

NO. XXVIII.—ON THE OLD RED SANDSTONE AND CARBONIFEROUS  
ROCKS OF THE NORTH END OF THE ISLAND OF ARRAN.  
By JAMES NEILSON, *Vice-President*.

[Read 17th October, 1895.]

IF there is one canon in geology more firmly established than another, it is that fossils indicate a certain definite time in the earth's history, that the various species which they represent appeared, lived, and died out at certain definite times, and that, therefore, fossil evidence has come to be considered the most trustworthy of all evidence as an index to the age and succession of the various rock-formations. In fact, that, as Dr. Mantell put it, fossils are the "Medals of Creation." Associated with this there is another belief, viz., that the various formations succeeded each other in a certain distinct order, *one at a time*; that each formation was newer than that below, and older than that overlying it, but was contemporaneous with neither.

With these beliefs, it appears, however, that Sir Archibald Geikie does not agree, at least, judging from the third edition of his "Text Book of Geology," 1893, according to which fossils cannot be depended on as indications of the age of rocks, as they may be found in formations to which they do not really belong; and that the difference between two formations may be geographical rather than geological, as two entirely separate formations may have been formed contemporaneously in different, though possibly neighbouring, geographical areas.

Thus, at page 665, it is stated that in Bohemia and Russia some of the most characteristic Upper Silurian organisms are found beneath strata full of Lower Silurian life forms. At page 760, when speaking of the close of the Silurian period, it is said—"There is every reason to believe that for a long time the marine sedimentation of Upper Silurian type continued to prevail in some areas, while the *probably lacustrine* type of the Old Red Sandstone had already been established in others." At page 828 we find—"In the West of Scotland there occur among the red sandstones (some of which contain Old Red Sandstone fishes) bands of limestone full of true 'Carboniferous limestone corals and brachiopods.'" At page 665 we read—"In Australia a flora with Jurassic affinities and a Carboniferous limestone fauna were

contemporaneous," and again at page 660—"At the present day, the higher fauna of Australia is more nearly akin to that which flourished in Europe far back in mesozoic time than to the living fauna of any other region of the globe."

Without passing any opinion as to the general bearing of these extracts, I propose to consider them so far as regards the question whether marine Carboniferous limestone fossils are, or are not, found in Old Red Sandstone strata in the West of Scotland, and this is the more important as it is, I understand, the only example Sir Archibald gives of the interlapping of Old Red Sandstone and Carboniferous strata. Consequently, if this instance fails, his whole theory, so far as these formations are concerned, must be modified.

It will here be necessary to make a lengthy quotation from the chapter on "Old Red Sandstone" (page 801)—

"In the Upper Old Red Sandstone of the Firth of Clyde, *Bothriolepis* (*Pterichthys*) *major* and *Holoptychius* occur at the Heads of Ayr, while a band of marine limestone lying in the red sandstone series in Arran is crowded with ordinary Carboniferous limestone shells, such as *Productus giganteus*, *P. semireticulatus*, *P. punctatus*, *Chonetes hardrensis*, *Spirifer lineatus*, &c. These fossils are absent from the great series of red sandstones overlying the limestone, and do not reappear till we reach the limestones in the Lower Carboniferous series; yet the organisms must have been living during all that long interval outside of the Upper Old Red Sandstone area.

"Not only so, but they must have been in existence long before the formation of the thick Arran limestone, though it was only during the comparatively brief interval represented by that limestone that geographical changes permitted them to enter the Old Red Sandstone basin, and settle a while on its floor.

"The higher parts of the Upper Old Red Sandstone seem thus to have been contemporaneous with a Carboniferous limestone fauna, which, having appeared beyond the British area, was ready to spread over it as soon as the conditions became favourable for the invasion. It is, of course, obvious that such an abundant and varied fauna as that of the Carboniferous limestone cannot have come suddenly into existence at the period marked by the base of the limestone. It must have had a long previous existence outside the present area of the deposit."

This subject is also returned to (page 828) when the author is treating of the Carboniferous system, thus—

“In the West of Scotland there occur among the red sandstones (some of which contain Upper Old Red Sandstone fishes) bands of limestone full of true Carboniferous limestone corals and brachiopods. Hence, it is evident that the Carboniferous limestone fauna had already appeared outside the British area before the final cessation of the peculiar conditions of sedimentation of the Old Red Sandstone period.”\*

I confess to a little difficulty in grasping the exact meaning of the above-quoted passages, but the natural reading seems to be that the red rocks of Arran contain Old Red Sandstone fishes, and, from similar statements made in certain modern text-books,† it is plain that their authors understood them in the same sense. As for example—“Too much weight must not be attached to the character of the fossils in the limestone for the purposes of stratigraphical classification, since, as is well known, there occur in the West of Scotland, among red sandstones yielding Old Red Sandstone fishes, bands of limestone full of corals and shells of common Carboniferous limestone species. See Geikie, *op. jam cit.* [*i.e.*, second edition of the “Text-Book”], pages 716, 739.”‡

The fact is that no Old Red Sandstone fishes have ever been recorded from, and, so far as I am aware, none have ever been found in Arran, nor are there in the West of Scotland any red sandstones yielding Old Red Sandstone fishes together with bands of limestone full of corals and shells of common Carboniferous limestone species. The fishes referred to in the “Text Book” were, I presume, the specimens discovered in red sandstone south of the Heads of Ayr, on the mainland, some 20 miles distant from the Arran limestones. But the fact that Old Red Sandstone fishes have been got near the Heads of Ayr (where there are no Carboniferous limestone fossils) by no means proves that Arran limestones charged with Carboniferous limestone fossils (where there are no

\* See also “Text Book,” 2nd ed., 1882, p. 716, 739.

