DEPARTMENT OF MINES AND AGRICULTURE.

MEMOIRS OF THE GEOLOGICAL SURVEY OF NEW SOUTH WALES.

E. F. PITTMAN, A.R.S.M., UNDER SECRETARY AND GOVERNMENT GEOLOGIST.

PALÆONTOLOGY, No. 14.

A MONOGRAPH

OF THE

FORAMINIFERA OF THE PERMO-CARBONIFEROUS LIMESTONES

OF

NEW SOUTH WALES;

BY

FREDERICK CHAPMAN, A.L.S., F.R.M.S.,
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AND

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MEMOIR.

LETTER OF TRANSMITTAL.

Geological Survey Branch,
Department of Mines and Agriculture,
Sydney, 22nd August, 1905.

Sir,

I have the honor to submit for publication Monograph No. 14 (Palæontology Series) on the *Foraminifera of the Permo-Carboniferous Limestones of New South Wales*, by Mr. Frederick Chapman, A.L.S., F.R.M.S., of the National Museum, Melbourne, and Mr. Walter Howchin, F.G.S., Lecturer in Geology at the Adelaide University.

At the time this work was originally undertaken, Mr. Chapman, who is regarded as one of the greatest living authorities on Foraminifera, occupied a position in connection with the Royal School of Mines, London; but it is a matter for congratulation to Australian geologists that he has since accepted an appointment in the National Museum, Melbourne. Mr. Howchin has devoted a considerable amount of time to the study of Australian Foraminifera, and for this reason he was asked to collaborate with Mr. Chapman. The Department has been extremely fortunate in obtaining the services of two such able specialists.

I have the honor to be,
Sir,
Your obedient servant,
EDWARD F. PITTMAN,
Government Geologist.

The Honorable S. W. Moore, M.P.,
Minister for Mines and Agriculture.

Stratigraphical Note.

By T. W. EDGEWORTH DAVID, B.A., F.R.S.,
Professor of Geology, University of Sydney.

I.—Introductory.

The Foraminifera described in this Monograph by Mr. Frederick Chapman and Mr. Walter Howchin were found by my geological survey party on at least two distinct and widely separated horizons in our Permo-Carboniferous system. The Upper Horizon, that of Wollong, belongs to the Branxton Beds (Branxton Stage) of the Upper Marine Series, and the lower, that of Pokolbin, is to be referred to the Lochinvar Beds (Lochinvar Stage) of the Lower Marine Series (*see* section appended).

The two foraminiferal horizons are separated from one another by a thickness of about 4,000 feet of strata, interstratified with which are the Greta Coal-Measures. The Wollong Foraminiferal Horizon is about 2,300 feet above the Greta Coal-Measures, whereas that of Pokolbin is about 1,700 feet below them.

II.—Details of the Foraminiferal Horizons and Intermediate Strata.

(*a*) At Pokolbin the Foraminifera occur in an earthy limestone through which are scattered small particles of volcanic rock. The limestone is fairly persistent on one particular horizon, and its outcrop can be traced continuously from a point a few chains east of Mr. J. MacDonald's house, "Ben Ean," in Portion 86, Parish of Pokolbin, to Mr. William Wilkinson's vineyard, "Maluna," in Portion 112 in the same parish, a distance of over three-quarters of a mile. It was at the latter locality that Mr. Eustace Wilkinson first called my attention to the outcrop of the limestone, which

upon further examination was found to contain Foraminifera. It is somewhat lenticular, and has a maximum thickness of about four feet, its average thickness being perhaps about two feet. It weathers into a soft brownish substance, superficially resembling bathbrick. It is essentially a bryozoal limestone, largely formed of beautifully preserved *Fenestellidæ*, in which genera allied to *Polypora* and *Fenestella* are abundantly represented.

The genus *Stenopora* is plentifully distributed throughout the limestone in the form of pencil-shaped types as well as of flat encrusting varieties. Fragments of brachiopod shells, mostly *Productidæ*, as well as of lamellibranch shells, and small complete shells of gastropods and valves of ostracods, are also numerous in the limestone. At the Katawba Vineyard large and more or less perfect shells of *Eurydesma cordata*, *Aviculopecten*, and *Platyschisma*, are associated with the Foraminifera. At the above locality numerous specimens of *Nubecularia* can be seen encrusting the inner surfaces of the valves of *Aviculopecten*.

The limestone, when slightly weathered, shows on its surface abundant milk-white shells of *Nubecularia*, sufficiently large to be easily seen without the aid of a pocket lens. Where weathering has proceeded further, the Foraminifera are represented only by hollow casts[1] in a soft greenish-brown rock, which does not effervesce in hydrochloric acid, and which represents mostly the siliceo-felspathic portion of the limestone. Such a rock, when passing from its original calcareous condition to its present weathered and non-calcareous condition, does not necessarily set free the foraminiferal shells from the enclosing matrix.

Several of the Foraminifera herein described were, nevertheless, obtained by Mr. Chapman, by washing the earth collected by Mr. Eustace Wilkinson from near the outcrop of this limestone; but it is likely that such shells were derived from the clay shales associated with the limestones rather than from the limestones themselves.

As regards the conditions under which the Pokolbin limestones were formed, the geological survey of the district shows that they were developed close to the shores of high volcanic islands, rising with steep slopes above the surface of the shallow sea belonging to the Lower Marine Stage of the

[1] Attempts were made at the Geological Laboratory at the University to obtain solid casts of these hollows by baking the weathered rock in Canada balsam, and then dissolving out the siliceo-felspathic material with hydro-fluoric acid, but the pseudomorphs in balsam obtained by this method were not sufficiently sharp in outline to make them of use for descriptive purposes.

Permo-Carboniferous System. These islands belong to the *Rhacopteris* Stage of the Carboniferous System, and are composed largely of rhyolitic lavas and fine tuffs and tuffaceous shales, together with later flows of plagioclase trachyte and hypersthene-andesite. Mantling around these old shore lines are coarse and massive conglomerates in which have survived only strong and thick shells such as *Eurydesma cordata* and *Platyschisma oculum.*

The horizon of these coarse conglomerates is about 200–300 feet below that of the foraminiferal limestones at Pokolbin. The conglomerates are partly tuffaceous, the tuff being of an andesitic character. At Pokolbin they form the base of the Permo-Carboniferous System, though they are by no means the lowest strata of that System as represented in the adjoining districts. For example, at Lochinvar, about eleven miles north-easterly from Pokolbin, over 2,500 feet of Permo-Carboniferous strata have been developed below the horizon of the conglomerates. The disappearance of these lowest strata between Lochinvar and Pokolbin is due to a gradual transgression of the conglomerates in the direction of Pokolbin on to the pre-Permo-Carboniferous inliers of Mt. Bright and its associated hills. In places a sheet of dolerite with red olivines and containing an abundance of secondary natrolite with datolite and analcite[1] overlies the conglomerate and underlies the foraminiferal limestone. The volcanic particles in the limestone appear, however, to have been derived from the older (andesitic) eruptions rather than from these later basic lavas.

As the material of the rocks above the conglomerates becomes finer-grained upwards, passing into mudstones and sandy shales, until the horizon of the foraminiferal limestone is reached, it is probable that the limestone was developed under conditions of subsidence, the adjacent volcanic islands of the Carboniferous System being more or less rapidly submerged, until eventually Foraminiferal limestone was formed.

(*b*) As regards the *nature of strata separating the two foraminiferal horizons,* a thickness of about 200 feet of sandy shale was deposited above the limestone with occasional thin ostracod limestones. The horizon of the Ravensfield Sandstone follows next in ascending order. This marks an epoch when the subsidence became slower, about 800–1,000 feet of the sandstones, known as the Farley Beds (Farley Stage), being then laid down. The former existence of floating ice in the sea of the Farley Stage in this district is proved by the presence of occasional erratics. At the close of the

[1] C. Anderson, M.A., B.Sc., Records Austr. Mus., 1904, V, Pt. 2, pp. 127–130.

Farley Stage stable conditions supervened, perhaps accompanied by slight elevation marked by the development of the Greta Coal-Measures. These measures are about 130–200 feet thick, comprising at least two coal seams 14–32 feet and 3–11 feet thick respectively, together with sandstones, shales, fireclays, and more or less coarse conglomerates. The most characteristic fossil plants are :—*Gangamopteris, Glossopteris, Noeggerathiopsis, Annularia,* and *Vertebraria.*

At the close of the deposition of the strata of the Greta Coal-Measures marine conditions once more supervened, and the beds of the Upper Marine Series were laid down. They are divided into a lower and upper stage, known respectively as the Branxton Beds, 3,000–3,400 feet thick, and the Crinoidal Shales, 1,500–3,000 feet thick. The basal bed of the Branxton Stage is formed of pebbly sandstone, passing upwards into mudstones, with occasional beds of sandstone, and the stage ends in very massive sandstones known as the Muree Beds, abounding in *Strophalosia.* The lowest of the Muree Beds has been named the Muree Rock, or Bolwarra Conglomerate, and is one of the most persistent horizons in the district.

(*c*) *The Wollong Horizon.*—The upper foraminiferal horizon (Wollong horizon) is situated in the Branxton Beds, at a depth of between 100 and 200 feet below the Muree Rock, and over 2,500 feet above the Greta Coal-Measures. The locality where Mr. J. E. Carne, Assistant Government Geologist, and I, first observed the Foraminifera is in Portion 112, in the Parish of Mulbring, County Northumberland. The spot was shown to us by Mr. Glennie Wyndham, of Wollong, and is situated on Mr. Dodds' property. The Coral *Trachypora Wilkinsoni* occurs there in great abundance, forming thin miniature reefs in the Upper Marine Mudstones. Numerous Foraminifera are distributed through the mudstones in the vicinity of these corals, and samples of the weathered shales, from this spot, which were collected by Mr. G. Wyndham, and forwarded to Mr. F. Chapman, yielded, on washing, the best preserved foraminiferal shells as yet obtained from any part of the Permo-Carboniferous System of N. S. Wales. Representatives of the *Fenestellidæ* are numerous near this horizon, but the pencil-shaped variety of *Stenopora,* so plentiful at Pokolbin, was nowhere observed at Wollong, and *Eurydesma cordata,* a very characteristic form at Pokolbin, is wholly wanting at Wollong. Ice-borne erratics, from a few pounds up to over a ton in weight, are tolerably frequent in the strata, both above and below the Wollong foraminiferal horizon.

