Bed.  
 78. \**L. marginata*, W. & B. Lower Bed, rare.  
 79. †*L. melo*, d'Orb. Upper Bed, very rare.

Genus—NODOSARIA, *Lamarck*.

The representatives of this genus in the material, although not common as to individuals, represent a relatively large number of species, and include some specimens of unusual size. In classification I have followed Mr. Brady's method of including the Dentaline and Glanduline varieties under the present heading.

80. \**N. soluta*, Rss. Fine typical specimens. Lower Bed, rare.  
 81. *N. pauperata*, d'Orb. One example (faintly striated) is one-sixth of an inch in length. Lower and Upper Beds, rare.  
 82. \**N. scalaris*, Batsch. The specimens are mostly limited to two or three chambers. Lower Bed, rather scarce.  
 83. \**N. multilineata*, Borne. A few fine examples occur. Lower Bed.  
 84. \**N. obliqua*, Linné. Lower Bed, rare.  
 85. \**N. plebeia*, Rss. A single specimen. Lower Bed.  
 86. \**N. costulata*, Rss. A single example, consisting of three inflated chambers, apiculate, and with strongly developed costæ bridging the sutural depressions. Lower Bed.  
 87. \**N. affinis*, d'Orb. One large example of this species measures five-sixteenths of an inch in length. It consists of seven segments, with a constriction near the middle of the test, which gives it the appearance of being nearly nipped in two. Lower Bed, rare.  
 88. *N. raphanus*, Linné. Not common. One example measures a quarter of an inch in length. Lower and Upper Beds.  
 89. †*N. consobrina*, d'Orb. Upper Bed, very rare.  
 90. †*N. (G.) æqualis*, Rss. Upper Bed, rare.  
 91. *N. (G.) lævigata*, d'Orb. Lower Bed, rare. Upper Bed, very rare.

Genus—LINGULINA, *d'Orbigny*.

92. \**L. carinata*, var. *seminuda*, Batsch. A single very fine example, consisting apparently of only two segments. Lower Bed.

Genus—MARGINULINA, *d'Orbigny*.

93. \**M. costata*, Batsch. Lower Bed, rather scarce.

Genus—FRONDICULARIA, *DeFrance*.

94. *F. complanata*, Def. Lower Bed, rare. Upper Bed, very rare.

Genus—VAGINULINA, *d'Orbigny*.

95. \**V. linearis*, Montag. Lower Bed, very rare.

Genus—RHABDOGONIUM, *Reuss*.

96. †*R. sp.* Two shells, one a remarkably fine example of a *Rhabdognonium* with symmetrical outline and strongly developed tricarinate test, were obtained from the Upper Bed. I have little doubt that they represent an undescribed species, but the specimens have been unfortunately mislaid, and therefore cannot be determined at present.

Genus—CRISTELLARIA, *Lamarck*.

97. \**C. rotulata*, Lamk. Lower Bed, rare.  
 98. \**C. cultrata*, Mont. Lower Bed, rare.  
 99. \**C. articulata*, Rss. Lower Bed, rather scarce.  
 100. \**C. convergens*, Borne. Lower Bed, very rare.  
 101. \**C. tricarinnella*, Rss. Lower Bed, rare. Recent specimens have been obtained from three localities, all in the Western Pacific.

Genus—POLYMORPHINA, *d'Orbigny*.

102. \**P. regina*, Br. P. & J. A few rather fine examples. Lower Bed.  
 103. *P. elegantissima*, P. & J. This fine species is most at home in recent waters on the eastern shores of Australia from Torres Straits to Bass Straits. In the Muddy Creek beds it is a common form, but very variable in contour. Specimens can be found in every intermediate stage, from a nearly circular outline in one direction to sub-cylindrical in elongated varieties. Lower and Upper Beds, common.  
 104. *P. oblonga*, d'Orb. Lower Bed, very rare. Upper Bed, rather scarce.  
 105. *P. gibba*, d'Orb. Lower Bed, a moderately common form, including some fistulose examples. Upper Bed, rather scarce.  
 106. *P. lactea*, W. & J. Rare in both Lower and Upper Beds.  
 107. \**P. lactea*, var. *oblonga*, Will. Lower Bed, very rare.  
 108. *P. communis*, d'Orb. Rather scarce in both Lower and Upper Beds.  
 109. \**P. ovata*, d'Orb. Lower Bed, rare.  
 110. \**P. dispar*, Stache. A strong, compressed, inequilateral and twisted shell, determined by Prof. Stache from examples obtained from the New Zealand Tertiaries. Lower Bed, moderately common.  
 111. †*P. rotundata*, Born. Upper Bed, rare.  
 112. †*P. compressa*, d'Orb. Upper Bed, moderately common.