† See “Geology: Chemical, Physical, and Stratigraphical,” vol. ii., p. 93, by Joseph Prestwich, M.A., F.R.S., F.G.S., 1888; and “Historical Geology,” by A. J. Jukes Browne, B.A., F.G.S., 1886, p. 139.

‡ “Handbook of the Geology of Northumberland and Durham,” edited by Prof. G. A. Lebour, M.A., F.G.S., p. 77. This book formed the Official and Local Guide issued for the visit of the British Association to Newcastle-upon-Tyne, 1889.

Old Red Sandstone fishes) belong to the Old Red Sandstone formation. And it is noticeable that while no remains of plants have been recorded from the red sandstones of the Heads of Ayr, those of Arran both above and below the limestone are charged with fragments of Carboniferous plants.

Arran is classic ground to the geologist; its fame has travelled far beyond the limits of the United Kingdom, and the problems it presents have engaged many able pens. Amongst others, Sedgwick and Murchison,\* Ramsay,† and Bryce,‡ have written of these particular rocks, and all of them identified not only Old Red Sandstone but also Carboniferous strata.

The northern half of the Island of Arran consists—1st, of a central granite nucleus of somewhat circular form, which contains all the higher hills. The granite nowhere reaches the sea, being surrounded by a complete ring of slate and schistose rocks. These again are overlaid by another series (of which red is the prevailing colour), but these rocks do not completely surround the last-mentioned ones, as they do not appear on the north-west side. Previous writers assigned these latter rocks partly to the Old Red Sandstone and partly to the Carboniferous formations, and it is to them that I now propose to direct your attention, going over the evidence already recorded, arranging it in form for discussion, and adding some further observations of my own.

Investigation of the Arran rocks is much facilitated by the fact that the upheaval of the granite (or the final upheaval, if there was more than one) occurred subsequent to the deposition of the highest of the sedimentary rocks, which are upheaved all round the coast, and their upturned edges, which are exposed all along the Raised Beach down to low-water mark, afford unrivalled opportunities for observation.

As was first pointed out by Sedgwick and Murchison, the lowest of these Old Red Sandstone strata are seen at North Sannox, where there is an anticline from which the rocks dip north and south. They consist mostly of red sandstones and conglomerates, and, as will readily be acknowledged, those north of the anticline

\* *Proceedings of the Geological Society of London*, vol. i., p. 41, 1828. This appears to be only an abstract of their paper.

† “Geology of the Island of Arran,” by Sir Andrew Crombie Ramsay, 1841.

‡ “Geology of Arran and the other Clyde Islands,” by James Bryce, M.A., LL.D., &c., 4th edition, 1872.

correspond with those to the south. These writers set them down as Old Red Sandstone, which formation, according to them, extends for about 3 miles along the shore—the northern junction with the Carboniferous rocks occurring north of the Fallen Rocks, and the southern junction  $\frac{1}{4}$  of a mile north of Corrie, *i.e.*, 100 yards north of the great split boulder which forms such a conspicuous object on the shore. They are overlaid by Carboniferous rocks for several miles both north and south of these points, and are finally overlaid by strata of New Red Sandstone age.

Ramsay also supports this theory, and Bryce differs from it only in referring the uppermost rocks to the Upper Carboniferous instead of to the New Red Sandstone formation.

No time need be lost in discussing the beds which Sedgwick and Murchison state are Old Red Sandstone, as the fact is admitted on all hands. The question to be decided is whether the beds considered by these, and subsequent writers, to be Carboniferous are really so, or whether they are Old Red Sandstone, as stated in the "Text Book."

Coming for this purpose to the junctions of these two formations we find that both on the north and south the Old Red Sandstone conglomerates are succeeded by calcareous conglomerates and concretionary limestones (cornstones) alternating with sandstones. These strata overlie the Old Red Sandstone conglomerates conformably, and if Arran alone had been in question it is doubtful whether the line would have been drawn here. Some geologists hold that at least part of that which is considered to be the Upper Old Red Sandstone should be tacked on to the Carboniferous system. We have not observed in Arran anything condemnatory of that opinion. At least, in the absence of Old Red Sandstone fossils, the differences in the strata are no greater than those between different divisions of the Carboniferous formation.

Unfortunately the strata at the south end are cut off about 50 yards from this junction by a dyke, of which the cross section extends for more than 320 yards along the shore. As it seems to me that this dyke marks a fault, cutting off a considerable thickness of strata, I am compelled to fill in the gap by referring to the corresponding northern section, where we find that the same cornstone series is overlaid by beds of sandstone, black shale, and volcanic ash. This shale contains charred plant-remains belonging

to the genera *Calamites*, *Lepidodendron*, and *Lepidostrobus*; also a species of *Spirorbis*; besides, and of more interest, the remains of fishes. Dr. R. H. Traquair reported upon the latter as follows:—

“The fish remains from Arran, submitted to me by Mr. Neilson, are unfortunately so fragmentary that it is scarcely possible to identify any of them specifically. All that I can do is to indicate the general affinities of some—while, as regards others, I can say nothing.

“No. 1 is a portion of the basal end of a rhizodont tooth, which I should have attributed to *Rhizodus* itself had there been any trace of the lateral trenchant edges characteristic of that genus. As, however, the distance from the base of the tooth where these edges begin to be prominent in ordinary specimens of *Rhizodus*—teeth vary in different individuals—I hardly like to say that it does *not* belong to that genus. It wants the fine striæ seen in *Strepsodus Portlocki*, which it resembles in the oval form of its transverse section.

