

No. XXV.—NOTES ON A SMALL GROUP OF CARBONIFEROUS FORAMINIFERA FOUND IN THE LOWER LIMESTONE SHALES OF THE MUIRKIRK DISTRICT IN AYRSHIRE, WITH A LIST OF THE GENERA AND SPECIES FOUND IN THE COALFIELDS OF WESTERN SCOTLAND.
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THE Foraminiferal group of organisms, recent and fossil, have always afforded an interesting branch of investigation to those persons who have taken it up, either for examination and study under the microscope, or for the purpose of forming a collection. This interest is much increased by the varied and beautiful forms of many of the shells when viewed externally, as also by the internal structure of the organisms when examined in transparent section under the microscope. In exhibiting to the Society this evening a series of sections and mounted specimens of Scottish Carboniferous Foraminifera from the marine limestone strata of our coalfields, I shall shortly refer, in the first place, to their mode of occurrence in the strata. In doing this I may state that they are found in nearly all the fossiliferous marine limestones and shales, but they are not always equally abundant, certain forms being often restricted to special horizons of strata and to particular localities.

When a search was first made in our limestone strata for this group of organisms by members of this Society, their attention was directed to the weathered limestones and shales in which many other forms of Microzoa, or minute life, of the limestone period had already been found. After having been carefully washed and searched, these rocks yielded on examination upwards of 30 species of Foraminifera, and I may state that, with the exception of *Saccamina Carteri*, Brady, found in the limestone, all the other forms were obtained in single specimens picked from the limestones and shales.

It is only comparatively recently that attempts have been made to grind thin transparent sections of our limestones and harder shales, which are suspected to contain Foraminifera, as by this method they are found *in situ* in the matrix in which they had been entombed. By following this plan many interesting sections have now been obtained, and to some of these I will shortly refer

later on. In the meantime it may be stated that when the late Dr. H. B. Brady, F.R.S., commenced his valuable and interesting Monograph on the British Carboniferous Foraminifera, printed by the Palæontographical Society in 1876, nearly all the genera and species submitted for his determination, and whose structures he had to work out, figure, and describe, were sent as single specimens free from the matrix, and seldom showing more than surface characters. Dr. Brady had often, therefore, to section some of these minute shells to transparency so as to obtain some knowledge of their shell-wall structure and of the arrangement of their chambers internally. These microscopical sections were not made, he tells us, without difficulty, owing to the smallness of the bodies; but this was amply repaid when it unfolded structures of such great interest, especially in their relations to other well-known types of Foraminifera. Had the same work now to be done, he would, in many cases, with the aid of the sections in existence, have been saved a great deal of labour, and he would have been delighted, I am sure, with the sight of many transparent sections of small Foraminifera which he never had the opportunity of sectioning.

To get a more correct knowledge of the structure and external characters of the fossil Foraminifera, they should always be examined by two methods, where that is possible. 1st. By the examination of their true external forms, and surface-markings, or other ornamentation, as seen on the most perfect examples of the shells. 2nd. By the examination of transparent sections of their shells, or of the rocks containing them, so as to inspect thoroughly the structure of the shell-walls, and the form of the chambers, where such exist. It is, however, not always easy to find material which will permit of both methods of investigation, and collectors have, of course, to take the rocks containing Foraminifera just as they are locally found. If they are in a weathered condition, and only fit to search after washing, unweathered specimens hard enough for grinding should be searched for, and in this way both methods of investigation may be carried out.

Foraminifera are found, as I have already stated, in nearly all the fossiliferous marine limestones and shales of both the lower and upper groups of the limestone series in Western Scotland. Indeed, there are few transparent sections of these rocks in which

examples of some of the forms may not be detected under the microscope by the practised eye. In some sections they are seen to be moderately common, and represent various genera and species; but the richest rock which I have yet examined from Western Scotland is a fine-grained limestone shale from the Muirkirk district of Ayrshire, found in connection with, or attached to, masses of the Carboniferous coral, *Chætetes septosus*, Fleming.

In order to obtain as full a knowledge as possible of the number and varied forms of the species present in this shale, I have ground to a thin transparency upwards of thirty sections, and for specimens of the coral with the shale attached, I am indebted to Dr. J. R. S. Hunter, Daleville, Carlisle, and to Dr. David Forsyth, of Leeds, both members of this Society. The specimens were respectively from Durnhunch quarry, and Ashawburn, Muirkirk, and it is interesting to note that there is some difference in the distribution and abundance of the Foraminifera present in the two localities. Thus in the shale from Ashawburn, *Archædiscus Karreri*, Brady, is the most abundant and characteristic Foraminifer present, and it may be counted by the dozen in most sections. Along with it are examples of other genera, such as *Endothyra*, *Stacheia*, *Trochammina*, and *Valvulina*, each being represented by one or more species. In the sections of this shale, there is also to be seen, under the microscope, numerous minute yellowish-brown crystals of a rhombohedral shape, each having a darker-coloured centre than its outer walls. They are so abundant that many of the sections are seen to be crowded with them, the rock being thus, in a measure, characterised by their presence. I cannot yet say what is their mineral composition, but it may be either dolomite or siderite, or a combination of these with calcite. In no other sections of Carboniferous shale have I yet met with similar crystals.