Genus—UVIGERINA, *d'Orbigny*.

113. \**U. Canariensis*, d'Orb. Lower Bed, rather scarce.  
 114. †*U. pygmaea*, d'Orb. Upper Bed, very rare.

Genus—SAGRINA, *d'Orbigny*.

115. \**S. limbata*, Br. Pl. i., fig. 7. A single specimen of this very rare form was obtained from the Lower Bed. The test is longer and more slender than Mr. Brady's figure, and is also more curved in outline, but in all essential features agrees perfectly with the type. The specimens on which the species was determined by Mr. Brady came from Torres Straits, and this is only one of the many illustrations of the identity of forms between the last-named locality and the Lower Tertiaries of Southern Australia.

## FAMILY GLOBIGERINIDÆ.

Genus—GLOBIGERINA, *d'Orbigny*.

116. *G. bulloides*, d'Orb. Lower Bed, very common. Upper Bed, rare.

117. \**G. bulloides* var. *triloba*, Rss. Lower Bed, rather scarce.

118. \**G. inflata*, d'Orb. Lower Bed, rather scarce.

119. \**G. helicina*, d'Orb. Lower Bed, rare.

Genus—ORBULINA, *d'Orbigny*.

120. *O. univversa*, d'Orb. Lower Bed, very common, frequently large. Upper Bed, rather scarce.

Genus—SPHÆROIDINA, *d'Orbigny*.

121. \**S. bulloides*, d'Orb. Lower Bed, examples small but moderately common.

## FAMILY ROTALIDÆ.

Genus—SPIRILLINA, *Ehrenberg*.

122. \**S. decorata*, Br. Differs from the recent form in possessing a rounded edge instead of being carinate, and in the absence of transverse furrows. Lower Bed, rare.

123. *S. tuberculata*, Br. Mr. Brady's figures show the convolutions as visible on the exterior surface, wholly or in part, but the Tertiary examples have a greater tubercular growth which completely hides the septal lines, and often renders the shell slightly biconvex. Lower Bed, rather scarce. Upper Bed, very rare.

124. \**S. limbata*, Br. Lower Bed. Specimens small and somewhat rare.

125. \**S. inæqualis*, Br. The convolutions of the superior face are strongly marked by raised, limbate ridges, with the depressed areas coarsely pitted. The inferior side of the shell is of greater extent than the superior, perfectly flat, shows no septal lines exteriorly, and is uniformly covered with tubercles. Lower Bed, rather scarce.

Genus—DISCORBINA, *Parker & Jones*.

The Discorbinæ of the Lower Bed are represented by a considerable number of species, but as individuals are almost without exception small and starved examples and in limited numbers. In the Upper Bed they are finer examples, and more numerous, and include several species not found in the Lower Bed.

126. *D. turbo*, d'Orb. Lower Bed, rather scarce; Upper Bed, very common.

127. *D. rosacea*, d'Orb. Rather scarce in both Beds.

128. *D. globularis*, d'Orb. Lower Bed, rather scarce; Upper Bed, rare.

129. \**D. Araucana*, d'Orb. Lower Bed, rare.

130. \**D. Bertheloti*, d'Orb. Lower Bed, rare.

131. *D. biconcava*, P. & J. Much compressed bilaterally. Lower Bed, rare; Upper Bed, rather scarce.

132. \**D. patelliformis*, Br. Lower Bed, rather scarce.