“No. 2 is a small rhizodont tooth which it is also very difficult to refer with certainty to its genus or species. In shape and appearance it most resembles the smooth variety of *Strepsodus striatulus*, Traq., from the Carboniferous limestone series of the East of Scotland.

“No. 3 is an imperfect scale also belonging to the rhizodont family.

“Nos. 4 and 5 are small palæoniscoid scales which, judging from the comparatively coarse serration of their posterior margins, probably belong to the genus *Rhadinichthys*, Traq., but more it is impossible to say.

“Although the specimens are unfortunately not such as to permit me to give any list of species, it is to be noted that they exhibit an unmistakably Carboniferous facies.”

It should be noted that these fossils were obtained from a very small part of the shale and that, were it properly opened out, a largely extended list might be the result.

Overlying this bed is one of volcanic ash, also containing fish remains—consisting, so far as my examination went, of fragments of bones and scales, some pretty large, but I was not fortunate enough to find any of them in a condition to admit of identification.

My informant as to the ash-bed was our old honorary member Mr. James Thomson, F.G.S.—whom I believe to be its discoverer—and, when hunting for it, I came across the black shale-bed above mentioned.

It speaks volumes for the accuracy of the earlier writers upon Arran that here, within a few yards of the line they drew as separating the Old Red and the Carboniferous formations, a bed charged with characteristic Carboniferous fossils should be found. So far as I am aware this is the lowest horizon where Carboniferous species have been got, occupying as it does a position several hundreds of fathoms below the marine limestones which, according to the "Text Book," are in the Old Red Sandstone formation.

When proceeding onwards it should be remembered that owing to the anticline the rocks dip away from us in the direction in which we are travelling, so that we see first only their upturned edges. It will thus be evident that each bed we come to is higher in the section than the preceding one, and that, as the strata dip at angles of from  $20^{\circ}$  to  $70^{\circ}$ , a mile along the shore represents a considerable thickness of strata. For a distance of about 3 miles from this point onward the red colour of the rocks is very occasional indeed, and not till we pass the Salt Pans does the red rock again predominate, and then (as will afterwards be shown) at a horizon several thousands of feet higher in the geological scale.

Succeeding and overlying the fish-beds we have next a great thickness of white and grey calciferous sandstones, and, passing them, at Millstone Point, about 1 mile north of the Fallen Rocks, we come on black shales full of plant-remains in the condition of anthracite.

Shortly after this we reach the interesting sections of trap and ash-beds, interbedded with shales and thin seams of coal, amongst which Mr. Edward A. Wünsch, F.G.S.,\* long an active member and vice-president of our Society, made his interesting discovery of a forest buried in volcanic ash, yet buried in such a way as to preserve the minute structures of the plants. Mr. Wünsch recorded† the disinterment of fourteen large tree-stems, and

\* I regret to state that since this paper was read Mr. Wünsch has died. His death took place in Cornwall on the 19th November, 1895. A short obituary notice was given in the *Geological Magazine* for February, 1896.

† *Transactions*, vol. ii., p. 97. For descriptions of new species from this deposit, see the monographs of the Paleontographical Society, 1870.



some others were taken out during the meeting of the British Association in Glasgow in 1876. Dr. Bryce also recorded (page 127) the finding of a palatal tooth of *Ctenodus cristatus* (surely a Carboniferous fish). The plants recorded from this bed are *Sigillaria*, *Halonina*, *Lepidodendron*, *Lepidostrobus* (three sp.), *Antholithes*, *Sphenopteris*, and *Stigmaria*.

Mr. Wünsch estimated the thickness of these igneous rocks with the interbedded shales, &c., at about 1000 feet, and probably between them and the Old Red Sandstone conglomerate there is at least as much more, even with a liberal allowance for faulting. We are now near the limestone, which we reach after passing some white or grey sandstone, so that there are here some 2000 feet of strata not red, underlying the fossiliferous limestones. I do not hesitate to assign these strata to the calciferous sandstone series, and the great thickness of igneous rocks, in which Mr. Wünsch's discovery was made, to the huge outburst of trap which marks the close of the calciferous and the beginning of the lower limestone periods, and, extending across Scotland, gives us the trap hills of South Bute, Little Cumbrae, North Ayrshire, Kilpatrick, Campsie, Fifeshire, and the Lothians.

Should this be the case, it may be more than a coincidence that in the three principal localities where fossil wood showing minute structure has been found, viz., in the present beds, at Burntisland, and at Bowling, the same series of volcanic rocks should have enveloped the forests in such a way as to preserve the microscopic structure of the trees. It is just within the limits of possibility that this may mark a distinct horizon.

The fossiliferous limestone which occurs about 100 yards north-west of the shepherd's house at Laggan is undoubtedly the same as that at Corrie, and contains the same fossils, the prevailing one being *Productus giganteus*, which is extraordinarily abundant. The peculiarity about the Laggan beds is that the shales are black, while at Corrie they are red, which shows that the red colour does not help us to identify strata, as it does not represent a difference of thousands or millions of years, but is merely a local phenomenon. These limestones are succeeded by white and grey sandstones, with alternating black shales. Some of the shales are charged with the usual marine Carboniferous fossils, and extend along the shore to Salt Pans, where they are succeeded



by beds of a different character, but as these beds are not represented on the southern part of the district it is better to defer their consideration till I have finished with the others.

Let us now return to the consideration of the similar beds at the southern portion of the section, where we left off, viz., at the broad dyke of which the southern edge terminates on the shore opposite the school-grounds at Corrie. As already stated, this dyke marks a great fault, and I am rather surprised that the present should be the first mention of it, as the evidence seems clear enough. The cornstones occur immediately to the north of it, while the marine limestones are only a few hundred yards south; so that it cuts off all the strata represented along about 2 miles of shore on the northern section (*viz.*, from the cornstones north of the Fallen Rocks, to the shepherd's house at Laggan), *i.e.*, nearly all the calciferous sandstone series, a displacement which may be roughly estimated at about 300 fathoms. I am under the impression that, failing to recognise the existence here of a great fault, Sir Archibald Geikie wrongly supposed the marine limestones to be in their natural position only a little way above the cornstones.

