V.—*Notes on Scottish Carboniferous Microzoa, and the Methods by which they may be Collected and Mounted.* By JOHN YOUNG, F.G.S.

(Read 26th February 1880.)

Until comparatively recent years, collectors of Scottish Carboniferous fossils contented themselves generally with whatever of the larger organisms they could find, picked up at quarries, pits, and natural sections where fossiliferous strata were exposed. Little or nothing was then known of the rich field of investigation that lay before them, in the examination of the same strata for the Microzoa or minuter forms of life of the period.* About the year 1864, however, a start was made in the washing and examination of one or two of the soft, weathered, fossiliferous shales that alternates with the Marine Limestone strata. These yielded such good results in the hands of expert collectors, that the investigation has been continued up to the present time, with unabated interest, amongst all sorts of weathered fossiliferous shales, and rotted limestones, wherever they are to be found in the coalfields of Scotland. The result of these researches has been an immense increase of knowledge regarding the minuter forms of life that tenanted the lakes and seas of the Carboniferous period, and this result will yet become more apparent when the whole of the various groups of Microzoa that have been obtained shall have been worked out, figured, and described. In the meantime, I may mention, that at the period to which I have referred, less than half-a-dozen species of Entomostraca were then known as having been found in our Scottish Carboniferous strata. At the present time more than seventy species are known, a large proportion of which are new to science. At that time no Foraminifera or other Protozoa had been described from our limestone strata, now we have a "Monograph on the British Carboniferous Foraminifera," by Henry B. Brady, F.R.S., in which some forty-three species are

* I must not omit to notice here, that the Rev. David Ure, one of the earliest collectors and delineators of Scottish Carboniferous fossils, describes and figures, p. 311-12, pl. XIV., in his "History of Rutherglen and East Kilbride" (1793), three or four species of what he terms microscopic shells. These are now known to be Entomostraca, and the specimens which are still in existence show that they were collected from weathered shales, but he has omitted to state the method by which he obtained them, and the nature of the material from which they were collected, although he says, "from Kilbride, however, I have made a collection of these extremely small objects of nature, that might furnish abundance of specimens for all the museums in Europe."

figured and described, the great majority of which have been obtained from our weathered limestone shales. We have recently found evidence of the abundant existence of another division of the Protozoa, viz., the Sponges, in the form of beautiful spicules, and other portions of the skeleton, that shows that these sponges must belong to several genera and species. In nearly all the other groups of our Scottish Carboniferous fossils, our lists of species have been much enriched by the discovery of many minute forms not previously recognised, while the recent discovery of that obscure and interesting group of organisms, termed Conodonts, found in our rotted limestones, along with the vertebræ and minute dermal covering of fishes, has very much increased the interest attached to this method of collecting.

Any geologist interested in Carboniferous fossils, who may desire to obtain some of these Microzoa, can always find plenty of material for this branch of investigation at most of the limestone quarries, or at natural sections where the fossiliferous shales crop out. In the working of our limestones on the open cast principle, it is generally the custom of the quarrymen to throw the overlying shales on the banks behind them. If this shale is not too hard and calcareous, it soon, on exposure to the atmosphere, breaks up into fragments, and according to the nature of the shale, resolves itself into a species of clay, or soft mud, in a shorter or longer period of time as the case may be. Many of these limestone shales are richly fossiliferous, and if these banks are examined from time to time as the shale weathers, or is moved by the feet, and washed by the rains, many of the larger organisms that the strata contains may then be found, often in the finest state of preservation; but to get at the Microzoa that the beds contain, some of the best weathered and most promising fossiliferous clay must be bagged, or carried home in a vasculum, which is an excellent plan when the shale is very wet and muddy. The shale is afterwards carefully dried, as this assists the washing process very much. Every collector will find out for himself a method of washing the clay best suited to his own conveniences. For those, however, who have not tried the washing, the following plan may do for a beginning:—Dry the clay to its centre, until it becomes as hard as a brick, and all moisture has been expelled. Then break it up into pieces with a hammer. Put the pieces into a hand-pail with water. After they have lain in the water for an hour or so, the clay will be found to have resolved itself into a loose mud, quite different from the condition in which it was collected, and which can now be freely washed. To do this, stir up the contents of the pail with the hand, until the clay and the water is well mixed, then let the heavier materials settle for a minute or so, and pour off the muddy water gently. Continue to fill the pail with water, and

stir with the hand, until the water remains comparatively clear ; care being always taken in pouring out the water so as not to lose any of the organisms. It assists the searching very much to have the material well washed, besides leaving the organisms in a much cleaner condition. When the material has been well washed it can be dried before the fire, or in an oven, upon a flat dinner plate. It is then ready for searching when dried ; but before doing this, it is advisable to put the material through various sizes of wire gauze, or muslin, so as to sort the material into various degrees of fineness, as the coarser material is apt to conceal the smaller specimens. This sorting of the material into various degrees of fineness, assists the eye very much when picking out the organisms. The picking out is done by sprinkling a little of the washed material upon a small writing slate, with close fitting wooden frame around the edges, and examining the material with a pocket lens, giving the slate a slight shake from time to time to bring the organisms better into view. The lifting of the specimens from the slate can be easily done with a fine pointed hair pencil moistened with the tongue, or a finely pointed lucifer match-stick answers very well, both for picking, and for mounting the specimens on the slides. By keeping the washed material ready at hand, the picking can be done at any odd minutes, when there is good light, the organisms being put into a small pill-box until they are wanted for mounting. The mounting is best done by placing the specimens neatly, in one or more rows, on a black paper ground, on white card-board slides, 1 inch in breadth, by 3 inches in length, in which a centre space is stamped out to receive the specimens. This space, according to taste or convenience, may either be a round, oval, or oblong square with scalloped corners ; the card-board slides being of varying thickness so as to suit the depth of the specimens that are to be mounted. The slides, for the safe preservation of the organisms, should be covered with glass, care being taken that none of the organisms are above the level of the paper, as they then would be liable to get crushed by the cover, which is fixed to the ends of the slides by a narrow strip of gummed paper. These Microzoa, when neatly mounted after this fashion, can always be conveniently kept, and can be easily examined, either by a pocket lens, or under a low power of the microscope. Many of them are beautiful, and all of them are interesting objects, as illustrating the varied kinds of smaller life that have been preserved to us in the rocks of the Carboniferous period.