133. \**D. orbicularis*, Terq. Lower Bed, rare.

134. \**D. (?) tabernacularis*, Br. If this be rightly assigned, it is a feeble example destitute of limbation, although resembling the species in other respects. Lower Bed, rare.

135. *D. polystomelloides*, P. and J. Lower Bed, a single example of this fine species. Upper Bed, rather scarce.

136. †*D. pileolus*, d'Orb. Upper Bed, rather scarce.

137. †*D. vesicularis*, Lamk. Upper Bed, rare.

128. †*D. Vilardeboana*, d'Orb. Upper Bed, moderately common.

139. †*D. opercularis*, d'Orb. Upper bed, rare.

140. †*D. rarescens*, Brady. Upper Bed, rare.

141. \**D. cruciformis*, sp. nov. Pl. i., figs. 13, 14.

Test subglobular, slightly compressed laterally, consisting of about three convolutions arranged inequilaterally on a Rotaliform plan, so that usually four segments are visible on the inferior and about eight on the superior face. Segments inflated, their convex surfaces on the superior face studded with short thickly-set spines; sutural lines depressed, excavated, and free from spines. Inferior surface smooth, its four segments arranged in form of a Maltese cross. Umbilicus depressed. Aperture a small circular orifice situated in the umbilical depression. Average size,  $\frac{1}{5}$  in.

This peculiar little shell is obese, but unequally convex. Its superior surface is rendered rugose by the presence of short spines so thickly set that they cannot be distinguished as spinous growths except by viewing them laterally where they terminate in an abrupt line. Its nearest analogue is perhaps *Discorbina pulvinata*, a new species obtained by Mr. Brady from two localities in Challenger material, viz., Admiralty Islands and Torres Straits. The species now described can be easily distinguished from the one referred to by its greater number of chambers, the

absence of ornamentation from its inferior surface, and the cruciform aspect which the final whorl of chambers assumes. Lower Bed, moderately common.

Genus—PLANORBULINA, *d'Orbigny*.

142. \**P. mediterraneensis*, d'Orb. Lower Bed, rare.

143. \**P. acervalis*, Br. Lower Bed, a single example, but characteristic.

144. \**P. larrata*, P. and J. A very symmetrical discoid test, often developing on superior surface tubercular growth of shell substance. In the recent condition it is an exclusively tropical species. The specimens from Muddy Creek are rarely tuberculated, but exhibit a smooth flat test with regularly imbricated margin. Lower Bed, moderately common.

Genus—TRUNCATULINA, *d'Orbigny*.

145. \**T. lobatula*, W. and J. Lower Bed, rather scarce.

146. \**T. variabilis*, d'Orb. Several irregular-growing examples have been referred to this species. Lower Bed, rare.

147. *T. reticulata*, Czjzek, Lower Bed, moderately common. Upper Bed, rare.

148. \**T. echinata*, Br. A globose shell with large circular aperture, the surface of test more or less studded with short blunt spines irregularly distributed. In the recent condition it is mostly a coral-reef species. Lower Bed, rather scarce.

149. *T. echinata*, var. *laevigata*, var. nov. Pl. i., fig. 8.

Closely resembles the typical form in general features, but is devoid of all spinous appendages, the exterior surface of test being perfectly smooth. The aperture is also less conspicuous than in *T. echinata*, and has no bordered rim as in that form. It is more common than the type in the Muddy Creek material, and as such seems to require at least a varietal distinction. Lower Bed, moderately common. Upper Bed, rare.

150. *T. Ungeriana*, d'Orb. Lower Bed, common. Upper Bed, rather scarce.

151. *T. Haidingerii*, d'Orb. Lower Bed, rather scarce. Upper Bed, rare.

Genus—ANOMALINA, *d'Orbigny*.

152. \**A. rotula*, d'Orbigny. Lower Bed, rare.

153. *A. ammonoides*, Rss. Lower Bed, moderately common. Upper Bed, rare.

154. \**A. polymorpha*, Costa. Three examples, two of which are spinous. Lower Bed.