To the south of this dyke the strata are mostly, though not all, of a red colour, and consist of sandstones, shales, limestones, ironstones, and (what have not previously been noted) various beds of fireclay. The beds known as the Corrie limestone consist, we are told, of twenty-two beds of limestone interstratified with red shale, the total thickness of the limestone being about 20 feet. These are referred to in the "Text Book" \* thus—"A band of marine limestone lying in the red sandstone series in Arran is crowded with ordinary Carboniferous limestone shells, such as *Productus giganteus*, *P. semireticulatus*, *P. punctatus*, *Chonetes hardrensis*, *Spirifer lineatus*, &c." This part of the quotation I very heartily endorse, the strata, consisting of sandstones, shales, &c., being mostly red. Even the limestone fossils are as red as the sandstones, and they occur in great profusion. *Productus giganteus* exists by the million, and one of the sights, even of Arran, not only for the geologist, but also for the ordinary summer visitor, is to stand at the entrance of one of the old mines, and see this shell not only crowding the roofs, but many layers of

\* "Text-book," p. 801.

the rock, the concave dorsal valves of one generation serving as the resting-places of the next succeeding one.

Owing to a great upthrow, these limestones appear on the northern flank of the hill called Maoldon, where they have been worked for industrial purposes. They are similar in character and colour to those of Corrie, but the fossils are more easily procured. Several magnificent slabs crowded with shells, and fit for any museum, are to be seen lying among the fallen débris, and when among them I could not resist the temptation of chiselling the shale out of some of the shells, so as better to expose them, a work which, it is to be hoped, will be appreciated by some future geologist. Three other upthrows of the same limestones occur further to the south, on the slopes towards Brodick Bay, but it is unnecessary to refer to them at the present time. There can be no doubt that these are the same limestones as those previously observed on the north shore, near the shepherd's house at Laggan. Generally speaking, the fossils are the same, as is also the character of the limestone and the interbedded shale, in all but the colour.

With regard to the redness of the strata, on which the "Text Book" lays some stress, it is simply due to hematitic iron ore distributed through the rock, and many seams have this to such an extent as to soil the hands, while some of the fossils do so even even after years of exposure to the weather. These ores also appear sometimes as seams of red ironstone, and at other times are aggregated into detached nodules or nodular bands, good examples of both kinds being met with in old quarries on the hills behind Corrie, and also on the shore. But, although red is the prevailing colour, it is not by any means universal, as white sandstones are, and have been, quarried behind the village, both above and below the limestones, *e.g.*, in a quarry behind Corrie Hotel, where a white sandstone may be seen overlaid by a bed of fireclay containing the usual rootlets of *Stigmaria*. As has already been shown, the same limestones, shales, and sandstones which are red at Corrie are respectively black and white at Laggan, so that I believe the redness to be only a local peculiarity in the same strata.

Taking up the last quotation at the point we left off, we find\*—

\* "Text-book," p. 801.

“These fossils [*i.e.*, *the limestone fossils*] are absent from the great series of red sandstones overlying the limestones, and do not reappear till we reach the limestones in the lower Carboniferous series; yet the organisms must have been living during all that long interval outside of the upper Old Red Sandstone area” (page 828). I admit that the limestone fossils are absent from the great series of red sandstones, but I challenge the production of even a single fish of the Old Red Sandstone formation from any part of the Island. That marine fossils should be “absent from the great series of red sandstones overlying the limestone” was to be expected, the fossils found in Carboniferous sandstones elsewhere being exclusively plant-remains, and I am only aware of one bed of sandstone which contains marine remains, in the West of Scotland, and that one is in the upper limestone series.

Plant-remains are even more common in Arran than I have observed them elsewhere, a fact, already sufficiently recorded by previous writers, which may be easily verified by anyone who walks along the shore at Corrie, where they protrude every here and there from the sandstones, while one sandstone bed, intercalated between the limestones in front of Corrie Hotel, is packed with rootlets of plants. Plant-remains are also abundant all along the northern sections, and also towards the south in the cliffs of Maoldon.

A notice of a section at Lochrim Burn,  $\frac{1}{4}$  of a mile south of Corrie, where there is exposed a bed of red sandy shale with marine fossils, will be found in the *Transactions* of the Edinburgh Geological Society,\* the list containing fifteen species, certified by Mr. John Young, LL.D., F.G.S., every one being common in the Carboniferous limestone strata of the West of Scotland. This bed is overlaid by another containing abundant plant-remains, of which a list of seven species is given. The Rev. David Landsborough of Kilmarnock found here another plant, viz., *Carpolithes sulcata*, L. & H.,† which Mr. Kidston considers to be characteristic of the calciferous sandstone series. I considered the point of importance in determining the position of a great fault which passes at some place close at hand, and which throws up the Corrie limestone at Maoldon. If these strata are calciferous, then

\* *Trans. Edin. Geol. Soc.*, vol. v., p. 316.

† Lindley and Hutton's "Fossil Flora," plate 220.

NEILSON—OLD RED AND CARBONIFEROUS ROCKS OF ARRAN. 291

the fault is to the north; while if they belong to the limestone series, it probably passes to the south. It seems to me, however, that the evidence is rather in favour of them belonging to the limestone series.