Besides the Microzoa to be obtained from the weathered fossiliferous limestone shales, they are also to be found in abundance in many of the limestones that are traversed by fissures, joints, and other cavities, through which the rain-water from the surface, charged with carbonic acid, has been allowed

to percolate. These fissures, etc., are often found to contain a quantity of the debris of the rotted limestone, and if this is dried, washed, and searched in the same way as recommended for the limestone shales, many interesting organisms may be obtained. Very often the Microzoa found in the eroded limestone exist in the form of casts, but where the shells and other organisms have been silicified, or have had their shells changed into some substance other than carbonate of lime during fossilization, they are then found in a beautiful state of preservation.

The limestones are found in many instances to contain organisms differing from that of the shales. This being the case, no opportunity should be lost in minutely examining the contents of fissures, and other open cavities in the rock, wherever such is to be found. I may state that it is in such positions that the recently discovered Conodont remains and sponge spicules have chiefly been found.

It is not a very uncommon thing to find boulders of both Fresh-water and Marine Carboniferous Limestones lying in the surface soil, or in the upper portion of the boulder clay, that have had their surface rotted or eroded into a soft condition, for an inch and more in depth, through the action of water containing carbonic acid. If these boulders contain any Microzoa, they can easily be collected by scraping or breaking away portions of this rotted surface, which if too hard to dissolve in the water, may be gently pounded with a hammer before washing. From such boulders have been obtained numerous Foraminifera, Entomostraca and other minute organisms in a most wonderful state of preservation, which were not to be seen in, nor could be obtained from, the unweathered portion of the limestone boulder itself. All such boulders should therefore be carefully examined, as they may have been derived from tracts of limestone strata not now visible at the surface of the land, through accumulations of boulder clay and other recent masses of debris.

There are other sources in which Microzoa can be obtained from our Carboniferous rocks, especially Entomostraca. One of these is fish coprolites, which sometimes contain great quantities of the carapace valves of these minute crustaceans. In a large coprolite sent to me by Dr Rankin, Carlisle, I once extracted 300 perfect examples of a rather large Entom., *Cypridina primæva*, of which only one example was formerly known. Other fish coprolites have also yielded equally rare species. Entomostraca are also to be obtained from the material filling the hollow stems of plants in some of the blackband ironstones. Where Entomostraca are seen to exist in abundance in any of the ironstones, shales, or limestones, but which are too hard to be obtained by the usual method of washing, the organisms, if they exist in the stone in an uncrushed condition, and with their valves united, can be extracted in considerable numbers, by

pounding small pieces of the stone inside a flat iron ring or washer, such as is often put upon screw-bolts. The pounding must be done with a flat-headed hammer upon a block of iron. The iron ring in which the stone is pounded prevents it flying away, or being too much crushed by the blows of the hammer. The pounded material is afterwards sifted, washed, and searched in the usual manner, when numerous examples will be found to be quite free from the matrix, and often in fine preservation.

Before bringing these remarks to a close upon some of the methods employed in obtaining the more perfectly preserved smaller organisms of our Carboniferous deposits, I may also state, that they are well adapted likewise for obtaining fragments of some of the larger organisms, such as the Polyzoa, in a condition well fitted for microscopic examination. These fragments of Polyzoa are found in the best preserved condition in those weathered limestone shales that are not too aluminous, or where the organisms have not in any way become pyritized. Where the conditions of preservation are favourable, fragments of Polyzoa have been found that have thrown much light upon the perfect condition of their cells, and other points of their surface ornamentation, often in a way that could hardly ever have been expected from such ancient deposits. The same thing may also be stated of the other groups of Microzoan life, viz., that there are some shales in which all the ornamentation and other external characters are much more beautifully preserved than in others; but while this is the case, all should be carefully examined, as we often find in different beds, and in different localities, evidence of as much diversity in the fauna of the former Carboniferous lakes and seas, as in those of our own days. We also find by this exhaustive method of examining our strata, that certain forms of Microzoa may be abundant in the beds of one quarry, and in the same strata of a neighbouring quarry they may be rare or altogether absent. There can be little doubt, therefore, that these varying conditions in the distribution of life were regulated then as now by similar varying conditions of the sea-bottom.

In conclusion, I hope that several of the members of this Society will be induced by these few remarks to enter upon an exhaustive examination of the Microzoa from the eastern districts of Scotland. There remains much to be discovered. In fact, the work of research may be barely said to have commenced. The work is light and very interesting, and may be carried on at odd intervals of time, in all seasons of the year. Should any of the members feel inclined to do so, they will find a very full list of Scottish localities, in which are included the several counties in which Microzoa have been obtained, in the excellent lists prepared by Henry B. Brady for his "Monograph on the British Carboniferous Foraminifera"—"Palæontographical Society's Transactions," 1874, pp. 35-43, and Table II. pp. 155-56.