Genus—CARPENTERIA, *Gray*.

155. \**C. proteiformis*, Goës. Very fine examples up to two-fifths

of an inch in length. Large specimens sometimes branched, and contain over twenty chambers. This is the first record of this interesting species in a fossil condition. The nearest point of distribution in the recent state, so far as known, is Torres Strait, but the recent specimens do not appear to be so fine as those from Muddy Creek. Lower Bed, moderately common.

Genus—POLYTREMA, *Risso*.

156. *P. miniaceum*, var. *alba*, Carter. Small specimens, and destitute of colour. Whether the absence of colour be original or due to age and fossilization it is difficult to say. I have, however, classed them with the variety with which, in their present appearance, they perfectly agree. Lower Bed, moderately common. Upper Bed, very rare.

Genus—GYPSINA, *Carter*.

157. *G. globulus*, Rss. The spherical form of *Gypsina* differs widely as to the size of individuals, and is not uncommon in Lower Bed. Upper Bed, rather scarce.

158. *G. vesicularis*, P. & J. Examples of the typical hemispherical form are rare, these being replaced by individuals of a discoid shape, with thick rounded periphery, which are common in the Lower, and rather scarce in Upper Bed.

159. \**G. inhaerens*, Schultze. Lower Bed, rare. The "Challenger" collections of this species were limited to two localities, Bass Straits and south of New Guinea.

Genus—PULVINULINA, *Parker and Jones*.

160. *P. repanda*, Fichtel and Moll. The typical form, passing into and including the next in this list, are amongst the commonest forms in the Lower Bed material. Upper Bed, rather scarce.

161. \**P. pulchella*, d'Orb. A very neat little shell, with limbate sutures. Lower Bed, common.

162. \**P. Schreibersii*, d'Orb. The septation on the superior side of the test is obscure, but in other respects the examples agree with the above. Lower Bed, rather scarce.

163. \**P. Berthelotiana*, d'Orb. A few specimens of a small, convex, many chambered, limbate shell, appear to belong to this species. Lower Bed.

164. \**P. Partschiana*, d'Orb. Lower Bed, rather scarce.

165. \**P. Patagonica*, d'Orb. Lower Bed, rare.

166. \**P. Hauerii*, d'Orb. Lower Bed, rare.

167. \**P. auricula*, Fichtel and Moll. Lower Bed, rare.

168. \**P. oblonga*, Will. Lower Bed, rare.

169. \**P. semiornata*, sp. nov. Pl. i., figs. 12a—c. Test subglo- bular, more or less compressed on superior face; periphery, obtuse

or rounded ; convolutions few in number (generally three). Segments few (three or four in final convolution), and much inflated. Superior surface, ornamented by raised papillæ, or by thick exogenous shell-growth, with deep excavations at intervals, giving a roughly reticulate appearance to the test. Inferior surface highly convex, without ornamentation, and smooth. Sutures non-limbate, marked externally by depressed lines. Umbilicus slightly excavated, and usually possesses several large perforations. Aperture, an inconspicuous slit (sometimes spanned by shelly growths), situated on the umbilical margin of final segment. Large specimens measure  $\frac{1}{16}$  inch.

A large shell, combining in some degree the external features of *Rotalia papillosa*, Br., and *Pulvinulina punctulata*, d'Orb. It can be easily distinguished by its nearly plano-convex outline, inflated chambers, and fewness of its segments. Its size renders it conspicuous in the material, but it is not very common. Lower Bed.

Genus—*ROTALIA*, Lamarck.

170 *R. clathrata*, Br. One of the new species of the "Challenger" collection. The home of this very striking form appears to be between Bass Straits and Cooks Straits, New Zealand, where it was taken at four stations, with a bathymetrical range of 275 fathoms. The only other note of its occurrence is at two stations on the west coast of Patagonia, but the specimens from the latter locality were small and not so characteristic. At Muddy Creek it is moderately common in Lower Bed and very common in Upper Bed.