Although the plant-remains of Arran are in a very poor state of preservation, yet I have been able to identify the following genera:—

- |                                  |   |   |   |                                     |
|----------------------------------|---|---|---|-------------------------------------|
| <i>Calamites</i> ,               | - | - | - | Maoldon—(changed into ironstone).   |
| „                                |   |   |   | Ash, shale, north of Fallen Rocks.  |
| „                                |   |   |   | Millstone Point.                    |
| „                                |   |   |   | Corrie.                             |
| <i>Lepidodendron</i> ,           | - | - | - | Maoldon—at cliffs, in lime-working. |
| <i>Lepidostrobus</i> .           |   |   |   |                                     |
| <i>Sigillaria</i> (large stems). |   |   |   |                                     |
| <i>Stigmaria ficoides</i> ,      | - |   |   | Everywhere.                         |

Besides these there are innumerable rootlets and unrecognisable fragments scattered through the red, yellow, and black shales.

Then, as already noted, there are the fireclays, of which there are several distinct beds along the Corrie shore. There is also a bed of fireclay in the old quarry behind Corrie Hotel (within 100 feet of the *Productus giganteus* limestone). This overlies a bed of fine, white sandstone. Fireclays also occur at Lochrim Burn, south of Corrie, while several crop out on the northern cliff of Maoldon, and also in the gap between the northern and the great north-eastern cliff.

So far as I know, fireclays have not hitherto been recorded from Arran, but they have an important bearing on the question presently at issue. Let me here again quote the “Text Book” \* —“Fireclay or shale, through which rootlets branch freely in all directions. . . . They appear to be the soil on which the plants of the coal grew.” These Arran fireclays differ in no respect, except that some of them are redder or whiter, from those we are so familiar with in the vicinity of Glasgow, being crowded with rootlets, while here and there the familiar *Stigmaria ficoides* is to be seen. Some of them show the peculiar slickensides so well known, and nodules of ironstone are distributed through them. I am under the impression that fireclays are not known to occur earlier than in the Carboniferous formation. At all events, the “Text-book” does not mention them as occurring in the Old Red Sandstone.

But not only do these red sandstones contain fireclays, but also ironstone, which occurs not only as nodules (in the fireclays and

\* “Text Book,” p. 806; see also p. 514.

shales) from half the size of pin-heads to about a foot in diameter, also in nodular and regular bands, which may be seen at Corrie, both on the shore and in the old quarries already referred to, and on Maoldon and in the Mill burn at Brodick. The ironstone is nearly all in the state of peroxide—hematite iron ore, which is doubtless the colouring material of all the red rocks of Arran; in fact, I have come to the conclusion that the nodules, and possibly seams of hematite, have been simply segregated from the abundance of this material—one very striking instance of a nodular band, about an inch thick, seeming to have entirely exhausted the red matter from the clay in which it lies, leaving it of a creamy white colour.

Let us return now to the question of the marine limestones. If they belonged to the Old Red Sandstone age, we should expect their fossils to be of Devonian rather than of Carboniferous type. It would indeed be strange if there should have existed at the same time in the sea, where Devonshire and Arran now are, two faunas so dissimilar as those of the Devonian and Carboniferous, if changes should have occurred which involved the annihilation of the entire Old Red Sandstone and Devonian faunas, and yet have left these Carboniferous fossils unchanged throughout all the long period represented by the upper members of the Old Red Sandstone, and the whole of the calciferous sandstone period, to be again introduced unaltered into the British area at the beginning of the Carboniferous limestone period. On the contrary, the proof is all the other way; the fossils show undoubtedly that these are true Carboniferous limestone strata. Bryce\* records from them some thirty-six species of marine fossils, all found elsewhere in the Carboniferous series of the West of Scotland. Nay, as if to render the Old Red Sandstone theory more manifestly untenable, four of these species are fishes of Carboniferous type, of which two are got at Corrie, viz., *Megaclichthys Hibberti* and *Cochliodus magnus*.

The most striking feature in the limestones at Corrie and at Laggan and Maoldon is the enormous number of the shells of *Productus giganteus*.† Now, it will be generally conceded that

\* "Geology of Arran," p. 224.

† Measuring a square yard in the roof of one of the mines I counted in it 48 shells of this species, and in the face section I counted 21 layers of the shells. A simple calculation shows that at this rate an imperial acre contained over 232,000 shells per layer, and 21 layers would yield nearly 5,000,000 shells per acre—a number which, however enormous, is, I am persuaded, under rather than over the actual amount.

species, like individuals, have first a period of infancy, and then of full development, after which they dwindle and gradually die out. This shell has been no exception to this rule, and its period of overwhelming development is well known in the West of Scotland, near the bottom of the limestone series, where some of the beds are known as the *Productus giganteus* limestone. This series of beds, the thickest of our lowest limestones, generally called the main limestone, has been extensively worked at Beith and Dalry, near Busby, at Hurlet, Campsie, and Carluke, amongst other places, and there need be no hesitation in setting down the Corrie limestones as its equivalents in Arran. In position they correspond stratigraphically, if we accept Mr. Wünsch's ash-beds as part of the great igneous outburst of calciferous sandstone age.

## PART II.

I intended to have re-examined the rocks in Brodick Bay, so as to have worked out the evidence in that direction, but the broken weather of last summer stopped that portion of my work. I may, however, say that the evidence there is not so complete nor so continuous as in the ground I had already gone over, while the greater part, if not the whole, of the strata between those already described and the thick sandstones which overlie the upper limestone near the Cock of Arran, appear to be entirely wanting.