III.—Comparison of the New South Wales Permo-Carboniferous Foraminiferal Horizons with those of Tasmania and West Australia.

(*a*) *Tasmania.*—The first Foraminifera of Permo-Carboniferous Age discovered in Australasia were recorded from Tasmania by T. Rupert Jones;[1] Mr. W. S. Dun has kindly called my attention to this notice. Later, Mr. T. Stephens, M.A., F.G.S., of Hobart, briefly referred to some Foraminifera of the above age found by himself in Tasmania. Subsequently these Foraminifera were described by Mr. Walter Howchin, F.G.S., now Lecturer in Geology and Palæontology at Adelaide University.[2] The locality is the Piper River, and is distant about fifteen miles easterly from Launceston. The Foraminifera are preserved in a dark calcareous mudstone of Permo-Carboniferous Age. As the Greta Coal-Measures, though developed west of Launceston, at Latrobe, are not known to exist at the Piper River, it is difficult to determine whether that horizon should be referred to the Upper or to the Lower Marine Series of the Permo-Carboniferous System.[3] At no great distance below the Piper River Foraminiferal Horizon, glacial beds are met with on a grand scale. The latter have already been described in the papers referred to below.[4]

Erratics, transported by floating ice, are also found in great numbers in Tasmania, as near Hobart, and at Maria Island, Peppermint Bay,[5] etc., on a horizon which is, perhaps, higher than that of the Piper River foraminiferal mudstone.

(*b*) *West Australia.*—One of the most interesting sections showing the stratigraphical relations of a foraminiferal limestone of, perhaps,

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[1] Brit. Mus. Cat. Foss. Foram., 1882, p. 6.

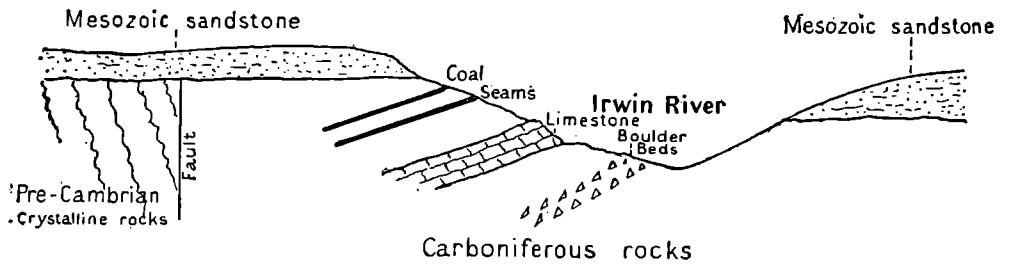
[2] Rept., Austr. Assoc. Adv. Sci., 1893, V, pp. 344–348, pls. x–xi.

[3] Since *Nubecularia stephensi* is restricted to the Lower Marine Series in N. S. Wales, and is also abundant in the Piper River beds, it is very probable that the two beds are at or near the same geological horizon.—(*F. C. and W. H.*)

[4] Rept. Austr. Asssoc. Adv. Sci., IX, Report of Glacial Committee, p. 193. See also A. E. Kitson, Proc R. Soc. Vict., 1902, XV (n.s.), Pt. i, pp. 28–35, t. 3.

[5] E. G. Hogg.—The Glacial Beds of Little Peppermint Bay, Tasmania. Papers R. Soc. Tas. for 1900–01, pp. 45–47.

Carboniferous age in West Australia, has been described by Mr. A. Gibb Maitland, F.G.S., in a letter to myself. He gives the following sketch section :—



This foraminiferal limestone contains also a great abundance of exquisitely preserved crinoids. Numerous fossils have been described by Mr. A. H. Foord from the Irwin River, in the Victoria District.[1]

The general facies of the Marine Fauna, especially the brachiopods, is Carboniferous rather than Permo-Carboniferous, as it contains such forms as *Productus undatus*, *Spirifera exsuperans*, *Reticularia lineata*, *Orthotetes crenistria*, &c., none of which ascend into the Permo-Carboniferous rocks of N. S. Wales. The exact relation of the rocks containing the above brachiopods to the foraminiferal limestone has not been ascertained, but apparently they all form part of the Carboniferous System.[2] An account of the Foraminifera has been given by Mr. Walter Howchin.[3]

They comprise the following:—*Cornuspira schlumbergi*, Howchin, *Nodosaria irwinensis* Howchin, *Frondicularia woodwardi*, Howchin. A species of *Nubecularia* is also present in large numbers in a crinoidal limestone from the Irwin River, collected by Mr. Panton.[4] Porcellaneous types largely predominate. A feature of special interest is the occurrence of a bed of glacial erratics a short distance below the foraminiferal limestone.

In Mr. Foord's opinion, the Irwin River limestones are of Carboniferous Age. If this view be accepted (and the Palæontological evidence strongly supports it), the Irwin River district has a foraminiferal horizon, as well as a glacial horizon, of Carboniferous Age, and thus older than the Permo-Carboniferous foraminiferal and glacial horizons of N. S. Wales.

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[1] Geol. Mag., 1890, VIII (3), pp. 145–155, pls. vi–vii.

[2] Mr. R. Etheridge, however, informs me that he is satisfied as to the occurrence of *Productus brachythærus* in considerable numbers in the Marine Strata of the Irwin River, and he considers that some, at any rate, of the strata shown in the above section beneath the mesozoic sandstone are of Permo-Carboniferous Age, in the meaning of that term as used by N. S. Wales Geologists for the period which was contemporaneous with the *Glossopteris* and *Gangamopteris* Flora of that State. Mr. A. Gibb Maitland, considers that the coal seams shown are perhaps the equivalents of the Greta coal-measures (Permo-Carboniferous) of N. S. Wales.

[3] Rept. Austr. Assoc. Adv. Sci., 1893, V, p. 366; also Trans. R. Soc. S.A. xix, 1895, pp. 194–200, pl. x.

[4] A thin slice of this is preserved at the Geological Survey offices, N. S. Wales. This was collected by Mr. Panton, and labelled "Irwin River."

IV.—Summary and Conclusions.

(1) The Foraminifera described in this Monograph occur chiefly on two horizons, separated from one another by a thickness of about 4,000 feet of strata. The Upper Horizon (Wollong Horizon) is in the Upper Marine Series, and the Lower Horizon (Pokolbin Horizon) is in the Lower Marine Series of the Permo-Carboniferous System of N. S. Wales.

The great thickness of the marine beds separating the two horizons, and the fact that the Greta Coal Measures are also interposed between them, as well as the differential facies of the associated fossils, proves the age of the Wollong Horizon to be distinctly newer than that of Pokolbin.

(2) The nature of the sediments associated with the Foraminifera, as well as the palæo-geography of the surrounding country, shows that the Foraminifera of both Wollong and Pokolbin lived in shallow seas close to the old shore-lines of the Carboniferous land.

(3) Volcanic eruptions, producing basalts and submarine basic tuffs partly preceded and partly perhaps accompanied the growth of the Pokolbin argillaceous limestone.

(4) Glacial erratics are met with on a horizon not much below that of the Pokolbin limestone, while they are actually present in the Wollong Horizon; thus it may be concluded that the shallow seas, in which the Foraminifera flourished, had their waters occasionally chilled by floating ice. At the same time, the fact must be borne in mind that at Wollong an abundance of the Coral *Trachypora Wilkinsoni* is associated with the Foraminifera, from which it may be inferred that the temperature of those seas was after all not very low.

(5) The further study of the Foraminifera of the Upper and Lower Marine Series of N. S. Wales may supply valuable data for correlating members of the Permo-Carboniferous System of Australasia even in widely-separated areas. The Piper River Foraminiferal Horizon of Tasmania is probably homotaxial with that of Pokolbin, as rendered probable by the great abundance of *Nubecularia* in both series, and both may, perhaps, be approximately homotaxial with that of the Irwin River Limestone in West Australia.

If this conclusion is correct, the principal Palæozoic Foraminiferal Horizon of Australia is situated, as far as is at present known, in the Lower Marine Series. At the same time, it is quite possible that the Irwin River Horizon may be of the Carboniferous age, and so be considerably older than the Permo-Carboniferous horizons of Wollong, Pokolbin, and the Piper River.

Obviously, the as yet unknown history of the Palæozoic Foraminiferal Fauna of N. S. Wales in pre-Permo-Carboniferous time offers an inviting field for research, as also does the relation of the Permo-Carboniferous Foraminifera to those of the Great Cretaceous Basin of Australia. The general absence of any Marine Trias-Jura rocks in Eastern and Central Australia makes it improbable that the missing evidence will be supplied from those regions.

