

FORAMINIFERA from an UPPER CAMBRIAN HORIZON in the
MALVERNS; together with a NOTE on some of the EARLIEST
KNOWN FORAMINIFERA. By FREDERICK CHAPMAN, Esq., A L.S.,
F.R.M.S. (Communicated by Prof. T. T. GROOM, M.A., D.Sc.,
F.G.S.)

[PLATE XV.]

Occurrence.

THE foraminifera here described were found in a shaly limestone which Prof. Groom obtained 'from the débris of a small ridge composed of black shales, with intercalated basalts, which forms a spur on the north-west side of Chase End Hill. The locality is a short distance south of the village of Whiteleaved Oak. In the same specimens of limestone were found traces of Oboloid brachiopoda, and of what appear to be minute gasteropoda, bivalved crustacea or mollusca, and other fossils. The rock belongs to the well-known and widely-spread zone of *Sphaerophthalmus*, *Peltura*, and *Ctenopyge*, which in Britain forms the upper half of the Dolgelly Beds or Upper *Lingula*-Flags.'¹

So far Prof. Groom has been unable to find the rock in place, although there can be no doubt, he informs me, that it occurs not many yards away from the spot where it is now found.

On examining the limestone with a pocket-lens, Prof. Groom noticed a number of small bodies, some of which, when looked at under a high power, had the appearance of foraminifera. Thereupon a thin slice of the rock was prepared, which revealed to him the presence of undoubted foraminifera.

The specimens, courteously placed in my hands by Prof. Groom for description, have been sliced; and they have yielded a few forms other than *Spirillina*, which was the first one seen. Some pieces of the limestone are dark or nearly black, while others are whitish and speckled over with minute dark-blue spots. When thin sections of either variety of limestone are examined, they are seen to be remarkably full of organic remains, chiefly *Spirillina* (see Pl. XV, fig. 1), together with sections of echinoderm-spines, ostracod-tests, and occasionally sponge-spicules (?). The black limestone appears to show the foraminifera in the best state of preservation.²

Besides the *Spirillinae* other foraminiferal remains occur in the limestone, but these are very rare; and it was only by examining a considerable number of thin slices of the rock that the few forms here gathered together could be discovered. In nearly all cases traces of the finely tubulated and hyaline structure of the test can be seen.

¹ For these notes of the occurrence of the rock I am indebted to Prof. Groom.

² See Prof. Groom's map, pl. xiii, in Quart. Journ. Geol. Soc. vol. lv (1899).

The tests of the foraminifera are infilled with a crystalline substance, which is broken up or traversed in all directions by cracks. In the examples of *Spirillina* the cracks often extend from wall to wall nearly at right angles to the surface, so that at first sight this might give rise to a false impression of septation within the tubular shell. A little careful study, however, will convince the observer that these are simply cracks, and therefore quite a secondary structure.

Description of the Forms.

The determinations of the various forms given in this paper are as near as it is possible to make them, from a mere outline of the test seen in section; but the structure preserved here and there has been of some assistance.

Family LAGENIDÆ.

Subfamily LAGENINÆ.

LAGENA, Walker & Boys.

LAGENA LÆVIS (Montagu). (Pl. XV, fig. 2.)

Vermiculum læve, Montagu, 1803, 'Test. Brit.' p. 524; *Lagena lævis* (Montagu) Brady, 1884, Chall. Rep. vol. ix, p. 455 & pl. lvi, figs. 7-14, 30.

Several examples, closely resembling that figured, occur in the Malvern limestone. The species has been previously recorded from beds as old as Silurian (Wenlock Limestone), and its range extends throughout most of the fossiliferous strata up to recent times.

The Cambrian examples measure about $\frac{1}{100}$ inch in length, being maller than the recent specimens in the ratio of 1 : 1.6.

LAGENA APICULATA (Reuss). (Pl. XV, fig. 3.)