I shall therefore take up the strata on the north coast of the island at the point where we left off, half a mile north of the shepherd's house at Laggan. This part is generally called Salt Pans, but I have hitherto avoided the name, desiring to reserve it for the higher strata about to be described. These consist of sandstones and shales with two or three seams of coal which have been wrought down to the level of the sea, also several bands of ironstone. In one little bay there are exposed three beds of hematite ironstone, beautifully tessellated, and forming a very interesting and striking object well worthy of a visit.

No marine remains have been recorded from these strata, but they contain numerous plant-remains, mostly unrecognisable, although *Stigmaria* is common. I found, however, one small frond of *Sphenopteris*. These beds have evidently been deposited in fresh water.\*

\*Dr. Bryce ("Arran," p. 128) states that "the shale and coal tract is bounded by a black limestone below, and red limestone above, 1400 yards apart."

These strata lie between the upper and lower limestone series and are, I believe, the representatives of what is known in the West of Scotland as "the middle coal and ironstone group," represented near Glasgow by the Possil and Govan coals and ironstones, with which they correspond in geological position, mineral character, and economic products (coal and ironstone), although I have not observed in the Arran beds the *Lingula* which elsewhere is so characteristic of this division.

### PART III.

Proceeding still in a north-westerly direction along the shore we reach another series of red rocks—even redder than before—which consist of sandstones, shales, and several limestones. The limestones are loaded with fossils, one bed, the lowest, being charged with the shells of *Productus latissimus*, while another abounds with large stems of *Encrinites*, and a third with various other fossils. These exhibit a decided change from the last group of beds, viz., from fresh-water to marine conditions. Not only the beds themselves, but the fossils they contain are as red as any Old Red Sandstone rocks in Scotland. I set them down as the equivalents of the upper limestone series, to which they correspond in stratigraphical position, and am inclined to consider the bed, charged with *Productus latissimus*, as the true "Index" limestone itself. This shell attains its greatest development at a certain horizon known as the *Productus latissimus* limestone.

Overlying these rocks we come to thick beds of sandstone, then breccias, then sandstones again, till the whole are cut off by a great fault, the slates coming down to the shore. These sandstones, &c., were described by Sedgwick and Murchison, and by Ramsay, as belonging to the New Red Sandstone formation, while Bryce sets them down as belonging to the Upper Carboniferous series (I presume the equivalents of the Bothwell red sandstones which overlie the highest of the Lanarkshire coal-seams).

It will, however, be observed, if my theory is correct, that these sandstones occupy the position of the millstone grit, and, as there does not appear to be any break or unconformity in the sequence, I am inclined to relegate them to that position.

In the New Geological Map of Scotland, 1892, these rocks are



set down as Upper Old Red Sandstone, but they clearly overlie thousands of feet of strata containing Carboniferous fossils, while the pebbles in the associated breccias contain fossils of Carboniferous limestone age, originally discovered by Mr. James Thomson, F.G.S., a fact well known to the members of this Society twelve years or so before the publication of the map referred to. But I can see no necessity for placing these rocks either on the horizon of the Bothwell sandstone, or of those of Ballochmyle or Dumfries.

Lying conformably as they do over the upper limestone series they occupy the position of the millstone grit, and *prima facie* they are these beds, the onus of proof being therefore thrown on those who would dispute this point. The omission of the Upper Coal measures would likely be marked by some unconformability, while none is recorded; and that the phenomena of their stratification are not sufficient to locate them satisfactorily is amply shown by the fact that they have been set down by three distinguished geologists as belonging respectively to the New Red Sandstone, to the Upper Carboniferous, and to the Upper Old Red Sandstone periods. Considering these rocks then as of millstone grit age, and the highest in the North of Arran, it is evident that the Upper Coal measures are absent.\*

The synopsis of the Carboniferous limestone series given in the New Geological Map of Scotland, 1892, is as follows†:—

CARBONIFEROUS LIMESTONE SERIES.

Group of sandstones and shales with three or more seams of limestones (Castlecary, Calmy or Arden, and "Index" limestones). Sandstones, shale, coals, and ironstones, but with no limestone bands. Sandstones, shales, fireclays, coals, and ironstones, with several thin limestones (Hosie's) towards the top, and the thick Main or Hurlet limestone at the bottom.

This, as will be seen, agrees with the character of the Arran rocks.

Having now given a survey of the whole, I claim that, both

\* Ramsay ("Arran," p. 33) says—"These rocks rest conformably above the Carboniferous formation." Bryce says nothing about it. The statement in the Report of the Science and Art Department, 1894, p. 284 (see extract at p. 300), that "the Red Sandstone conglomerates and breccias lie unconformably on the Carboniferous formation" is, so far as I am aware, a new discovery, and disposes of my objections to consider these rocks as New Red Sandstone. The rocks below this unconformity I still hold to be of millstone grit age.

† Explanatory Notes accompanying "A New Geological Map of Scotland," 1892.

296 TRANSACTIONS—GEOLOGICAL SOCIETY OF GLASGOW.

on account of stratigraphical, mineral, and fossil evidence, these Arran rocks are the equivalents of the West of Scotland Old Red Sandstone and Carboniferous strata, and I venture to correlate them as follows :—

	MAINLAND.	ARRAN.
[Upper Coal Measures,	- Lanarkshire, -	- Absent.]
Millstone Grit, - -	- Bishopbriggs, -	- Cock of Arran.
Upper Limestone Series,	- Highfield, -	- Salt Pans.
"	Arden,	"
"	Orchard,	"
"	Cowglen,	"
Middle Ironstone and Coals,	Possil, Govan, &c.,	"
Lower Limestone Series,	- Campsie, }	{ Laggan.
"	Hurlet, }	{ Corrie.
"	Carlisle, }	{ Maoldon.
"	Beith, }	{ Brodick.
Great Volcanic Outburst,	- Ayrshire Hills, }	- Mr. Wunsch's discovery.
"	Campsie, }	
Calcareous Sandstones,	- Ballagan, -	- Lagantuin Bay.
"	West Calder,	"
"	Edinburgh,	"
Old Red Sandstone, - - -	- - -	- $\frac{1}{4}$ -mile north of Corrie to Fallen Rocks.

