PROCEEDINGS

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THE GEOLOGICAL SOCIETY.

POSTPONED PAPERS.

1. *On the* Carboniferous Flora *of* Bear Island (lat. 74° 30′ N.). By Prof. Oswald Heer, F.M.G.S.

[Communicated by Sir Charles Lyell.]

(Read November 9, 1870 *.)

It has long been known that strata of Coal and Mountain Limestone are found in Bear Island; but the true geological conditions of this island were first ascertained by Professor Nordenskiöld, who visited it with the Swedish expedition of 1868. He and Professor Malmgren collected a large number of fossil plants out of the coal and the associated rocks. These plants, according to Nordenskiöld, point to the following relations of the strata:—

Mountain limestone.	Siliceous schists.
	Productus-limestone with large, thick-shelled species of *Productus*.
	Spirifer-limestone with gypsum. Many *Spiriferi*, some of them of colossal size.
	Cyathophyllum-bearing limestone and dolomite.
Sandstone with intercalated coal and clay-shale. Contains the plants.	
Russian-island limestone. Greyish yellow dolomite with beds of calcareous shales.	
Red Devonian (?) shales.	

The plants, therefore, were found under the Mountain Limestone. The Russian-island limestone contains no determinable fossils; and its geological position is therefore doubtful, as is also that of the red shales, which last Nordenskiöld is inclined to place in the Devonian. The plants lie partly in the coal itself, partly in the sandstone, and partly in the dark-coloured shale, which in some places is quite filled with plant-remains. They are all land-plants; no trace of marine plants or animals is to be found. The whole deposit containing the plants is therefore probably of freshwater origin; and the coals,

* See Quart. Journ. Geol. Soc. vol. xxvii. p. 1.

in any case, owe their origin entirely to land-plants. The number of species of plants is inconsiderable in proportion to the large number of specimens which Nordenskiöld and Malmgren have collected. I received the following species:—*Calamites radiatus*, Br. (*C. transitionis*, Göpp.), *Cardiopteris frondosa*, Göpp. sp., *C. polymorpha*, Göpp. sp., *Palæopteris Rœmeriana*, Göpp. sp., *Sphenopteris Schimperi*, Göpp., *Lepidodendron Veltheimianum*, Sternb., *L. commutatum*, Schimp. (*Ulodendron*), *L. Wickianum*, Hr., *L. Carneggianum*, Hr., *Lepidophyllum Rœmeri*, Hr., *Knorria imbricata*, Sternb., *Kn. acicularis*, Göpp., *Cyclostigma Kiltorkense*, Haught., *C. minutum*, Haught., *Halonia tuberculosa*, Brgn.?, *Stigmaria ficoides*, Sternb., *Cardiocarpum punctulatum*, Göpp., and *C. ursinum*, Hr.,—in all eighteen species, of which only three have not yet been discovered in other places. The greater number of the plants, and all the most abundant forms, belong to known, and partly to widely spread species, and thus furnish us with the means of comparing this flora with those of other lands, and of the different subdivisions of the coal-formation. It contains three species in common with the *Coal-measures*; but of these *Lepidodendron Veltheimianum* is the only one of importance; for the determination of *Halonia tuberculosa* is not certain, and the *Stigmariæ*, consisting only of rhizomes of different plants, do not afford sufficient data for a comparison of species.

The flora of Bear Island differs, therefore, much from that of the Coal-measures, but quite as much on the other hand from that of the Devonian. If we compare it with the flora of the *Cypris*-shales of Saalfeld, in Thuringia, which belong to the Upper Devonian, we do not find a single species in common. Altogether the Devonian flora of Germany has no species in common with Bear Island; for the statement that *Calamites radiatus* occurs in the Devonian is only founded on its presence at Kunzendorf, in Silesia, which locality belongs rather to the Lower Carboniferous than to the Devonian.

With the Lower Carboniferous flora the relations of that of Bear-Island are quite different. Of the eighteen species, fifteen occur in other localities in the Lower Carboniferous formation, ten in the Mountain Limestone, and nine in the Millstone-grit. It cannot, therefore, be doubted that the Bear-Island flora belongs to the Lower Carboniferous series. If we compare it carefully with fossil deposits of other lands, even neglecting the stratigraphical relations of the rocks containing the plants, it is clear that it has the greatest resemblance to the flora of the sandstones and shales lying immediately under the Mountain Limestone, and that it forms a distinct stage (étage) of the Lower Carboniferous, constituting a passage into the Upper Devonian. We may call this stage the Bear-Island or Ursa stage (Ursa-Stufe).

To this Ursa-stage belong the following plant-bearing localities:—Kiltorkan, and generally the Yellow Sandstones and Carboniferous Shales of the south-west of Ireland; the Greywacke of the Vosges and the southern Black Forest; the Verneuilii-shales of Aix, and St. John's in New Brunswick (Canada). As several of these have till now been regarded as Upper Devonian, it will be necessary

for me to confirm this classification in detail. I have discussed it more fully in my treatise, which will be published by the Swedish Academy, and have illustrated the plants in fourteen plates.