Oolina apiculata, Reuss, 1850, Haidinger's Naturwiss. Abhandl. vol. iv, p. 22 & pl. i [ii], fig. 1; *Lagena apiculata* (Reuss) Brady, 1884, Chall. Rep. vol. ix, p. 453 & pl. lvi, figs. 4, 16-18.

The earliest record of this species dates from the Lias.

Our specimens are slightly smaller than other known examples from later deposits. The species is very rare in the limestone from the Malverns.

LAGENA OVUM (Ehrenberg). (Pl. XV, fig. 4.)

Miliola ovum, Ehrenberg, 1843, Monatsber. k. Preuss. Akad. Wissensch. Berlin, p. 166; *id.* 1864, 'Mikrogeologie,' pl. xxiii, fig. 2, pl. xxix, fig. 45 & pl. xxxi, fig. 4; *Lagena ovum* (Ehrenb.) Brady, 1884, Chall. Rep. vol. ix, p. 454 & pl. lvi, fig. 5.

This species has been hitherto known from beds as old as the Lower Lias, and it continues to the present day.

The specimen here figured (the only one found) is of the same proportionate size, compared with the recent specimen figured by Brady, as *Lagena lævis* was with the recent form previously mentioned. The specimen under notice appears to show traces of an entosolenian orifice.

Subfamily NODOSARIINÆ.

NODOSARIA, Lamarck.

? NODOSARIA (GLANDULINA) sp. (Pl. XV, fig. 5.)

Cf. *Glandulina pygmæa*, Terquem, 1866, 'Foram. du Lias' 6^{me} Mém. (Acad. Imp. Metz) p. 478 & pl. xix, fig. 6.

It is obviously difficult to say with certainty to what genus or subgenus this specimen belongs. Terquem's figure above quoted seems to come nearest to it in outline. In our specimen only two chambers are present, but in the Liassic specimen there are three.

NODOSARIA (DENTALINA) ABNORMIS? (Reuss). (Pl. XV, fig. 6.)

Dentalina abnormis, Reuss, 1863, Sitzungsab. k. Akad. Wissensch. Wien, vol. xlviii, pt. i, p. 46 & pl. ii, fig. 24.

This specimen appears to belong to the *Dentalina* subsection of the genus *Nodosaria*, and in outline is perhaps best matched by Reuss's *D. abnormis*. The apertural extremity is situated hardly far enough to the side for a typical *Marginulina*, although this would depend upon the plane in which the specimen happens to be cut. As regards *Vaginulina*, the chambers are probably too much inflated for it to be related to that genus.

Nodosaria (Dentalina) abnormis is known from Cretaceous and Tertiary deposits.

MARGINULINA, d'Orbigny.

MARGINULINA SOLUTA(?) Reuss. (Pl. XV, figs. 7 & 8.)

Marginulina soluta, Reuss, 1860, Sitzungsab. k. Akad. Wissensch. Wien, vol. xl, p. 206 & pl. vii, fig. 4.

The two specimens (one fragmentary) here figured from the Malvern shaly limestone approach the above-quoted form in general outline: the suture-lines being nearly at right angles to the long axis of the test, with the swollen initial, and subsequent full and unequal chambers. *M. soluta* is known from the Cretaceous.

CRISTELLARIA, Lamarck.

CRISTELLARIA ACUTAURICULARIS? (F. & M.). (Pl. XV, fig. 9.)

Nautilus acutauricularis, Fichtel & Moll, 1798, 'Test. Micr.' p. 102 & pl. xviii figs. g-i.

In outline the Cambrian specimen resembles a *Cristellarian* of the *Cr. acutauricularis* type; but the chambers are remarkably few in number, there being apparently only four in the specimen under notice. The specimen has a very perfect outline.

Family ROTALIIDÆ.

Subfamily SPIRILLINÆ.

SPIRILLINA, Ehrenberg.

SPIRILLINA GROOMII, sp. nov. (Pl. XV, figs. 1, 10 & 11.)