It has been already mentioned that the ring of slates or schists completely encircles the granite, yet the New Geological Map of Scotland, 1892, shows on the east the granite in contact with the Old Red Sandstone for a distance of about 3 miles. That this is not the case can be seen in the White Water, described in the books of the authors already quoted, and also in the Punch Bowl, or Cioch na h-Oighe junction, discovered and first described by our esteemed member Mr. John Smith,\* where the granite and slate are clearly in contact. On the eastern slope we have in the Map the Lower Old Red Sandstone, then Upper Old Red Sandstone, succeeded by calciferous sandstone, and that again by Upper Old Red Sandstone; but I hold that there are no Lower Old Red Sandstone rocks in this part of Arran. We are told\* that the Lower Old Red Sandstone is "covered unconformably by every rock younger than itself," but all the red rocks I have seen lie conformably to one another. The beds near the Cock of Arran, set down as Upper Old Red Sandstone, overlie something like 1000 fathoms of strata which are charged with Carboniferous fossils, and contain marine limestones, workable seams of coal, fireclays, and ironstones.

\* "Text-book," p. 799.

PART IV.

Some very striking instances of what appear to be the results of segregation are met with in this district. In one place we have red limestone (cornstone) with white nodules, as if by some subtle force the iron which at one time coloured the whole bed had been driven out from the portions which are now nodules. This is succeeded by another bed in which exactly the opposite is the case, the iron being drawn completely out of the general body of the stone and concentrated in the nodules, which are red in a white matrix.

The colouring matter of the red rocks is peroxide of iron, of which a very small quantity will colour a large mass, and it affords very striking testimony to the power of affinity to find that rocks which were once red are now white with the iron concentrated in nodules, sometimes many feet apart. An example of this may be seen on the shore opposite Corrie Hotel, where there is a thick white sandstone containing large irregular balls of red sandstone, 8, 10, and even 12 feet in diameter.

The hematites with which Arran abounds are, I believe, due to segregation. They sometimes occur as detached nodules, sometimes as nodular bands, and sometimes as regular bands, although these latter may simply be nodules closely packed together at their edges; but it is very striking to find these nodules in strata almost pure white, as if every atom of the iron had been attracted or drawn out of the stratum into the nodule. Good examples may be found in the old quarry immediately south of Corrie limestone quarry, from which the specimen exhibited was taken.

Another very striking instance is from Maoldon, in the hollow between the northern and the eastern cliff, where a bed of fireclay contains a seam of clay, or shale, from 2 to 3 inches thick, crammed with minute ironstone nodules, each nodule not half the size of an ordinary pin-head, yet regularly distributed through the clay. Where the surface has been exposed to weather these nodules may readily be separated from the matrix, and when seen in mass have somewhat the appearance of turnip seed. It is remarkable that while abounding in iron the shale should be nearly white, owing, I believe, to the whole of the iron having been removed through the strong attraction of segregation.

Mr. John Young, LL.D., F.G.S., about the same time discovered

specimens of a similar kind at the north-east corner of Brodick Bay, about 2 miles south-east of the above-mentioned locality, though they differ considerably from the others. The Mill burn also carries down and deposits hematite iron, which on the lower part of its course is gathered by the natives and visitors, and used for reddening the doorsteps of their houses. Notwithstanding the difference of the specimens, I think that they are from a continuation of the same bed, as a considerable fault occurs between these parts, upthrowing the limestones and the accompanying strata.

And now, in conclusion, the question may be asked—Is there any way of accounting for the redness of the Arran rocks, so different in many cases from their equivalents elsewhere? The ironstones appear to have been deposited in a manner exactly similar to the clayband ironstones of the mainland, and I am strongly of opinion that originally they were similar, and that the alteration to peroxide of iron took place subsequent to their deposition and segregation, and was due to some cause which was local, and did not apply to the West of Scotland generally.

This cause might have been heat. The red rocks of Arran are situated round, and at no great distance from, a granite nucleus, upheaved to its present position subsequent to the deposition of the stratified rocks, and it is just possible that to the slow and long-continued baking to which they must have been subjected the alteration to red oxide, both in the ironstones and sandstones, is due. We know that clay assumes its red colour by firing, and, although a heat sufficient to burn a brick might destroy a fossil in the limestone or shale, yet that required to effect the change in colour may not have been so great if continued for a length of time. I throw out this suggestion with considerable diffidence, however, knowing it to be open to many and serious objections.

Since these remarks were penned, a curious circumstance, with a bearing on the point, has come under my notice. Some time ago, during excavations for a gasholder tank at Thornliebank works, the excavated material was carted and thrown down at Arden old limestone quarry. It proved to be a fossiliferous shale containing a large number of nodules. After lying for some time it took fire, and has been smouldering away for some months.

NEILSON—OLD RED AND CARBONIFEROUS ROCKS OF ARRAN. 299

The heat in the deeper parts was high, but on the surface much less—probably from 120° to 150° Fahr.—yet it has been sufficient to alter the colour of the nodules from bluish gray to red (as shown by the specimens exhibited, some of which contain fossils which have been altered, but not destroyed).