171. \**R. papillosa*, Br. With a single exception this is only known as a South Pacific species. The Challenger Report records it from eight stations, the majority of which occur in the neighbourhood of New Guinea and northern and eastern coasts of Australia. It is a rare form in the Lower Bed material, and the examples are not quite so globose in outline as the type.

172. \**R. papillosa* var. *compressiuscula*, Br. A few not very characteristic examples occur. They are really passage forms between the present variety and *R. clathrata*. In the recent state it is usually associated with the type in distribution. Lower Bed, rare.

173. \**R. calcar*, d'Orb. Lower Bed, rare.

Genus—*CALCARINA*, d'Orbigny.

174. †*C. rarispina*, d'Orb. The examples usually exhibit from three to six spines. Upper Bed, moderately common.

## FAMILY NUMMULINIDÆ.

Genus—NONIONINA, *d'Orbigny*.

175. \**N. umbilicatula*, Montagu. Lower Bed, rather scarce.  
 176. *N. depressula*, W. & J. Rare in both Lower and Upper Beds.  
 177. \**N. stelligera*, d'Orb. Lower Bed, rather scarce.

Genus—POLYSTOMELLA, *Lamarck*.

178. *P. macella*, F. & M. A very common form in the Lower Bed material, including some fine examples. It seems to take the place of the more widely diffused *P. crispa*. Upper Bed, rather scarce.

179. *P. craticulata*, F. & M. Occurs as a recent form on the Australian Coral Reef. Rare in both Lower and Upper Beds.

180. \**P. verriculata*, Br. Only known in the recent state from two localities off East Moncœur Island (Bass Straits) and Curtis Straits, Queensland. Lower Bed, rare.

181. †*P. imperatrix*, Br. The examples, although fine and striking, are not, as a rule, very characteristic. One example was noticed with well-developed spines. The test is invariably sub-angular, but rarely spinous. It is probably a varietal or intermediate form which cannot be more accurately classed. Upper Bed, common.

Genus—AMPHISTEGINA, *d'Orbigny*.

182. *A. Lessonii*, d'Orb. Mostly of the compressed variety. Lower Bed, moderately common. Upper Bed, rather scarce.

Genus—OPERCULINA, *d'Orbigny*.

183. \**O. complanata*, Def. Specimens large and very common in Lower Bed.

184. \**O. complanata*, var. *granulosa*, Leymerie. Examples with more or less of surface ornamentation are also common. Lower Bed.

Genus—NUMMULITES, *Lamarck*.

185. *N. variolaria*, Sowerby. This is the most common and striking of the foraminiferal forms in the Muddy Creek Lower Bed. Its occurrence in company with several other large and striking species gives the Lower Tertiary of Australia a foraminiferal facies very closely resembling beds of a similar age in the Northern Hemisphere. It occurs sparingly, along with examples of *Operculina*, in the Upper Bed, but it is very probable that both these forms in the Upper Bed have been derived from the older formation.

Genus—ORBITOIDES, *d'Orbigny*.

186. \**O. Mantelli*, Morton (sp.). Mostly small specimens, common in the Lower Bed. One example is much larger than the average size, and is  $\frac{9}{20}$  in. in diameter. A few subglobular examples, surrounded with fringe of delicate translucent chamberlets, might perhaps be referred to *O. dispansus*, Sow.

187. \**O. stellata*, sp. nov. Pl. i., figs. 9—11. Test free, compressed, lenticular; peripheral margin attenuate, angular in outline, or produced at more or less regular intervals into flat spinous projections. Surface of test rough and vesicular, destitute of areolæ, but in well preserved specimens exhibits externally a few tubercles of clear shell substance. Primordial region occupied by one or more chambers of large size; chamberlets of medial disc, numerous, cylindrical, or roughly hexagonal in section, arranged in concentric annuli; investing chamberlets compressed laterally, arranged in successive layers on either side of the medial plane; septal partitions thin, except where columns of clear shell substance pass radially from the primordial region to the external surface of test. Spinous projections formed by intermittent extensions of chamberlets at the peripheral margin. Average size,  $\frac{1}{8}$  inch.