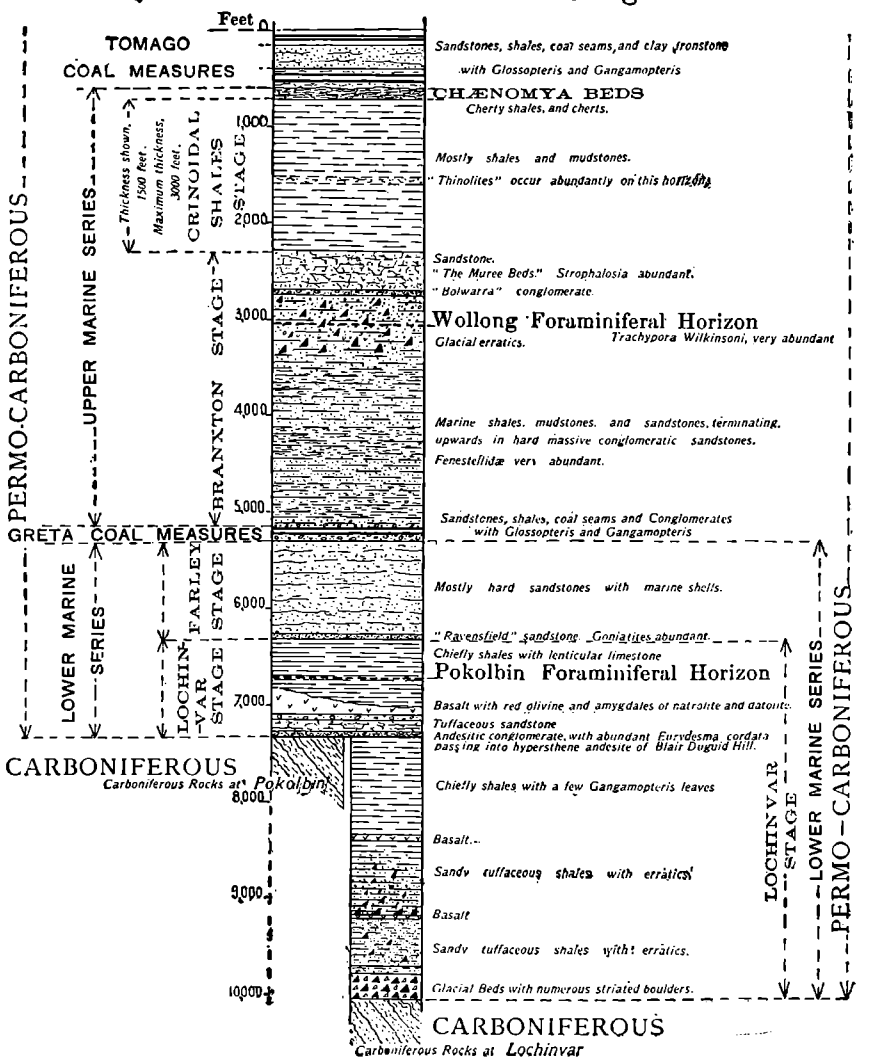
West Australia, however, possesses a Marine Jurassic Fauna, and it is not unlikely that the deeper marine strata beneath the Jurassic basins may be even of Triassic Age.

It is, therefore, chiefly to West Australia that we may look for an ultimate solution of the problem as to how our Cretaceous Foraminiferal Fauna became evolved out of the Permo-Carboniferous ancestors described in this Monograph.

Appended is a section showing the stratigraphical relations of the Foraminiferal Horizons of Wollong and Pokolbin.

SECTION IN HUNTER DISTRICT

Showing Foraminiferal Horizons of Wollong and Pokolbin.



LIST OF PLATES.

Plate I.—*Nubecularia stephensi*, *Lituola cristellarioides*, *Haplophragmium agglutinans*, *H. emaciatum*, *H.* cf. *tenuimargo*. *H. pokolbiense*, *Lituola* cf. *rhætica*, *Anomalina supracarbonica*, *Valvulina bulloides* (*?*), *Ammodiscus*, *Endothyra bowmani*.

Plate II.—*Hyperammina vagans*, *Pelosina hemisphærica*, *Ammodiscus millettianus*, *Stacheia simulans* (*?*), *Pleurostomella antiqua*, *Nodosaria permiana*, *Bulimina affinis*, *Geinitzina triangularis*, *Nodosaria* (*Dentalina*) cf. *farcimen*, *N.* (*D.*) (*?*) *bradyi*, *Thurammina papillata*.

Plate III.—*Ammodiscus anceps*, *Frondicularia woodwardi*, *Truncatulina haidingeri*, *Nodosaria labiata*, *Monogenerina pyramidis*, *Lunucammina* sp., *Lituola* cf. *rhætica*, *Vaginulina* cf. *legumen*, *Placopsilina tenuitesta*, *Lagena acuta*, *Marginulina* cf. *breoni*, *Nubecularia stephensi*.

Plate IV.—Sections of the Pokolbin Limestone.

I.—INTRODUCTORY REMARKS.

About four years ago we were favoured with the request by Mr. Edward F. Pittman, A.R.S.M., Government Geologist of New South Wales, and Prof. T. W. Edgeworth David, B.A., F.R.S., to undertake the investigation of the fossiliferous limestones of Pokolbin and other localities in New South Wales, with a view to describing their foraminiferal contents. To this request we acceded, and in the prosecution of the work we were kindly assisted by Prof. David, who sent us a collection of thirty-three thin sections of the Pokolbin foraminiferal rock, and also some typical specimens of the Pokolbin limestone for the purpose of slicing, as well as some decomposed material for washing, in order to separate any specimens which might perchance have broken free from the matrix.

The disintegrated material first sent to us, when washed, yielded very little in the way of isolated foraminiferal tests; but within the last year or so, Professor David and Mr. W. S. Dun, of the Department of Mines, Sydney, have kindly made further efforts to secure suitable material for this purpose. Some of the samples from Pokolbin and Wollong sent us by the above-mentioned gentlemen, have afforded us a fair number of highly interesting forms. These have been of great value in correcting our determinations of the Foraminifera seen in the thin slices of the limestone.

II.—THE LITERATURE OF THE (PERMO-CARBONIFEROUS) CARBO-PERMIAN[1] AND PERMIAN FORAMINIFERA.

THE published information regarding the Foraminifera of the beds referred to the above horizons is somewhat scanty in comparison with that relating to the Carboniferous formation below, and the Mesozoic horizons immediately above. This seems to be due, primarily, to the general scarcity of minute marine fossils in the Permo-Carboniferous series, on account of the sediments being so frequently of estuarine, lacustrine or even terrestrial origin. It may be also owing to the difficulty of obtaining suitable material for disintegration; and, further, the lithological condition of the series is not as a rule suitable for the preservation of the microzoa, which in all probability existed in some abundance in certain areas.

The principal authors who have contributed to the subject of this fauna are—Prof. T. Rupert Jones (9, 10), Dr. A. E. von Reuss (13), Dr. H. B. Geinitz (3), Dr. E. E. Schmid (14), Messrs. Jones, Parker and Kirkby (11), Dr. H. B. Brady (1), Dr. C. W. von Gümbel (5), W. Howchin (6, 7, 8), Erich Spandel (15, 16), and F. Chapman (2).

Respecting the foregoing works, it may be briefly stated that Prof. Rupert Jones, as early as 1850, gave descriptions and figures of six species of Foraminifera, including the form previously described by Geinitz in 1848, under the name of *Serpula pusilla* (now known as *Ammodiscus pusillus*, Gein. sp.).

The *Nodosaria geinitzi* described from the Zechstein (Permian) of Wetterau by Reuss is referable to *N. radicula* (Linné).

The Foraminifera of the Permian series of Central Germany were summarised in 1861 by Geinitz, who figured thirteen species. The same author described two species of *Fusulina* from the Permo-Carboniferous of Nebraska in 1866.

Dr. Schmid's work on the Foraminifera of the Zechstein at Wetterau in 1867, chiefly resulted in the description of *Trochammina filum*, but referred by that author to the genus *Serpula*.

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[1] The Authors desire to point out that whilst they are in favour of the use of the term "Carbo-Permian," "Permo-Carboniferous" is used in deference to the custom of the Geological Survey of N. S. Wales. The question of the nomenclature of the formations associated with the coal measures of Eastern Australia will be fully discussed by Professor T. W. Edgeworth David in his forthcoming "Geology of the Hunter River Coal-field."

An important memoir on *Trochammina* (*Ammodiscus*) *pusilla* and its allies was written by Messrs Jones, Parker, and Kirkby, in 1869. This was followed in 1876 by Dr. H. B. Brady's monograph on the Carboniferous and Permian Foraminifera, an exhaustive work which summarised our knowledge of the group from these formations, and added much that was new.

From the *Bellerophon*-kalk of the Alps, Gümbel, in 1878, obtained and enumerated several species of Foraminifera.

The British Museum catalogue of Fossil Foraminifera by Prof. Rupert Jones contains the earliest record of the Tasmanian foraminifer now referred to as *Nubecularia stephensi*, but which was there recorded as a "new species of *Cornuspira*." In this work there are also enumerated nine species in the museum collection from the Permian of England and Germany.

Coming nearer home, the discovery of Foraminifera in the Permo-Carboniferous rocks of the north-east of Tasmania by Mr. Thos. Stephens, has an especial interest for us. The occurrence was noted in the proceedings of the Royal Society of Tasmania for 1889, p. 54, and the various forms met with were described and figured by one of us in the report of the Adelaide meeting of the Australasian Association for the Advancement of Science for 1893 (1894). This was followed in the succeeding year by the description of species of *Cornuspira*, *Nodosaria* and *Frondicularia* from beds of probably similar age in the Irwin district, W. Australia. Since then, Spandel has published two important papers, one of which deals with the Foraminifera of the Zechstein of Germany, the other with similar fossils from the Permo-Carboniferous of Kansas. The former paper usefully summarised the foraminiferal fauna of the Zechstein, and also contains descriptions and figures of some new forms, including the interesting genera *Geinitzella* (afterwards changed to *Geinitzina*) and *Lunucammina*. The second paper of Spandel's contains an account of some new genera and species, determined, however, from specimens seen in section, in thin slices of rock.

The general facies of the Foraminifera of the newest upper Palæozoic series is further dealt with in a lately published work by one of us (2, pp. 258–260.)

III.—THE GENERAL MICROSCOPIC STRUCTURE OF THE FORAMINIFERAL LIMESTONES OF POKOLBIN.