Test discoidal, convex on the superior, and concave on the inferior

face; consisting of a coiled tube, which is reniform in section owing to the inner surface of each whorl being impressed, as it were, against the rounded edge of the previous whorl; usually having four turns to the whole coil, but sometimes as many as five or even six. The coiled tubular shell often commences with a spherical chamber, which sometimes appears to be partly divided from the rest of the shell. In places the shell-wall is seen to be finely perforate. Average diameter = $\frac{1}{120}$ inch.

The above form differs materially from the well-known species *Sp. vivipara* of Ehrenberg¹ in having a concavo-convex form of test. The tube forming the coils of the disc is also more inflated than in *Sp. vivipara*, the Cambrian examples showing the tube to be higher than broad in vertical section.

Another species, *Sp. obconica* of H. B. Brady,² possesses the concave feature of the disc, but it is invariably ovoid in outline.

As regards the number of whorls, the manner in which the coils are enwrapped, and the presence of a conspicuous primordial chamber, we can compare the *Cornuspira crassa* of Zwingli & Kübler,³ which appears to be a true *Spirillina*, from the Callovian beds of the Swiss Jurassic.

The *Spirillinae* which occur in the Cambrian limestone of the Malverns are in a very good state of preservation, considering the fragility of the test. Where there are valves of molluscs cut through in section, they are seen to be filled, in many cases, with the tests of *Spirillinae* crowded together, to the exclusion of other material.

The genus *Spirillina* appears to have been hitherto unknown from beds older than the Jurassic. At the present day the genus is characteristic of fairly shallow and muddy deposits, or of areas where calcareous accumulations are sparingly present.

Note on some of the Earliest-known Foraminifera.

The oldest foraminifera of which we have any record are perhaps those which have been figured and described by Dr. L. Cayeux⁴ from quartzites and phthanites of pre-Cambrian age in Brittany. These bodies are subspherical or globular, and conjoined in many instances; they bear upon their surfaces blunt spines or processes, and their walls are finely perforate. Their excessively minute size, however, renders it very difficult to say with certainty that they belong to this particular group of organisms, for the largest of the chambers measure only 10μ ($\frac{1}{2500}$ inch) in diameter.

¹ Abhandl. k. Preuss. Akad. Wissensch. Berlin, 1841, p. 443 & pl. iii, fig. 41.

² Quart. Journ. Micr. Sci. vol. xix (1879) p. 279 & pl. viii, figs. 27 a, b; see also Chall. Rep. vol. ix (1884) p. 630 & pl. lxxxv, figs. 6 & 7.

³ 'Foram. d. schweiz. Jura' Winterthur, 1870, p. 19 & pl. ii, fig. 2 (Callovien); see also Jones, Quart. Journ. Geol. Soc. vol. xl (1884) p. 770 & pl. xxxiv, fig. 13.

⁴ 'Sur la Présence de Restes de Foraminifères dans les Terrains précambriens de Bretagne' Ann. Soc. Géol. Nord, vol. xxii (1894) pp. 116-19.

Next in order of age are the remains of foraminifera figured by Ehrenberg¹ from the so-called 'Silurian clay' near St. Petersburg. The blue clay of the Baltic Provinces is now known to belong to the Lower Cambrian, since it underlies the *Olenellus*-beds. The foraminiferal remains are in the form of glauconite-casts, and seem referable to the genera *Verneuilina*, *Bolivina*, *Nodosaria*, *Pulvinulina*, and *Rotalia*.

The same author had also previously described² many glauconitic casts of foraminifera, etc., from various formations, including some which he had found in the glauconitic sandstone near St. Petersburg, but of these the only definite forms appear to be two specimens of a *Textularia* near to *T. globulosa*, Ehrenb. and a *Rotalia*? (figs. 1 a, 1 b, & 1 c on pl. vi, *op. cit.*).