This is an interesting modification of the genus in the direction of *Tinoporus*, but whilst simulating the latter in external appearances, it is destitute of the supplemental skeleton characteristic of that genus; and is clearly differentiated from both *Tinoporus* and *Gypsina* by possessing the duplex arrangement of segments, which marks-off *Orbitoides* so clearly from these genera. The periphery is sometimes produced into a thin carina composed of a single layer of chamberlets, which from their regularity of shape and disposition can be determined as extensions of the medial disc. The spinous projections, whilst seldom entirely absent, vary considerably in their number and arrangement. Specimens occur having the outline of an inequilateral triangle, and pass through every degree of variation in angular outline to that of a symmetrical arrangement of radiating spines, as in fig. 9, pl. i.; the thickness of the walls separating the chamberlets is relatively much less in comparison with the chamber cavities than is commonly the case in this genus, as shown in pl. i., fig. 10*b*. The primordial region, when examined in flat sections, is seen to consist of several large inflated and spirally arranged segments, which are not visible in the transverse section shown in fig. 10*a*. Figs. 11*a*—11*b* represent a large and very abnormal specimen assumed to belong to this species, having two medial planes growing at right angles to each other, so as to give a triangular or prismatic form to the test when seen in transverse section. Lower Bed, common.

## GENERAL REMARKS.

With regard to the Foraminifera, the Muddy Creek Beds contain one of the richest local fauna that is known, either recent or fossil. The rich gatherings from the Suffolk Crag (Pliocene) yielded 100 species, and the greatest number of species from any one locality in the British area in this formation was 62 species. The Lower Bed at Muddy Creek has yielded 163 species, and the Upper Bed 76 species. Of these 52 species are common to both formations, leaving a net total of 180 species and seven varieties for the section as a whole. Mr. Brady ("Challenger" Report) makes special mention of a remarkably rich dredging off Raine Island, Torres Straits, which contained a greater number of species in this class than any other haul made during the cruise, and included many rarities. There is a close resemblance in the number of species obtained from Torres Straits and Muddy Creek, whilst many of the rarer forms are common to both.

The stratigraphical distinction between the two beds of the section concerned is sufficiently marked from the fact that the Foraminifera common to both only amount to 28 per cent. of the whole. There is also a marked change in the general facies of the rhizopodal fauna as we pass from the lower to the upper geological horizon, pointing to a shallowing of the sea bottom, which is indicated not only by the relatively larger numbers of shallow-water species in the Upper Bed, but these are proportionately more numerous and better developed as individuals.

With regard to climatic conditions, the majority of the Muddy Creek Foraminifera point to a higher temperature prevailing in the locality of their deposition than is proper to such latitudes in the present day. A very large proportion of species are characteristically tropical, and a decided majority in each case have their geographical range, in the present, restricted to the tropical and warmer temperate zones. So far as can be determined, the following summary will illustrate the bathymetrical and climatic distribution of the species concerned:—

## BATHYMETRICAL RANGE.

Lower Bed—68 (49 per cent.) shallow; 39 (28 per cent.) moderately deep to deep; 32 (23 per cent.) unrestricted.  
Upper Bed—42 (58 per cent.) shallow; 12 (16 per cent.) moderately deep to deep; 18 (25 per cent.) unrestricted.

## CLIMATAL RANGE.

Lower Bed—37 (26 per cent.) tropical; 47 (33 per cent.) warm temperate and tropical; 9 (6 per cent.) temperate; 48 (34 per cent.) cosmopolitan.

Upper Bed—13 (18 per cent.) tropical; 25 (35 per cent.) warm temperate and tropical; 2 (3 per cent.) temperate; 31 (43 per cent.) cosmopolitan.

In their geological range; the Lower Bed contains six species which date from Palæozoic times, five Trias, eight Lias, four Jurassic, 18 Cretaceous, 68 Tertiary, five Quaternary, whilst 37 have not been previously noted in a fossil condition, and three others only in Australian geology.

In the Upper Bed two have a Palæozoic record, three Trias, five Lias, three Jurassic, eight Cretaceous, 27 Tertiary, and 14 not previously observed as fossil forms.