THESE rocks contain numerous large fossils, visibly crowded together on the surface of weathered hand-specimens. Even by the unaided eye, the foraminifera may be easily detected, as their tests, especially in *Nubecularia*, present a whitish surface. In thin sections under the microscope the general appearance of the rock is that of an impure limestone, largely composed of calcareous organic fragments such as shells and polyzoa, bound together in part by a fine calcareous and silty mud. Quartz grains occur in the rock; they are very minute, and not at all abundant. Cavities seem to have been left between the fossils during the accumulation of the stratum, but the spaces have since been completely filled in with crystalline calcareous material, chiefly in the form of calcite. At the period of cementation, crystallisation took place around the separate fragments, much as they do at the present time around the pieces of coral and calcareous sand of a coral beach, until the interspaces were entirely filled up, either by primary aragonite crystals or by slender scalenohedra of calcite.

Occasionally the finer structure of the ground-mass of the Pokolbin limestone is granulated, as though incipient oolitic structure was being formed by chemical deposition. The composition of the rock is sometimes varied by the inclusion of fragments of igneous rocks, which are too decomposed for much to be said as to their nature, except that they appear to be mainly of an andesitic type.

The included organic fragments in the limestone are referable to Foraminifera, Radiolaria, Sponges, Crinoidea, Polyzoa, Brachiopoda, Pelecypoda, Gasteropoda, and Ostracoda. The molluscan shells have, in many cases, been bored by perforating Fungi or Algæ. Through the mass of the rock there is disseminated a good deal of peroxide of iron, chiefly in the form of tiny blood-red granules.

IV.—DESCRIPTION OF THE FORAMINIFERA.

Family—**MILIOLIDÆ.**

Genus—NUBECULARIA, *Defrance.*

NUBECULARIA STEPHENSI, *Howchin.*

(Plate I, Figs. 1 and 2; Plate III, Figs. 13 and 14; Plate IV, Figs. 1 and 4.)

Cornuspira, n. sp. Jones, 1882, Cat. Foss. Foram. Brit. Mus. p. 6.

Nubecularia lucifuga, Defr., var. *stephensi*, Howchin, 1894; Rep. Austral. Assoc. Adv. Sci., 1893 Meeting, p. 345, Pl. Xa, XIa.

Observations.—The chief differences between the present form, which we now prefer to regard as a distinct species, and *N. lucifuga*, lie in the fairly thin uniform character of the shell-wall of the former, and their tendency, in the shorter individuals, to increase on a milioline plan. *N. stephensi* was protean in its habit like *N. lucifuga*, sometimes coiling itself around a spicule, growing in chevron fashion over an angular fragment to which it had become attached, or even nestling in the crypts of polyzoa. These last-named examples usually have a very delicate shell-structure. Individuals of this species are difficult to separate from the rock. A figure of one of the more perfect specimens is shown in Pl. 1, Fig. 1. Another example, giving a sectional view of the test embedded in the rock, is shown in Pl. 1, Fig. 2. This shows a rude spiral arrangement, and calls to mind certain thin-tested *Haplophragmia.* Many of the thin rock-slices contain an abundance of the tests of this species, which is by far the commonest foraminifer in the limestones. A fine example of a test adherent to a flat surface is figured on Pl. 3, Fig. 13. In Fig. 14 of the same plate, a small, delicate-shelled example is seen nestling in the zoœcium of a polyzoan.

Occurrence.—*N. stephensi* is very abundant in the calcareous rock from Pokolbin; it was also found in the washings from Pokolbin No. 2 (Mount Vincent), and Pokolbin No. 3.

This foraminifer is also extremely abundant in the dark grey argillaceous limestone of the Piper River beds in Tasmania. A specimen of this rock in the British Museum (Natural History), London, is registered by Prof. T. Rupert Jones, as follows, "P. 1129, dark grey Carboniferous lime-stone, full of a contorted porcellanous Foraminifer (new species of *Cornuspira*)."

Family—**ASTRORHIZIDÆ.**

Genus—PELOSINA, *Brady.*

PELOSINA HEMISPHÆRICA, sp. nov.

(Plate II, Figs. 2a, b.)

Description.—Test somewhat irregularly flask-shaped, flattened on one side, convex on the other. Aperture, a short, but probably originally prolonged, tubular neck. Structure of test apparently composed of fine sandy, mud, in which are embedded various coarser bodies, such as fragments of shells, sand-grains, and other foraminiferal tests. Length, 1·4 mm.; breadth 1·07 mm.; thickness, about ·5 mm.

Observations.—The above species most nearly resembles *P. rotundata*, Brady,[1] but differs essentially in having a distinctly flattened, and a convex side. This appears to be its first occurrence as a fossil; but as it is likely to be easily overlooked, it may yet be found in various beds of later ages.

Occurrence.—*P. hemisphærica* was found in the decomposed limestones from Wollong and Pokolbin No. 3.

Genus—HYPERAMMINA, *Brady.*

HYPERAMMINA VAGANS, *Brady.*

(Plate II, Fig. 1.)

Hyperammina vagans, H. B. Brady, 1879, Quart. Journ. Micr. Soc., vol. XIX, N.S., p. 33, Pl. V, Fig. 3.

H. vagans, Brady, Haeusler, 1883, Quart. Journ. Geol. Soc., vol. XXXIX, p. 26, Pl. II, Figs 2-6.

H. vagans, Brady, Howchin, 1888, Journ. Roy. Micr. Soc., p. 535, Pl. VIII, Fig. 3.

Observations.—Our specimen is attached to a spicular body, around which it is loosely coiled. The walls are arenaceous and of somewhat coarse structure. The average diameter of the tube is about ·175 mm. Dr. Brady stated that the recent specimens range between the diameters of ·05 and ·2 mm.

The genus *Hyperammina* occurs in fossiliferous strata from the Silurian onwards; and the present species is already known from strata as old as the Carboniferous Limestone (N. of England).

Occurrence.—Rare in the decomposed limestone from Wollong.

[1] Rep. Chall. vol. IX, 1884, p. 236, Pl. XXV, Figs. 18-20.

Family—**LITUOLIDÆ.**

Genus—HAPLOPHRAGMIUM, *Reuss.*

HAPLOPHRAGMIUM AGGLUTINANS, *d'Orb*, sp.

(Plate I, Fig. 5.)

Spirolina agglutinans, d'Orbigny, 1846, Foram. Foss. Vienne, p. 137, Pl. VII, Figs. 10-12.

Haplophragmium rectum, Brady, 1876, Mon. Carb. and Perm. Foram., p 66, Pl. VIII, Figs. 8, 9.

H. agglutinans, (d'Orb.), Chapman, 1895, Ann. Mag. Nat. Hist., ser. 6, vol. XVI, p. 313, Pl. XI, Figs. 2a, b.

This species seems to occur but rarely in the washings from Pokolbin. Its first geological appearance dates from the Carboniferous in other parts of the world. The specimen figured is somewhat unusually irregular in the later portion of the test.

Occurrence.—*H. agglutinans* was found in the decomposed limestone from Pokolbin No. 2 (Mt. Vincent).

HAPLOPHRAGMIUM EMACIATUM, *Brady.*

(Plate I, Figs. 10a, b.)

Haplophragmium emaciatum, Brady, 1884, Rep. Chall., vol. IX, p. 305, Pl. XXXIII, Figs. 26-28.

H. emaciatum, Brady, Chapman, 1895, Ann. Mag. Nat. Hist., ser. 6, vol. XVI, p. 315, Pl. XI, Fig. 6.

This form is recognised by its thin, evolute spiral test. It has previously been noticed in strata as old as the Rhætic.

Occurrence.—It is found in the washings from the decomposed limestone of Wollong.

HAPLOPHRAGMIUM POKOLBIENSE, sp. nov.

(Plate I. Fig. 6.)

Description.—Test semi-circular to nearly circular; spiral; compressed or slightly inflated around the umbilicus; bilaterally symmetrical. Chambers narrow and strongly curved; sutural lines more or less covered by extraneous cement; the last chamber or so distinctly compressed as compared with the rest. Structure arenaceous, of medium coarseness. Length of the figured specimen ·84 mm. (an average-sized example).

Observations.—This species reminds us to some extent of *H. cassis*, Parker, sp., but is not so elongate, and the chambers are more strongly curved. As *H. cassis* is isomorphous with *Cristellaria crepidula*, so our specimens of *H. pokolbiense* may be compared with the shorter *Cristellariæ*, like *C. navicula*, d'Orb.

Occurrence.—*H. pokolbiense* is a common form in the material from Pokolbin No. 2 (Mt. Vincent), and also in Pokolbin No. 3.

HAPLOPHRAGMIUM, *cf.* TENUIMARGO, *Brady.*

(Plate I, Fig. 11.)

Haplophragmium tenuimargo, Brady, 1882, Proc. Roy. Soc. Edin., vol. XI, p. 715.

H. tenuimargo, Brady, 1884, Rep. Chall., vol. IX, p. 303, Pl. XXXIII, Figs. 13-16.

The specimen now figured somewhat resembles Brady's examples; but the spiral commencement, which in our specimen is rather obscure, does not seem to be so definitely inrolled as in the recent form. Like the "Challenger" examples, our specimen has the lateral edges sharp and jagged. The recent forms were taken, as a rule, from fairly deep-water areas. *H. tenuimargo* does not appear to have been previously recorded in the fossil condition.

Occurrence.—This example was found in the washings of the decomposed limestone from Wollong.

Genus—PLACOPSILINA, *d'Orbigny.*

PLACOPSILINA TENUITESTA, sp. nov.

(Plate III, Fig. 9.)

Description.—Test adherent; apparently spiral; consisting of a series of convex chambers, often arranged in three successive layers. Structure of the test thin, usually arenaceous although occasionally having the inner chambers covered by a chitinous investment. Some fairly large stolon passages occur in the outer layer of the test. Length of specimen figured, ·35 mm.; height, ·18 mm.; thickness of outer test, ·01 mm.

Occurrence.—This interesting form is fairly common in the thin sections made from the Pokolbin limestone.

Genus—LITUOLA, *Lamark.*

LITUOLA CRISTELLARIOIDES, sp. nov.

(Plate I, Figs. 3 and 4.)