In the sections of the shale from Durnhunch quarry these small crystals are absent, but there is a greater variety of the Foraminifera. *Archædiscus*, so plentiful in the former locality, is here somewhat rare, and its place is taken by *Endothyra* and *Textularia*, each being represented by several characteristic forms. Other genera represented are *Climacammina*, *Trochammina*, *Stacheia*, and *Valvulina*. The species belonging to the several genera from this Muirkirk shale will be found in the list given at the end of this paper.

Besides the Foraminifera, the Durnhunch shale contains examples of that curious organism first found in the Silurian rocks of the Girvan district, and named *Girvanella* by Prof. H. Alleyne Nicholson and R. Etheridge, jun., in their "Monograph on the Silurian Fossils of the Girvan district," p. 23, where it is placed with the Foraminifera. In my sections of the Muirkirk shale there are at least two varieties, one having much more minute tubes than the other; both are found in the shale in the form of small twisted bundles. There are also seen in the sections fragments of larger tubes having moderately thick walls, and with the same structure as that of the other arenaceous Foraminifera present. These tubes in longitudinal section are seen to taper gradually to one end, but are not chambered within. They may therefore belong to an uncoiled form of *Trochammina*, like that of *T. filum*, Schmid, figured and described by Dr. Brady from the Permian formation. This form consists, he states, "of a long tube of gradually increasing diameter, irregularly bent, and often partially coiled at its commencement." Should my conjecture prove correct, it will add another species of *Trochammina* to our Scottish Carboniferous list.

I have only further to remark respecting the Muirkirk Foraminifera, that all the forms are exceptionally well-preserved as regards their internal structure; in fact they are in better condition than those found in our purer limestones, which have, in many cases, lost much of their finer structure through crystallization of the limestone. I may also add, regarding my sections of limestone shale, that Foraminifera are not the only organisms they contain. Scattered throughout the sections there are the remains of Ostracoda, with fragments of various species of Polyzoa, Corals, Crinoids, Brachiopods, univalve and bivalve shells, and sometimes small teeth and scales of fish. We have, therefore, in this shale, all the preservable finer organic débris of a portion of an old sea-bottom of the lower Carboniferous limestone period, the fragments being wonderfully well-preserved when we consider the great antiquity of the rocks in which they are found.

Postscript.—Since the period when the foregoing paper was read to the Society I have been giving some attention to another Foraminiferal form found somewhat plentifully in one of the

limestone shales at Muirkirk, and less abundantly in a few of the other Carboniferous limestones of Western Scotland, and which is neither figured nor described in Dr. Brady's Monograph. This form is found to consist of small, evenly rounded spheres, and sections of spheres, of various shapes and sizes, showing clear evidence of having once been clustered together, as in the recent *Globigerinidæ*. When thin transparent sections of these spheres and their segments were examined under the microscope, and compared with similar sections of a deep-sea *Globigerina* ooze, which I have prepared, they were seen to be very much alike both as to size and form, as well as in the thickness and structure of their shell-walls. The only point of seeming difference is, that in the Carboniferous form the various segments which formed the clusters are now in a more broken-up and scattered condition in the surrounding sediments than is seen in the clusters from the deep-sea deposit. Separated segments of the latter are, however, seen in the sections from the recent deposits, with exactly similar appearances to those found in our limestone strata.

The Carboniferous form may be briefly described as consisting of complete spheres, which appear as perfect circles in the sections when they happen to be cut transversely along certain lines. They are also seen as segments of spheres of varying size and form which show, on one edge, where they were attached to other spheres or segments of the clusters of which they once formed part. These circles and segments are seen to be uniformly thin-walled, and generally show a dense, sub-arenaceous shell-structure when looked at under the microscope by transmitted light. From these characteristics they are easily distinguished from any of the other Foraminifera, which are thicker walled as well as different in form. The spheres and segments are often filled with a clear, structureless calcite; when this is not the case their inner walls are coated with some mineral deposit, or filled with the sediment which formed the rock matrix.

Dr. Brady, in his Monograph, makes no reference to *Globigerina* as being found in Carboniferous limestone strata, but states that *Textularia*, and one or two other forms found in the same strata, are now placed in the *Globigerinidæ* group, as they apparently possess the same kind of shell-structure, though they differ in

form from the recent *Globigerina*. So far, therefore, as form and other characters go, I am inclined to place this Carboniferous form provisionally in my list with *Globigerina*, as that genus, so far as known to me, is the only one which possesses characters which agree most closely with the new form. I leave its relationship to recent and living species for future determination.

In concluding, I have only further to remark that this interesting Carboniferous representative of a deep-sea Foraminifer which is still living in our seas is always associated in the limestones with other species of the group, some of which are also allied to recent living genera. The following are a few of the chief localities in which it is found, viz., Durnhunch quarry, Muirkirk, in the limestone shale; Trearne and Dockra, Beith, in the limestone; Baidland and Law quarries, Dalry, in the limestone; Campsie, in the main limestone, where it is found with *Saccamina*, a form still living. I have also found it moderately common in sections of the limestone from Closeburn quarry, Dumfriesshire, the strata there belonging to the Calciferous sandstone series of the lower Carboniferous formation.