Another point is the condition of fireclays and shales charged with plant-remains, which, as an invariable rule, are black in colour. I think I am safe in saying that any such beds which are not so have been subjected to alteration. The effect of heat upon such material as clay or shale is to drive off the carbon and leave it whitish or (if it contain iron) reddish. Now, none of the fireclays among the red rocks of Arran are black. They are either of a creamy white or reddish colour, an alteration which, as I have shown, could have been, and probably has been, produced by heat.

Proceeding from observation and theory to experiment, I took some specimens of fireclay filled with small ironstone nodules, and of a dirty black colour, which had been found by Mr. J. B. Wise at Blochairn (in the north-east of the city), and put a piece into my parlour fire, heaping up coals over it. After about two hours' roasting it was found that the black colour had disappeared and that the fireclay had become whitish, very similar to some of the Arran fireclays, while the ironstone nodules had been altered to red and blue oxide. A second experiment on the same lines, the heat applied being less, gave better results, and the specimen looked as if it had come from one of the Arran beds.

NOTE.—At the close of the paper the Hon. Secretary (Mr. Murdoch) read the following telegram which he had received in the course of the evening from Sir Archibald Geikie, F.R.S. :—

“ To Secretary, Geological Society,  
“ 207 Bath Street, Glasgow,

“ Statement about Arran limestones corrected. See *Annual Report Science and Art Department*, 1894, p. 284. GEIKIE.”

In the course of the subsequent discussion the author stated that up till the moment the telegram was read he was not aware that any corrections of the statements in the “Text book” had been published by Sir Archibald Geikie.

The Annual Report of the Science and Art Department, 1894, was received by the Mitchell Library, direct from the Department, on 5th September, 1895. This date may therefore be regarded as the date of its

300 . TRANSACTIONS—GEOLOGICAL SOCIETY OF GLASGOW.

publication, and is long subsequent to the time when the notes were taken by the author for the foregoing paper.

The following extract is taken from Sir A. Geikie's report (p. 284) referred to above:—

*Permian.*—"The age of the red sandstones which extend along the eastern shore of Arran from Corrie to Brodick and thence across the southern half of the island, underneath the various sheets of eruptive rocks, has been much discussed.

"By Sedgwick and Murchison these strata were classed as New Red Sandstone, a view that was subsequently adopted also by Ramsay. Afterwards, however, Bryce and other writers placed them in the Carboniferous system and correlated them with the red sandstones of the north of Ayrshire and Renfrewshire.

"A re-examination of the ground was made by me last spring in company with Mr. Peach and Mr. Gunn. We found that pebbles of the Carboniferous Limestone with its characteristic fossils actually occur in the breccias at the base of these red sandstones between Corrie and the north end of Arran, as was first observed some years ago by Mr. James Thomson.<sup>1</sup>

"Closer inspection of the coast-sections and of the interior showed us that, besides this evidence of a decided stratigraphical break, the red sandstone, conglomerates and breccias lie unconformably on the Carboniferous formations, though at the actual junction the two series seem almost conformable.<sup>2</sup>

"It was thus manifest that these red sandstones could not be Lower Carboniferous, as had been supposed, but must be later than the Carboniferous limestone series. North of Corrie they rest on the uppermost members of the limestone series, or the base of the Millstone Grit. In the interior, at the head of Banlister Glen, they lie on the Corrie Limestone, hundreds of feet lower down in the Carboniferous system, while on the west coast at the mouth of the Machrie Water, they appear to come directly down upon the Old Red Sandstone, the whole of the Carboniferous formations having there disappeared.

"These upper unconformable, and overlapping red strata may be divided into two fairly well-marked sections, a lower group consisting of massive

<sup>1</sup> The above reference to Dr. Bryce is hardly correct, as he especially excepts the rocks near the north end of Arran from the other overlying red sandstones of the east and south. These latter he considers of Lower Carboniferous (i.e., calciferous sandstone) age ("Geology of Arran," p. 15). The northern rocks he, however, considers to be Upper Carboniferous, as the following extract (p. 129) will show:—"These beds are the 'uppermost members of the whole series, which begins to overlie the Old Red Sandstone 'near the Fallen Rocks. From their position and mineral character they have been 'classed as New Red Sandstone by Murchison, Sedgwick, and Ramsay. Mineralogically they have a much greater resemblance to Lower Permian strata than any of the 'rocks in the southern district; but we refer them, notwithstanding, to the Upper Carboniferous series, to which they are more closely related by their fossils."

I am not aware of any writer who classes these rocks as Lower Carboniferous.

<sup>2</sup> This stratigraphical break and unconformability appears to be a new discovery, and if satisfactorily established would dispose of my objections to regard these rocks as in other than their natural sequence. In that case the rocks above this break might very well be referred to the Permian.

June, 1896.

J. N.

NEILSON—OLD RED AND CARBONIFEROUS ROCKS OF ARRAN. 301

false-bedded sandstones, varying from a bright brick-red colour to tints of yellow and grey, and an upper group of red marls and shales, containing thin sandstones and occasional thin seams of nodular limestone. The upper division extends through all the southern and a part of the western district of Arran, from Dippin round to beyond Drumadoon.

“No decisive evidence has yet been obtained to fix the geological age of this series of red strata. That they are probably Permian may be inferred on two grounds.

“In the first place the lower group of false-bedded brick-red sandstones presents the closest resemblance to the red sandstones which, within sight on the opposite mainland of Ayrshire, rest upon the Coal-measures and have been referred to the Permian period. In like manner, they resemble the red sandstones of the south of Ayrshire, Wigtownshire, and Dumfriesshire, which are also assigned to the same period.

“In the second place, the Arran red sandstones have been found by Mr. Gunn to enclose a contemporaneous volcanic group, a feature which is specially characteristic of the Permian series of the centre of Ayrshire and of Nithsdale.”