Description.—Test coarsely arenaceous, complanate, sub-elliptical, with an outline like *Cristellaria.* Internal structure labyrinthic, rather than simply divided or chambered. Length of specimen *a*, 2·15 mm.; width, 1·1 mm.; spec. *b*, length, 1·4 mm.; width, ·95 mm.

Observations.—At first sight this species reminds one of *Haplophragmium cassis*, Parker sp. That form, however, is neatly and regularly divided by curved septa into gradually increasing chambers; whereas our specimens, so far as could be ascertained with the limited material at our disposal, were internally labyrinthic.

Occurrence.—In the decomposed limestone of Pokolbin No. 2 (Mt. Vincent).

LITUOLA, *cf.* RHÆTICA, *Chapman*, sp.

(Plate I, Fig. 7; Plate III, Fig. 7.)

Haplophragmium rhæticum, Chapman, 1895, Ann. Mag. Nat. Hist, ser. 6, vol. XVI, p. 314, Pl. XI., Figs. 3, 4.

Observations.—The form which is referred with reservation to the above species is fairly common in the washed material from Wollong. The Rhætic specimens from Wedmore, England, are more correctly referred to the genus *Lituola* since they have no distinctly chambered internal structure, like *Haplophragmium.*

Occurrence.—In the washed material from the decomposed limestone of Wollong and Pokolbin No. 3; also in thin slices of the Pokolbin limestone.

Genus—THURAMMINA, *Brady.*

THURAMMINA PAPILLATA, *Brady.*

(Plate II, Fig. 13.)

Thurammina papillata, Brady, 1879, Quart. Journ. Micr. Sci., vol XIX n.s., p. 45, Pl. V, Figs. 4–8.

T. papillata Brady, Haeusler, 1883, Quart. Journ. Geol. Soc. vol. XXXIX, p. 27, Pl III, Figs. 2–6.

Observations.—By the occurrence of this interesting form in Permo-Carboniferous strata, the backward range of the species in geological time is

considerably extended, the earliest appearance previously recorded being in the Jurassic period. Our example appears to be quite typical. With regard to its recent occurrence, the habitat of *T. papillata* is in fairly deep water.

Occurrence.—In the washed material from Pokolbin.

Genus—AMMODISCUS, *Reuss.*

AMMODISCUS INCERTUS, *d'Orbigny*, sp.

Operculina incerta, d'Orbigny, 1839, Foram. Cuba, p. 49, Pl. V, Figs. 16, 17.

Trochammina incerta, (d'Orb.), Brady, 1876, Carb. and Perm. Foram., Pal Soc. Mon., vol. XXX, p. 71, Pl. II, Figs. 10–14.

Ammodiscus incertus (d'Orb.), Brady, 1884, Rep. Chall., vol. IX, p. 330, Pl. XXXVIII, Figs. 1–3.

Observations.—This species is not common in our material, but a few typical specimens have been found. The test, in common with those from other Carboniferous deposits, is very thin, and generally, exceedingly minute.

Occurrence.—From the decomposed limestone of Wollong.

AMMODISCUS MILLETTIANUS, *Chapman.*

(Plate II, Fig. 3.)

Ammodiscus millettianus, Chapman, 1898, Journ. R. Micr. Soc., p. 12, Pl. II, Figs. 6a, c.

Observations.—The specific characters given in the original description of the Gault specimens, and repeated below, apply equally well to the present examples, excepting as regards the aperture, which in the Permo-Carboniferous examples is obscure. "Test finely arenaceous, discoidal and flattened; consisting of a coiled and irregularly constricted tube, making only one or two convolutions. Externally the sutural lines are completely covered by the later growth, and are only visible at certain parts by slight linear depressions. When moistened, the form of the interior of the test can be more easily seen." The diameter of the Gault specimens average about ·4 mm., whereas the Permo-Carboniferous specimens have a diameter of nearly 1 mm.

Occurrence.—In washings from the limestone of Wollong and Pokolbin Nos. 2 and 3). Somewhat common.

AMMODISCUS ANCEPS, *Brady*, sp.

(Plate 3, Fig. 1.)

Trochammina anceps, Brady, 1876, Carb. and Perm. Foram. (Pal. Soc. Mon.), p. 76, Pl. III, Figs. 8a, b.

Ammodiscus anceps, (Brady), Chapman, 1895, Ann. Mag. Nat. Hist., ser. 6, vol. XVI, p. 316, Pl. XI, Figs. 10a, b.

Observations.—The specimen figured is typical, and agrees more closely with the original figure than the Rhætic specimens from Wedmore, the latter being relatively thinner and more compressed. The previous records are from the Carboniferous, Rhætic and Lias.

Occurrence.—In washings from the Pokolbin limestone.

? AMMODISCUS, sp.

(Plate 1, Fig. 12a, c.)

Observations.—It is impossible to more than tentatively indicate the affinity of this curious little fossil. The finely arenaceous structure and symmetrical shape, with its cavernous interior, seem to point in the direction of *Ammodiscus*. The projecting portion of the test seen in the figure suggests that it formed the apertural end of an internal flattened tube.

Occurrence.—From the decomposed limestone of Wollong.

Genus—STACHEIA, *Brady* (emend. Chapm.).

STACHEIA SIMULANS, sp. nov.

(Plate 2, Fig. 4.)

Description.—Test variably sub-elliptical, moderately compressed; the figured specimen roughly resembles in outline a spiral and rectilineally extended *Haplophragmium*. Surface corroded or marked by irregular depressions. Shell-texture sub-arenaceous, of medium fineness. Length of figured specimen, 1·4 mm.; greatest width, ·825 mm.

Observations.—In shell-texture this form resembles *S. cuspidata*[1] from the Rhætic of Wedmore; the latter differs, however, in having a sub-

[1] Ann. Mag. Nat. Hist., ser. 6, vol. XVI, 1895, p. 325, Pl. XII, Figs. 9, 10.

circular outline. The test in *S. simulans* is formed of small adventitious particles, both organic and mineral, cemented by a chitino-argillaceous base. A thin section of the test showed a cavernous interior, containing an irregular nodular fragment, itself probably of organic origin.

Occurrence.—*Stacheia simulans* is not uncommon in the decomposed limestone from Wollong, New South Wales.

Genus—ENDOTHYRA, *Phillips.*

ENDOTHYRA BOWMANI, *Phillips.*

(Plate 1, Figs. 13a, c.)

Endothyra Bowmani, Phillips, 1845, Proc. Geol. Tech. Soc. West Riding Yorks., vol. 11, p. 279, Pl. VII, Fig. 1.

E. Bowmani, Phillips, Brady, 1876, Mon. Carb. and Perm. Foram. (Pal. Soc.), p. 92, Pl. V, Figs. 1–4.

Observations.—The specimen in our series representing the above species is fairly characteristic. It is slightly crushed on one side, and apparently surface-corroded to some extent. There is an especial interest in meeting with this typically Carboniferous Limestone fossil of the northern hemisphere in Australia.

Occurrence.—In the decomposed limestone of Wollong, New South Wales.

ENDOTHYRA MACELLA, *Brady,* sp.

Involutina macella, Brady, 1869, Rep. Brit. Assoc., Exeter Meeting, pp. 379, 382.

Endothyra macella, Brady, 1876, Mon. Carb. and Perm. Foram. (Pal. Soc.), p. 98, Pl. V, Figs. 13, 14.

Observations.—This species is somewhat rare in the British Carboniferous rocks; it is interesting to meet with this form here, which one of us has already separated from the Irish Carboniferous Limestone shale of Castle Espie. The chief characters are the emaciated test, as compared with other species of the genus, and its thin peripheral edge.

Occurrence.—Not uncommon in the washings from the decomposed limestone of Wollong, and Pokolbin No. 3.

Family—**TEXTULARIIDÆ.**

Genus—MONOGENERINA, *Spandel.*

MONOGENERINA PYRAMIDIS, sp. nov.

(Plate III, Fig. 5.)

Description.—Test elongate, tapering, consisting of about seven chambers, each a little higher than broad. Primordial chamber ellipsoidal. Between each chamber there is a marked separation line. The summit of each chamber is centrally perforated in succession, and the border of each perforation, or stolon passage, is turned downwards into the chamber cavity. Shell-texture hyaline, finely and densely perforated. Length of figured specimen, 1·5 mm.

Observations.—The Genus *Monogenerina* was established by Spandel for the inclusion of those forms allied to *Bigenerina* which have the communication between chambers arranged along a single axis running vertically through the median line of the shell. *Monogenerina pyramidis* differs from the species previously described by Spandel[1] from the Permo-Carboniferous of Kansas, North America, in having a gently tapering and straight-sided test, the chambers having a sub-rectangular form in median section.

Occurrence.—In thin slices of the limestone from Pokolbin, New South Wales. Not uncommon.

Genus—VALVULINA, *d'Orbigny.*

VALVULINA BULLOIDES, *Brady.*

(Plate I, Figs. 9a, c.

Valvulina bulloides, Brady, 1876, Mon. Carb. and Perm. Foram. (Pal. Soc.), p. 89, Pl. IV, Figs. 12–15.

Observations.—This species, as Dr. Brady remarked, bears many points of similarity to the hyaline type, *Globigerina.* It is, however, more irregular in the shape of the last-formed chambers, and its shell-structure is sub-arenaceous.

Occurrence.—One specimen was found in the washings from the decomposed limestone of Wollong.

[1] Abhandl. der Naturhist. Gesellsch. in Nürnberg, 1901, pp. 9, 10. (Author's Copy.)

Genus—BULIMINA, *d'Orbigny.*

BULIMINA AFFINIS, *d'Orbigny.*

(Plate II, Fig. 7.)

Bulimina affinis, d'Orbigny, 1839, Foram. Cuba, p. 105, Pl. II, Figs. 25–26.

Observations.—The occurrence of this genus below the Jurassic is extremely rare; another species, *B. pyrula* has been recorded from the Rhætic series. The present example is typical of the species.