The occurrence of *Nummulites variolaria* in very great numbers in the Lower Bed is of special interest as showing uniformity of palæontological features between the Older Tertiaries of Australia and rocks of a like age in Europe. The resemblance in this respect is still further shown by the occurrence of large examples of *Operculina* and other types which are commonly found associated with *Nummulites* in the Eocene Beds of the Northern Hemisphere, and which are also conspicuous species from Muddy Creek.

In the material gathered by the "Challenger" expedition, the Australasian region supplied a high proportion of the new species obtained in this department of marine zoology. It was therefore to be expected that the later geological formations of Australia would show more or less resemblance to the dredgings in the adjacent waters, and give geological examples of some of the new species found in a recent condition. Including the new forms described in this paper, 50 species occur in the list which are now recognised for the first time as fossils. The general resemblance, which the Muddy Creek Foraminifera bear to the recent species now inhabiting the northern and north-eastern shores of tropical Australia, is very striking, and would appear to indicate that in early Tertiary times either the tropical currents of the ocean bore more directly on the southern shores of the continent, or that the zone of tropical heat reached nearer to the Pole in the Southern Hemisphere, as it appears to have done in the Northern, at the beginning of the Tertiary period.

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## DESCRIPTION OF PLATE I.

Figs. 1—3. *Miliolina angularis*, sp. nov.

Fig. 1. Longitudinal aspect. Exterior of test broken on one facet exhibiting the shallowness of chamber cavity. x 17 diam. Fig. 2. Transparent longitudinal section. x 22 diam. Fig. 3. Transparent transverse section, made near the centre of test, exhibiting the spiralline arrangement of chambers and angular contour of shell. x 40 diam.

Figs. 4—5. *Spiroloculina Tateana*, sp. nov.

Fig. 4*a*. Lateral view of an oval specimen, x 33 diam. Fig. 4*b*. Peripheral aspect of ditto. Fig. 5. Lateral aspect of circular example. x 30 diam.

Figs. 6*a*—6*b*. *Hauerina intermedia*, sp. nov.

Fig. 6*a*. Lateral view of average specimen. x 20 diam. Fig. 6*b*. Peripheral aspect of same object.

Fig. 7. *Sagrina limbata*, Br. x 30 diam.

Fig. 8. *Truncatulina echinata* var. *levigata*, var. nov. x 40 diam.

Figs. 9.—10*b*. *Orbitoides stellata*, sp. nov.

Fig. 9. Lateral aspect of regularly stellate example. x 13 diam. Fig. 10*a*. Transparent section through centre of test at right angles to medial plane. x 17 diam. Fig. 10*b*. Small portion of same section more highly magnified showing column of clear shell substance and the relative thinness of chamber walls. x 75 diam.

Figs. 11*a*—11*b*. Probably an abnormal example of *Orbitoides stellata*, possessing two medial planes growing at right angles to each other. x 12 diam.