Species from Muirkirk Shale.	LIST OF CARBONIFEROUS FORAMINIFERA FROM WESTERN SCOTLAND.	Lower Limestone Series.	Upper Limestone Series.	LIST OF CHIEF LOCALITIES WHERE SPECIMENS HAVE BEEN FOUND.
	<i>Saccamina Carteri</i> , Brady.	x		Braidwood, Carluke. Campsie main limestone. Brockley. Muirkirk.
*	<i>Climacammina antiqua</i> , Brady.			Robroyston. Muirkirk.
*	<i>Trochammina incerta</i> , (d'Orbigny).	x	x	Robroyston. Muirkirk.
*	„ <i>centrifuga</i> , Brady.	x	x	Robroyston. Muirkirk.
	„ <i>annularis</i> , Brady.	x		Capelrig, Kilbride.
	„ <i>gordialis</i> , P. and J.	x		South Shiells, Kilbride.
	„ <i>pusilla</i> , (Geinitz).	x	x	Trearne, Beith. Gare, Carluke.
	„ <i>Robertsoni</i> , Brady.		x	Gare, Carluke.
*	<i>Valvulina palæotrochus</i> , Ehrenberg.	x	x	Robroyston. Brockley. Muirkirk.
*	„ „ <i>var. compressa</i> , Brady.	x	x	Gare, Carluke. Brockley, Muirkirk.
*	„ <i>Youngi</i> , Brady.		x	Brockley. Trearne. Dalry. Muirkirk. Campsie.
	„ „ <i>var. contraria</i> , Brady.		x	Brockley. Trearne. Beith.

Species from Muirkirk Shale.	LIST OF CARBONIFEROUS FORAMINIFERA FROM WESTERN SCOTLAND.	Lower Limestone Series.	Upper Limestone Series.	LIST OF CHIEF LOCALITIES WHERE SPECIMENS HAVE BEEN FOUND.
*	<i>Valvulina decurrens</i> , Brady.	x	x	Gare, Carluke. Brockley, Muirkirk.
	„ <i>plicata</i> , Brady.	x		Calderside, Blantyre. Hairmyres.
	„ <i>rudis</i> , Brady.	x		Headsmuir, Carluke.
*	<i>Endothyra Bowmanni</i> , Phillips.	x	x	Calderside. Trearne. Dalry. Muirkirk.
*	„ <i>ammonoides</i> , Brady.	x	x	Gare, Gillfoot, Carluke. Muirkirk.
*	„ <i>globolus</i> , (d'Eichw).	x	x	Gillfoot. Braidwood. Muirkirk.
*	„ <i>crassa</i> , Brady.	x	x	Brockley. Muirkirk.
*	„ <i>radiata</i> , Brady.	x	x	Robroyston. Gillfoot. Brockley. Muirkirk.
*	„ <i>macella</i> , Brady.	x		Brockley. Muirkirk.
*	„ <i>ornata</i> , Brady.	x		Brockley. Muirkirk.
	„ „ var. <i>tenuis</i> , Brady.	x	x	Robroyston. Barmulloch.
	„ <i>subtilissima</i> , Brady.	x		Brockley.
	<i>Nodosinella concinna</i> , Brady.		x	Belston Burn, Carluke.
	<i>Stacheia marginulinoides</i> , Brady.	x		Brockley.
	„ <i>fusiiformis</i> , Brady.	x		Belston Burn. Brockley.
	„ <i>pupoides</i> , Brady.	x		Brockley. Hairmyres.
	„ <i>acervalis</i> , Brady.	x		Hairmyres. Gare, Carluke.
	„ <i>congesta</i> , Brady.	x	x	Belston Burn. Carluke.
*	„ <i>polytrematoides</i> , Brady.	x	x	Gare. Braidwood. Hairmyres. Muirkirk.
	<i>Lagena Parkeriana</i> , Brady.		x	Belston Burn, Carluke.
	„ <i>Howchiniana</i> , Brady.		x	Belston Burn, Carluke.
*	<i>Textularia gibbosa</i> , (d'Orbigny).	x		Brockley. Muirkirk.
*	„ <i>eximia</i> , (d'Eichw).	x		Brockley. Muirkirk.
*	„ (undetermined species).			Muirkirk.
	<i>Bigenerina patula</i> .	x		Headsmuir, Carluke.
*	<i>Archædiscus Karreri</i> , Brady.	x	x	Craigenglen. Brockley. Muirkirk. Belston Burn.
*	<i>Girvanella</i> , (sp.) (Nich. and Ether.).	x		Muirkirk. Law quarry, Dalry.
	<i>Haplophragmium rectum</i> (?) Brady.	x		Hillhead quarry, Beith.
*	<i>Globigerina</i> , (sp.)	x		Beith. Campsie. Dalry. Muirkirk.