Occurrence.—In the decomposed limestone of Wollong, New South Wales.

Genus—PLEUROSTOMELLA, *Reuss.*

? PLEUROSTOMELLA ANTIQUA, sp. nov.

(Plate II, Fig. 5.)

Description.—Test smooth, compressed, slender, tapering; sutures of chambers strongly marked. Earlier segments small, rapidly increasing in size. Length, 1 mm.

Observations.—The present example is referred, with some slight reservation, to the above genus, although it is closely comparable in some points with the attenuate forms found in the Cretaceous of Europe.

No examples of this genus have hitherto been detected in strata older than the Cretaceous.

Occurrence.—In the decomposed limestone of Wollong, New South Wales.

Family—**LAGENIDÆ.**

Genus—LAGENA, *Walker and Boys.*

LAGENA ACUTA, *Reuss*, sp.

(Plate III, Fig. 10.)

Fissurina acuta, Reuss. 1862, Sitzungsb. d.K. Ak. Wiss. Wien., vol. XLVI, p. 343, Pl. VII pp. 90, 91.

Lagena acuta, Reuss, sp., Brady, 1884, Rep. Chall., vol. IX, p. 474, Pl. LIX, Figs. 6 a, b.

Observations.—The specimen figured is a section of a *Lagena* taken through the vertical median line; it is most nearly matched by the above species.

Occurrence.—In thin section of the limestone from Pokolbin, New South Wales.

Genus—NODOSARIA, *Lamarck.*

NODOSARIA PERMIANA, *Spandel*, sp.

(Plate II, Figs. 6, 8a, b.)

Orthocerina permiana, Spandel, 1898, Die Foram. deutschen Zechsteins, p. 7 (Author's Copy), Fig. 2.

Observations.—The specimens before us, and also those figured, seem to be merely irregularly grown Nodosarines. It is unnecessary to retain *Orthocerina* in any restricted sense, as the specimens on which the genus was originally founded are included in other genera as *Rhabdogonium*. Spandel records this species from the Zechstein of Germany.

Occurrence.—In the decomposed limestone of Wollong. Occasional.

NODOSARIA (DENTALINA), *cf.* FARCIMEN, *Reuss* (after *Soldani*).

(Plate II, Fig. 11.)

"*Orthoceras farcimen*," Soldani, 1791, Testaceographia, vol. 1, pt. 2, p. 98, Pl. CV, Fig. O.

Dentalina farcimen, Reuss, Bull. de l'Acad. Roy. Belg., ser. 2, vol. XV, p. 146, Pl. 1, Fig. 18.

Nodosaria (*Dentalina*) *farcimen*, Soldani sp., Brady, 1884, Rep. Chall., vol. IX, p. 498, Pl. LXII, Figs. 17, 18; woodcuts, Figs. 13 a–c.

Observations.—This species seems to be represented in the present series by two segments of a subovate-chambered *Nodosaria*. *N. farcimen* is already familiar to us as a Permian fossil.

Occurrence.—In the decomposed limestone of Wollong, New South Wales.

NODOSARIA (DENTALINA) ? BRADYI, *Spandel*, sp.

(Plate II, Fig. 12.)

Dentalina bradyi, Spandel, 1901, Abhandl. der Naturhist, Gesellsch. in Nürnberg, p. 16 (author's copy), Fig. 9.

The original description of *N.* (*D*) *bradyi* was based on a specimen seen in a thin rock-slice of the Kansas Permo-Carboniferous limestone. Allowing for a certain range of variation, the specimen before us, although not so slender, nor so bulbous at the commencement, probably belongs to the same species. The aperture in the Australian specimen shows a modified stellate condition.

Occurrence.—In the decomposed limestone of Wollong, New South Wales.

NODOSARIA (DENTALINA) LABIATA, *Spandel*, sp.

(Plate III, Fig. 4.)

Dentalina labiata, Spandel, 1898, Die Foram. des Deutschen Zeichsteines, p. 10, f. 7.

Observations.—The form of this shell, with its transverse sutures, reminds us of *Nodosaria* (*D.*) *consobrina*, d'Orb. The present species, however, shows a peculiar thickening and eversion of the apertural border. The species seems characteristic of this particular horizon, since our specimens are identical with those found by Spandel in the Zechstein of Thuringia.

Occurrence.—Frequent, in the decomposed limestone of Pokolbin, No. 3, New South Wales.

Genus—FRONDICULARIA, *Defrance.*

FRONDICULARIA WOODWARDI, *Howchin.*

(Plate III, Fig. 2.)

This handsome form was first described from the Carboniferous rocks of the Irwin River, Western Australia. The figure given here is from an exceptionally well-developed specimen. A shell somewhat closely resembling this, but with fewer and higher chambers, has been figured by Spandel from the Zechstein of Germany under the name of *F. fischeri.*

Occurrence.—Frequent in the decomposed limestone of Wollong and Pokolbin No. 3, New South Wales.

Genus—GEINITZINA, *Spandel.*

GEINITZINA TRIANGULARIS, sp. nov.

(Plate II, Figs. 9a, b, 10.)

Description.—Test sub-triangular or triangular, compressed, decidedly hollowed along the median longitudinal axis. Primordial chamber globular, the remainder crescentic or feebly chevroned one within the other. More rarely the shells exhibit a flabelline commencement (Fig. 10). Length of a medium-sized example, ·64 mm.; greatest width, ·5 mm.

Observations.—This form differs from the succeeding species, *G. postcarbonica*, in its broadly triangular shape and greater compression of the lateral faces of the test.

Occurrence.—Frequent in the decomposed limestone of Wollong and of Pokolbin (No. 3), New South Wales.

GEINITZINA POSTCARBONICA, *Spandel.*

(Plate IV, Fig. 3.)

Geinitzina postcarbonica, Spandel, 1901, Abhandl. der Naturhist. Gesellsch. in Nürnberg, p. 15 (Author's copy), Figs. 8a-d.

No specimen of the above was isolated from the limestone washings. It was, however, occasionally seen in thin sections of the limestone. Fig. 3 gives one a good idea of the peculiarly shaped test, as seen in a longitudinal section.

Occurrence.—In the limestone of Pokolbin, New South Wales.

Genus—LUNUCAMMINA, *Spandel.*

LUNUCAMMINA, *cf.* PERMIANA, *Spandel.*

(Plate III, Figs. 6, 12.)

Lunucammina permiana, Spandel, 1898, Die Foram. des deutschen Zechsteines, p. 8, Figs. 5a, c.

Observations.—The specimens here figured are those seen in thin sections of the limestone. Fig. 6 is taken at right-angles to the lateral faces of the shell, whilst Fig. 12 represents a section nearly parallel with the plane of compression. The distinct tubulation of the shell-wall and the small central apertures at the summits of the later chambers may be noted in the above figures.

Occurrence.—In thin sections of the limestone from Pokolbin, New South Wales.

Genus—MARGINULINA, *d'Orbigny.*

MARGINULINA, *cf.* BREONI, *Terquem,* sp.

(Plate III, Fig. 11.)

Dentalina breoni, Terquem, 1863, Mem. Acad. Imp. Metz (1862-3), p. 176, Pl. VII, Fig. 16.

Observations.—The fragment of a test with elongate oblique chambers, and having a rugose exterior, which is here figured, seems most nearly allied to Terquem's shell from the Lower Lias of France.

Occurrence.—In a section of limestone, Pokolbin, New South Wales.

Genus—VAGINULINA, *d'Orbigny*.

VAGINULINA, *cf.* LEGUMEN, *Linn.*, sp.

(Plate III, Fig. 8.)

Nautilus legumen, Linné, 1758, Syst. Nat., ed. 10, p. 711.

Vaginulina legumen, Linn., sp., Brady, 1884, Rep. Chall., vol. IX, p. 530, Pl. 66, Figs. 13–15.

Observations.—The figured specimen is a longitudinal section of a shell comparable with the above species. *V. legumen* is a well-distributed fossil throughout Mesozoic and Tertiary strata, the oldest occurrence dating from the Trias.

Occurrence.—Not uncommon in thin sections of limestone, Pokolbin.

Family—**ROTALIIDÆ.**

Genus—ANOMALINA, *d'Orbigny*.

ANOMALINA SUPRACARBONICA, sp. nov.

(Plate I, Figs. 8a, c.)

Description.—Test rotaliform, sub-elliptical; having few chambers, which are well inflated. Superior face convex, showing a short spiral of two whorls, with a bulbous commencement. Inferior face convex, sutures only feebly excavated. Aperture, a conspicuous arched slit, nearly median. Greatest diameter, ·425 mm.

Occurrence.—In the washings from the decomposed limestone of Wollong, New South Wales.

Genus—TRUNCATULINA, *d'Orbigny*.

TRUNCATULINA HAIDINGERI, *d'Orb.*, sp.

(Plate III, Figs. 3a, c.)

Rotalina haidingeri, d'Orbigny, 1846, Foram. Foss. Vienne, p. 154, Pl. 8, Figs. 7–9.

Truncatulina haidingeri, d'Orb., sp., Reuss, 1867, Sitzungsb. d. K. Ak. Wiss. Wien, vol. LV, p. 28.

Observations.—The above species is a very common Tertiary fossil, and it was recorded by one of us from the Neocomian of Guildford, Surrey, England. An allied form, *T. stelligera*, Chapm., having sutural thickenings on the inferior surface of the shell, has been described from Rhætic strata at Wedmore, in Somerset.[1] The genus dates backward to the Carboniferous in England.

Occurrence.—From the decomposed limestone of Pokolbin, No. 3, New South Wales.

[1] Ann. Mag. Nat, His., ser. 6, vol. XVI, 1895, p. 327, Pl. 12, Figs. 14 a, b.

V.—SUMMARY.