[The occurrence of foraminifera in the Cambrian of Siberia has been recorded by A. de Lapparent.³ The limestone containing these organisms is found on the plateau traversed by the Olenek, after its confluence with the Argasala. *Dikellocephalus* is found in these beds, where the limestones become oolitic on account of the numerous foraminifera included in them, and recalling those of the glauconite-beds of the Baltic. On the Tonguska similar limestones contain glauconite.—March 15th, 1900.]

The remains of foraminifera have also been detected by Messrs. W. D. & G. F. Matthew in the Cambrian rocks of Southern New Brunswick. They were first found by Mr. W. D. Matthew in phosphatic nodules from the Acadian or lowest division of the St. John Series.⁴ The specimens have since been described by Mr. G. F. Matthew, together with many other fossils forming 'the *Protolenus*-fauna.'⁵ The foraminifera are referred to the two genera *Orbulina* and *Globigerina*, and seven new species are described.

In the Ordovician system the shales above the Bala Limestone at Guildfield, near Welshpool, contain foraminifera according to the late Walter Keeping,⁶ who also gave further information on the foraminifera of the Llandovery beds.

Foraminifera were first noticed in the slates of Cwm Symlog (Llandovery) by Prof. J. F. Blake,⁷ who compared the hollow casts with *Dentalina communis*, and referred to other uncertain forms. Subsequently Walter Keeping⁸ further investigated these slates and recorded from them *Dentalina*, *Rotalia* (?), and *Textularia*.

¹ 'Ueber andere massenhafte mikroskopische Lebensformen der ältesten silurischen Grauwacken-Thone bei Petersburg' Monatsber. k. Preuss. Akad. Wissensch. Berlin, 1858, pp. 324-37 & pl. i.

² 'Ueber den Grünsand u. seine Erläuterung des organischen Lebens' Abhandl. k. preuss. Akad. Wissensch. Berlin, 1855, pp. 85-176 & pls. i-vii.

³ 'Traité de Géologie' 4th ed. Paris, 1900, p. 790. [I am indebted to Prof. Sollas for kindly calling my attention to this notice.]

⁴ 'On Phosphate-nodules from the Cambrian of Southern New Brunswick' Trans. N. Y. Acad. Sci. vol. xii (1893) pp. 108-20 & pls. i-iv (in text; foraminifera in sections of nodules).

⁵ Trans. N. Y. Acad. Sci. vol. xiv (1895) pp. 109-11 & pl. i.

⁶ Geol. Mag. 1882, p. 490.

⁷ *Ibid.* 1876, p. 134.

⁸ *Ibid.* 1882, p. 490 & pl. xi, figs. 13-15.

In 1888 Dr. H. B. Brady gave an account of four species of *Lagena* from the Woolhope Limestone of the Malverns, etc.¹

I have also frequently met with *Lagena* in the Wenlock Limestone of Shropshire.

Terquem² described four species of *Placopsilina* attached to crinoid-stems from the Upper Silurian of Waldron (Indiana); and in the same paper he also figured and described casts of foraminifera which he referred to the genera *Lagenulina*, *Cristellaria*, *Orbulina*, *Globigerina*, and *Fusulina* from the Devonian of Paffrath.

Foraminifera are, however, rare at the best until the Lower Limestones of the Carboniferous period are reached.

In conclusion my best thanks are due to Prof. T. Rupert Jones, F.R.S., for many valuable suggestions made during the writing of this paper.

EXPLANATION OF PLATE XV.

- Fig. 1. Shaly limestone with *Spirillina Groomii*, in section. × 37.
 2. *Lagena levis* (Montagu). × 60.
 3. *Lagena apiculata* (Reuss). × 60.
 4. *Lagena ovum* (Ehrenberg). × 60.
 5. ? *Nodosaria* (*Glandulina*) sp., cf. *Glandulina pygmaea*, Terquem. × 60.
 6. *Nodosaria* (*Dentalina*) *abnormis*? (Reuss). × 70.
 Figs. 7 & 8. *Marginulina soluta* (?) Reuss. × 60.
 Fig. 9. *Cristellaria acutauricularis*? (Fichtel & Moll). × 60.
 10. *Spirillina Groomii*, sp. nov. Lateral aspect. × 112.
 11. The same. Peripheral aspect. × 112.