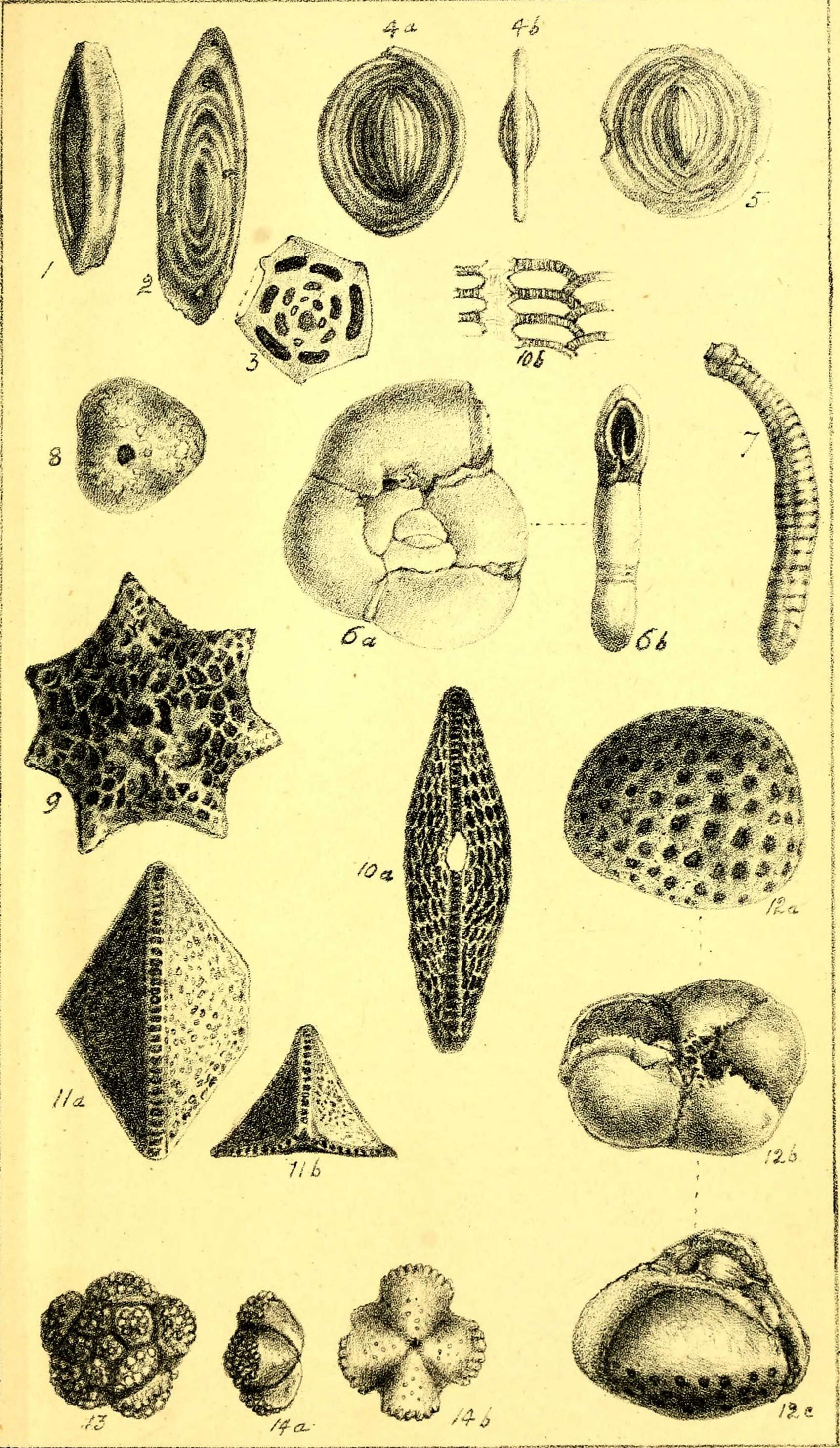
Figs. 12*a*—12*c*. *Pulvinulina semiornata*, sp. nov.

Fig. 12*a*. Superior aspect showing rugose shell growth. x 30 diam. Fig. 12*b*. Inferior aspect of same object entirely destitute of ornamentation. x 25 diam. Fig. 12*c*. Peripheral view. x 25 diam. The final segment in this example is broken and a specimen of *Lagena sulcata* has become fixed in aperture of test, as shown by figs. 12*b* and *c*.

Figs. 13—14*b*. *Discorbina cruciformis*, sp. nov.

Fig. 13. Superior aspect of test. x 40 diam. Fig. 14*a*. Peripheral view of another example. x 40 diam. Fig. 14*b*. Inferior aspect of ditto.





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# ROYAL SOCIETY of SOUTH AUSTRALIA.

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VOL. XII.

For 1888-89.

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EDITED BY PROF. R. TATE, F.G.S., F.L.S.

[WITH FIVE PLATES.]



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*PRICE FIVE SHILLINGS.*

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Adelaide :

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DECEMBER, 1889.

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Parcels for transmission to the Royal Society of South Australia, from Europe and America should be addressed "per W. C. Rigby, care Messrs. Thos. Meadows & Co., 35, Milk Street, Cheapside, London."