The following thirty-five forms are recorded in the foregoing section :—

Nubecularia stephensi, Howchin.
Pelosina hemisphærica, sp. nov.
Hyperammina vagans, Brady.
Haplophragmium agglutinans, d'Orb., sp.
H. emaciatum, Brady.
H. pokolbiense, sp. nov.
H. cf. *tenuimargo*, Brady.
Placopsilina tenuitesta, sp. nov.
Lituola cristellarioides, sp. nov.
L. cf. *rhætica*, Chapman, sp.
Thurammina papillata, Brady,
Ammodiscus incertus, d'Orb., sp.
A. millettianus, Chapman.
A. anceps, Brady, sp.
? *Ammodiscus*, sp.
Stacheia simulans, sp. nov.
Endothyra bowmani, Phillips.
E. macella, Brady, sp.
Monogenerina pyramidis, sp. nov.
Valvulina bulloides, Brady.
Bulimina affinis, d'Orb.
? *Pleurostomella antiqua*, sp. nov.
Lagena acuta, Reuss, sp.
Nodosaria permiana, Spandel, sp.
N. (*Dentalina*), cf. *farcimen*, Reuss.
N. (*D.*) ? *bradyi*, Spandel, sp.
N. (*D.*) *labiata*, Spandel, sp.
Frondicularia woodwardi, Howchin.
Geinitzina triangularis, sp. nov.
G. postcarbonica, Spandel.
Lunucammina, cf. *permiana*, Spandel.
Marginulina, cf. *breoni*, Terquem, sp.
Vaginulina, cf. *legumen*, Linn. sp.
Anomalina supracarbonica, sp. nov.
Truncatulina haidingeri, d'Orb., sp.

The most noteworthy fact connected with the above assemblage is, perhaps, the preponderance of arenaceous and sub-arenaceous forms. As in common with other Palæozoic foraminiferal faunas, there is also associated with them a large proportion of hyaline forms of the family *Lagenidæ*. True rotaline forms seem usually to be rare until we reach Mesozoic strata. Another striking feature in this assemblage is the enormous abundance, in certain specimens of rock, of the porcellanous foraminifer, *Nubecularia*.

Some of the above species were common to both the northern and southern hemispheres in Upper Palæozoic times, as *Hyperammina vagans*, *Haplophragmium agglutinans*, *Ammodiscus incertus*, *A. anceps*, *Endothyra bowmani*, *E. macella*, *Valvulina bulloides*, *Nodosaria permiana*, *N. bradyi*, *N. labiata*, *Geinitzina postcarbonica*, and *Lunucammina permiana*.

Another feature of especial interest is the occurrence of the genera lately described by Spandel from beds of similar age in Germany and North America, namely, *Monogenerina*, *Geinitzina*, and *Lunucammina*, which are apparently confined to strata of this particular age.

Nine of the above species appear to be new; they are,—*Pelosina hemisphærica*, *Haplophragmium pokolbiense*, *Placopsilina tenuitesta*, *Lituola cristellarioides*, *Stacheia simulans*, *Monogenerina pyramidis*,? *Pleurostomella antiqua*, *Geinitzina triangularis*, and *Anomalina supracarbonica*.

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EXPLANATION OF PLATES.

PLATE I.

Fig. 1. *Nubecularia stephensi*, Howchin. A coiled and closely adherent specimen attached to a ? phosphatic fragment. Pokolbin.— × 45.

Fig. 2. *N. stephensi*, Howchin. A fragment of the limestone, showing a transversely fractured test. Pokolbin.— × 45.

Fig. 3. *Lituola cristellarioides*, sp. nov. Pokolbin (No. 2). Mt. Vincent.— × 20.

Fig. 4. *L. cristellarioides*, sp. nov. Pokolbin (No. 2). Mt. Vincent.— × 40.

Fig. 5. *Haplophragmium agglutinans*, d'Orb., sp. Pokolbin (No 2). Mt. Vincent.— × 45.

Fig. 6. *Haplophragmium pokolbiense*, sp. nov. Pokolbin (No. 2). Mt. Vincent.— × 45.

Fig. 7. *Lituola, cf. rhætica.* Chapman, sp. Wollong.— × 40.

Fig. 8. *Anomalina supracarbonica*, sp. nov. (*a*) Superior aspect; (*b*) inferior aspect; (*c*) oral aspect. Wollong.— × 80.

Fig. 9. *Valvulina bulloides*, Brady. (*a*) Superior aspect; (*b*) inferior aspect; (*c*) peripheral aspect. Wollong.— × 85.

Fig. 10. *Haplophragmium emaciatum*, Brady. (*a*) Lateral aspect; (*b*) peripheral aspect. Wollong.— × 40.

Fig. 11. *Haplophragmium, cf. tenuimargo*, Brady. Wollong.— × 40.

Fig. 12. ? *Ammodiscus*, sp. (*a*) and (*b*) lateral aspects; (*c*) peripheral aspect. Wollong.— × 40.

Fig. 13. *Endothyra bowmani*, Phillips. (*a*) superior aspect; (*b*) inferior aspect; (*c*) peripheral aspect. Wollong.— × 40.

PLATE II.

Fig. 1. *Hyperammina vagans*, Brady. Wollong.— × 40.

Fig. 2. *Pelosina hemisphærica*, sp. nov. Wollong.— × 40.

Fig. 3. *Ammodiscus millettianus*, Chapman. Wollong.— × 40.

Fig. 4. *Stacheia simulans*, sp. nov. Wollong.— × 40.

Fig. 5. *? Pleurostomella antiqua*, sp. nov. Wollong.— × 66.

Fig. 6. *Nodosaria permiana*, Spandel, sp. Wollong.— × 60.

Fig. 7. *Bulimina affinis*, d'Orb. Wollong.— × 66.

Fig. 8. *Nodosaria permiana*, Spandel, sp.: (*a*) lateral aspect; (*b*) oral aspect. Wollong.— × 70.

Fig. 9. *Geinitzina triangularis*, sp., nov. Frondicularian type: (*a*) lateral aspect; (*b*) outline at distal end. Wollong.— × 50.

Fig. 10. *Geinitzina triangularis*, sp. nov. Flabelline type. Wollong.— × 40.

Fig. 11. *Nodosaria (Dentalina), cf. farcimen.* Reuss, after Soldani. Wollong.— × 40.

Fig. 12. *Nodosaria (Dentalina)? bradyi*, Spandel: (*a*) lateral aspect; (*b*) oral aspect. Wollong. — × 50.

Fig. 13. *Thurammina papillata*, Brady. Pokolbin.— × 48.

PLATE III

Fig. 1. *Ammodiscus anceps*, Brady, sp. Pokolbin.— × 95.

Fig. 2. *Frondicularia woodwardi*, Howchin. Wollong.— × 40.

Fig. 3. *Truncatulina haidingeri*, d'Orb., sp.: (*a*) superior aspect; (*b*) inferior aspect; (*c*) oral aspect. Pokolbin.— × 40.

Fig. 4. *Nodosaria labiata*, Spandel, sp. Pokolbin.— × 80.

Fig. 5. *Monogenerina pyramidis*, sp., nov. Longitudinal section of test. Pokolbin.— × 40.

Fig. 6. *Lunucammina*, sp. Longitudinal section of test. Pokolbin.— × 44.

Fig. 7. *Lituola*, *cf. rhætica*, Chapman. Median section of test. Pokolbin.— × 42.

Fig. 8. *Vaginulina*, *cf. legumen*, Linn, sp. Longitudinal section of test. Pokolbin.— × 60.

Fig. 9. *Placopsilina tenuitesta*, sp., nov. Longitudinal section of test. Pokolbin.— × 120.

Fig. 10. *Lagena acuta*, Reuss, sp. Longitudinal section of test. Pokolbin.— × 86.

Fig. 11. *Marginulina*, *cf. breoni*, Terq., sp. A section through three chambers. Pokolbin,— × 86.

Fig. 12. *Lunucammina*, sp. Longitudinal section of test. Pokolbin.— × 33.

Fig. 13. *Nubecularia stephensi*, Howchin. Longitudinal section of test, normal to surface of attachment. Pokolbin.— × 80.

Fig. 14. *N. stephensi*, Howchin. Section of a thin-shelled and nestling specimen. Pokolbin.— × 60.

PLATE IV.