DISCUSSION.

Prof. GROOM expressed his gratitude to the Author for his thorough investigation of the Cambrian foraminifera. Foraminifera had rarely been described from the oldest rocks in any part of the world, and many of the determinations appeared to be uncertain. In Britain no member of this group had been recorded from any horizon older than the Ordovician. *Spirillina* was now proved to be a very old genus. He might add that the Author had recognized foraminiferal casts in the Hollybush Sandstone and Hollybush Quartzite, although, so far, it had been found impossible to determine the genera.

Prof. SOLLAS congratulated the Author on the results of a very careful and thorough piece of work. It was interesting to observe that in this case lithological and palæontological evidence concurred in indicating that the foraminiferal limestone had been deposited in comparatively shallow water. The account of the distribution of foraminifera in Palæozoic systems with which the paper concluded would prove of great use to students; and in this connexion it might be mentioned that an oolitic limestone, the age of which was shown

¹ 'Note on some Silurian *Lagenæ*' Geol. Mag. pp. 481-84.

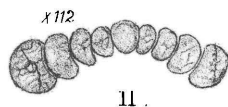
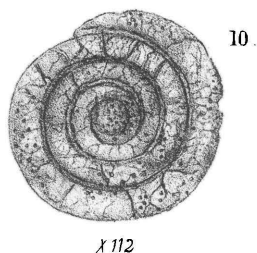
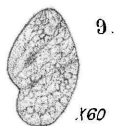
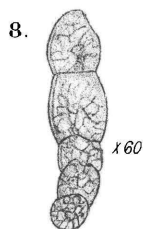
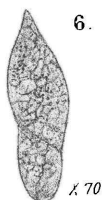
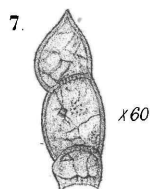
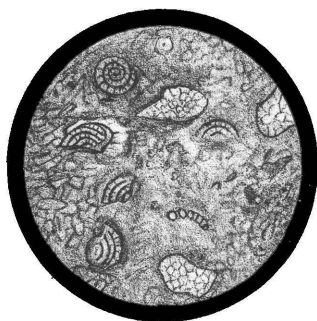
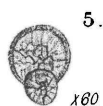
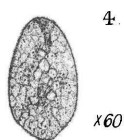
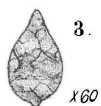
² Bull. Soc. géol. France, ser. 3, vol. viii (1880) pp. 414-18 & pl. xi.

by associated *Dikellocephalus*, occurred in Siberia and was crowded with various vitreo-perforate foraminifera.

Dr. G. J. HINDE enquired whether any of the characteristic zonal trilobites mentioned had been found in the same detached rock-fragments with the foraminifera, so that their age was incontestably fixed; and whether the Author was satisfied with respect to the nature of the presumed foraminifera from the pre-Cambrian rocks of Brittany.

Prof. GROOM, in reply to Dr. Hinde, stated that the characteristic trilobites of the *Sphaerophthalmus*-zone had not been detected in the limestone, although they occurred in the associated shales a few yards away. The foraminiferal rock evidently occurred in the heart of the zone.

The AUTHOR, also in reply to Dr. Hinde, said that the figures given by Cayeux of foraminifera from the pre-Cambrian rocks of Brittany did not show the structure of the test. Although they bore a general resemblance in outline to some genera with a finely arenaceous shell-wall, as *Hormosina*, yet they must be regarded as of doubtful organic origin.



F. Chapman del. ad nat.
A. T. Hollick lith.

Mintern Bros. imp.

FORAMINIFERA FROM THE UPPER CAMBRIAN
OF THE MALVERNS.