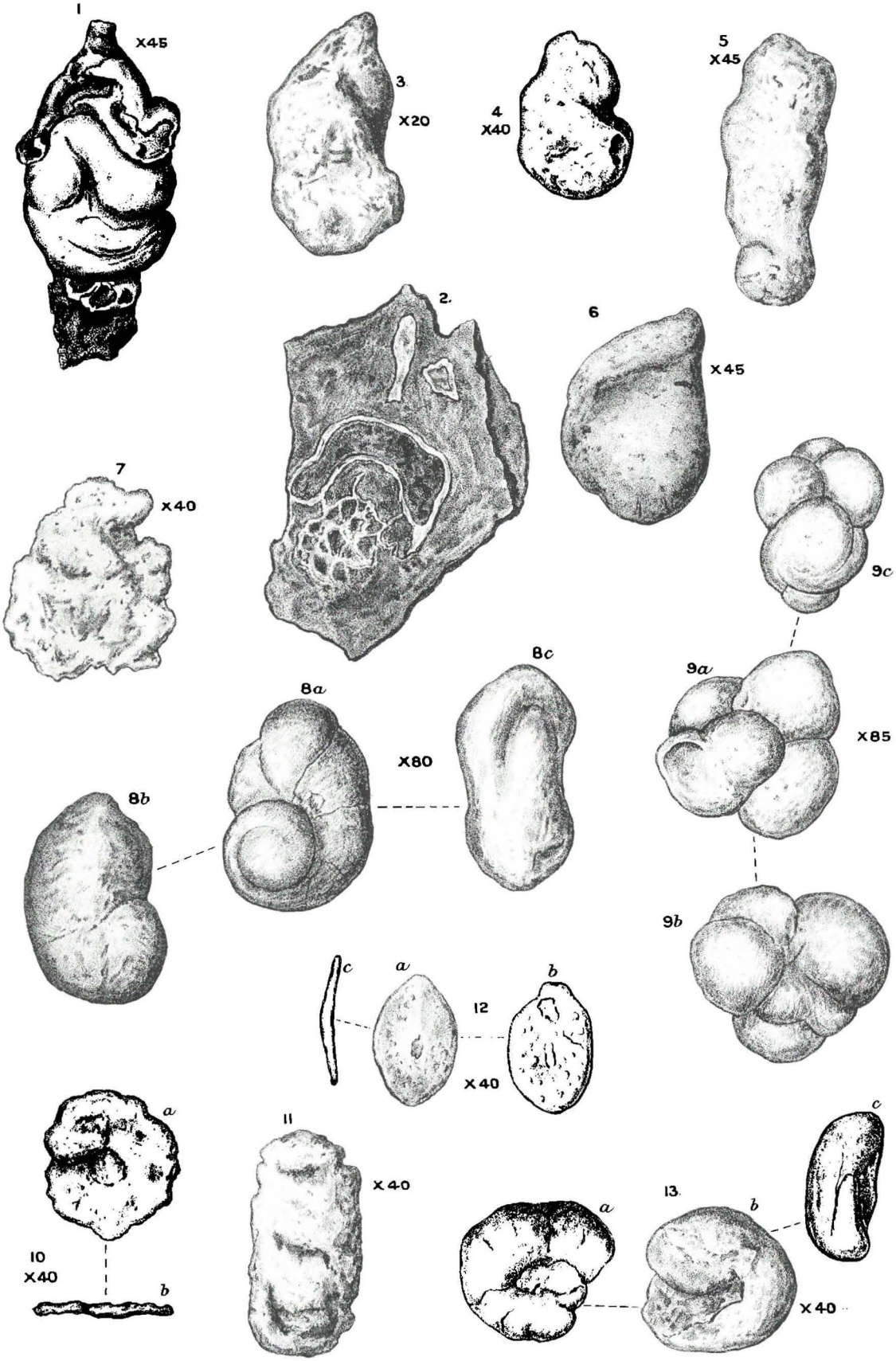
Fig. 1. A typical section of the Pokolbin limestone, with shell-fragments and tests of *Nubecularia stephensi*, Howchin.— × 36.

Fig. 2. *Nodosaria (D.) permiana*, Spandel, sp., in the limestone of Pokolbin.— × 36.

Fig. 3. *Geinitzina postcarbonica*, Spandel, in the limestone of Pokolbin.— × 36.

Fig. 4. A thin section of Pokolbin limestone, showing polyzoa and crinoid fragments; also a test of *Nubecularia stephensi*, Howchin, nestling in a fenestrule of a polyzoan.— × 14.

Fig 5. A thin slice of Pokolbin limestone, showing crinoid fragments, polyzoa, and tests of *Geinitzina* and *Lunucammina*.— × 14.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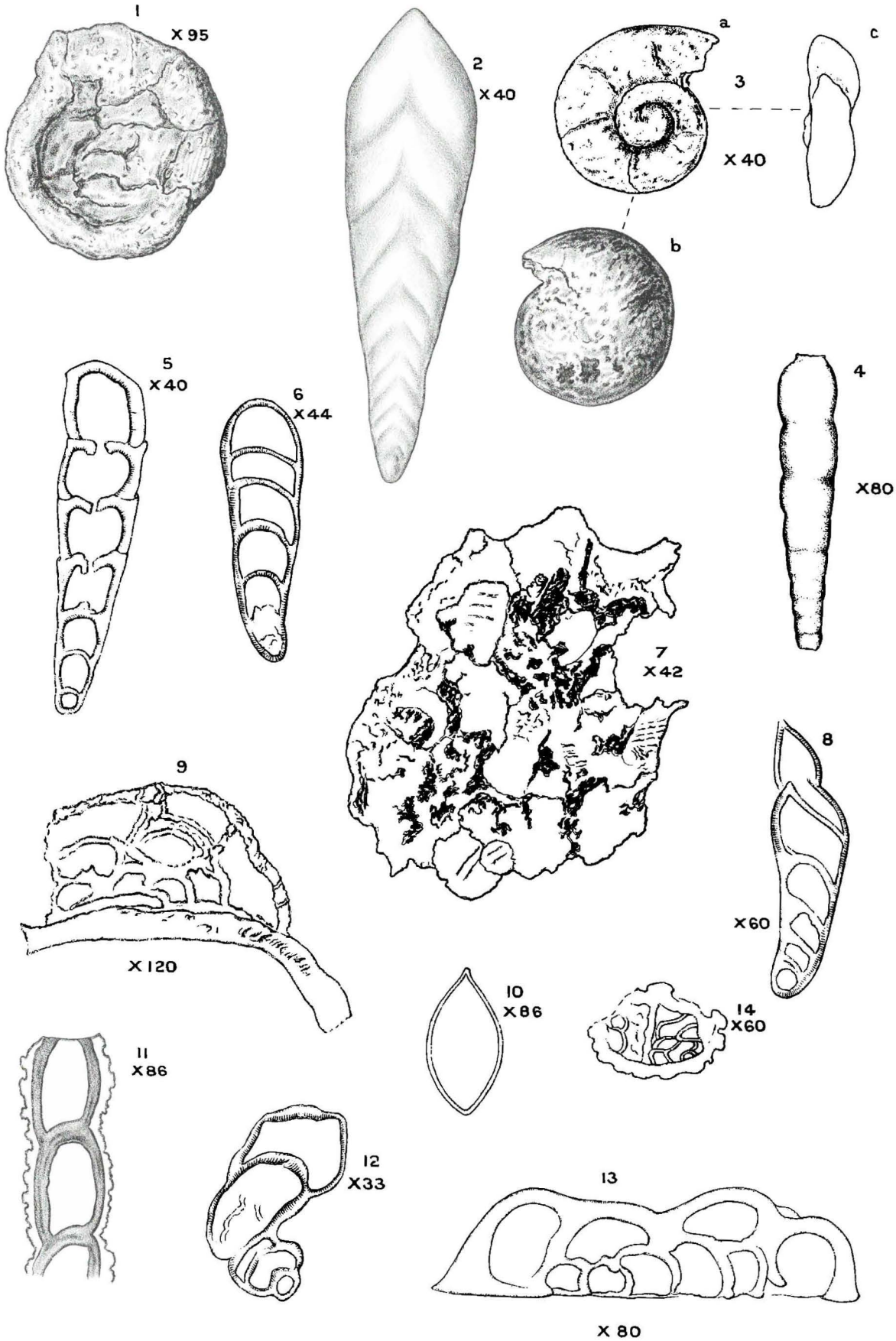
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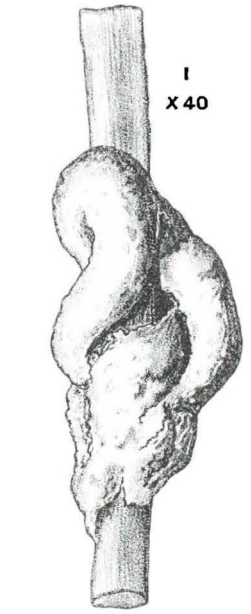
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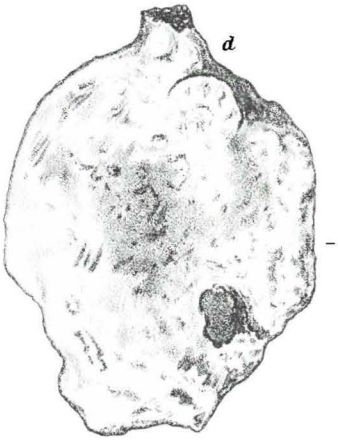
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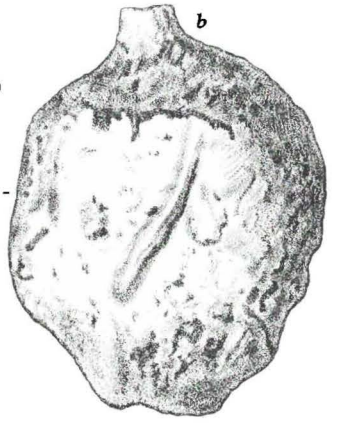
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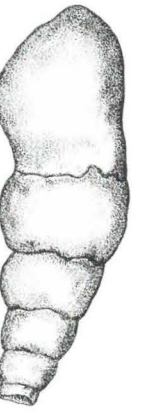

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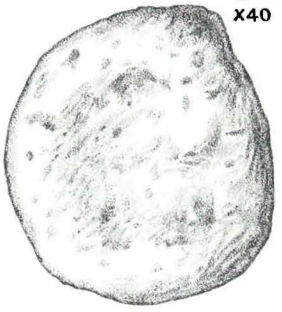


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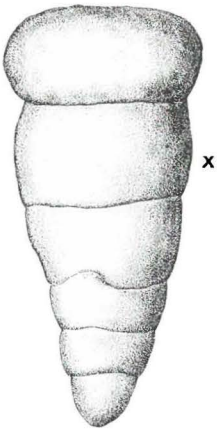
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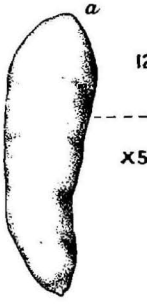
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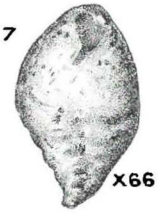
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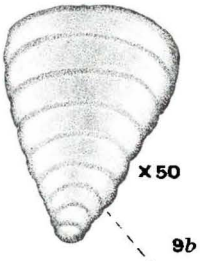
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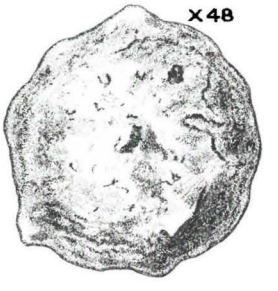

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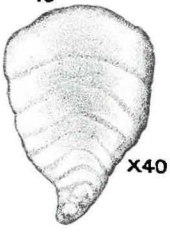
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