The Yellow Sandstone of Ireland is well known to lie immediately under the Carboniferous Shale, which, in its turn, is covered by the Mountain Limestone. It is regarded as the Upper Old Red, and, as such, is classed with the Devonian. But the flora of the Yellow Sandstones of Kiltorkan and the shales of Tallowbridge quite contradict this classification. I owe to the kindness of Messrs. W. H. Baily and Robert H. Scott a collection of plants from these localities, which have enabled me to make a comparison. It contains, from Tallowbridge, *Calamites radiatus*, *Lepidodendron Veltheimianum*, and *Knorria acicularis*; and, from the Yellow Sandstone of Kiltorkan, *Calamites radiatus*, in large pieces, *Cyclostigma kiltorkense*, *C. minutum*, *Lepidostrobus Bailyanus*, Schimp., *Lepidodendron Veltheimianum*, *Stigmaria ficoides*, and *Palæopteris hibernica*, Forb. sp., to which also *Sphenopteris Hookeri*, and *S. Humphriesiana* may be added.

The flora of Tallowbridge therefore, so far as it is known, agrees very nearly with that of Kiltorkan; and both of them coincide in a remarkable manner with that of Bear Island; for, of the ten Irish species, five or six are common to the latter. *Palæopteris hibernica*, of which beautiful fronds are found at Kiltorkan, has not yet, it is true, been discovered in Bear Island; but the nearly allied *Palæopteris Rœmeriana*, Göpp. sp., has been found there; *Calamites*, *Lepidodendron*, and *Knorria* are represented by important common species; and the two *Cyclostigmata*, which were formerly known only from the south of Ireland, reappear in the distant Bear Island. The complete agreement of such a relatively large number of species at such far distant localities, these species being besides of such frequent occurrence as to be true typical plants, leaves hardly any doubt that these floras must have belonged to the same epoch in time.

We have already seen that the Bear-Island flora is so nearly related to that of the Mountain Limestone and the Millstone-grit, that it must be classed with this and not with the Devonian. Therefore the flora of Kiltorkan must also belong to the Lower Carboniferous, and we must draw the line of separation between the Devonian and the Carboniferous below the Yellow Sandstone. It follows necessarily that the overlying Carboniferous shales must belong to the Lower Carboniferous, to which they are also more nearly allied by their marine remains than to the Devonian, as appears from the lists which Mr. Baily has published. The fish-remains from Kiltorkan present the only difficulty; for they agree more with those of the Old Red: but so long as no species are found which are decidedly identical with those of the Old Red of Scotland, these fish-remains can by no means be said to contradict the classification founded on the plants of the Yellow Sandstone of Kiltorkan, which confirms the published views of Sir R. T. Griffith, Prof. Haughton, and Mr. Symonds. These fish-remains only show that some genera, which were formerly regarded as belonging exclusively to the Old

Red, pass up into the Ursa stage of the Lower Carboniferous, represented, however, probably by other species than in the Old Red of Scotland. This happens also among the plants; and among the lower animals, not only many genera, but even numerous species pass up from the Devonian to the Mountain Limestone.

It is much to be regretted that the plants of the Marwood beds, and the Lower Carboniferous flora of England and Scotland generally, have been so imperfectly studied. They would certainly furnish very valuable materials for the decision of the much-vexed question where the limits are to be drawn between the Devonian and the Carboniferous in Devonshire.

On the Continent the flora of the Greywacke of the Vosges and of the southern Black Forest belongs to the Ursa stage. Of the twelve Vosges species which Prof. Schimper has described, nine occur in Bear Island, and four have been recognized in Ireland. *Calamites radiatus*, as in Bear Island and in Ireland, is very common, and forms, together with the *Lepidodendra*, *Stigmariæ*, and *Knorriæ*, the chief mass of the plants.

At Moresnet, in the neighbourhood of Aix, immediately under the Carboniferous Limestone, occurs a shale which rests upon the Eifel Limestone. This shale yielded *Palæopteris Rœmeriana*, and *Spirifer disjunctus*, Sow., and was entitled by Herr von Dechen the Verneuilii-shale, and placed at the uppermost limit of the Devonian. As, however, this *Spirifer* is also present in the Carboniferous shales of Ireland *, and therefore passes up from the Devonian into the Lower Carboniferous; and as we meet with the fern among the plants of Bear Island, we may probably class these Verneuilii-shales of Aix with the Ursa stage, and draw the dividing line with all the more reason below them, since they lie in unconformable stratification upon the Eifel Limestone.

Among the American fossil floras, that of St. John's, New Brunswick, belongs, according to my view, to the Ursa stage, and not to the Devonian, in which Dawson has placed it. Dawson's list ('Acadian Geology,' p. 534) contains forty-eight species; of these, thirty-seven have not been found elsewhere, nine are known in the Carboniferous, and three in the Devonian. The greater number, therefore, of those which are common to other localities belong to the Carboniferous; and it is remarkable that two of the Devonian species are only represented by a few leaf-fragments, and their determination may be still doubtful; while among the Lower Carboniferous species the Calamites are very abundant, and *Calamites radiatus* in some places fills whole strata, and is therefore quite as abundant as in Ireland, Germany, the Vosges, and in Bear Island. To this it may be added that, among the thirty-seven species of St. John's which as yet have not been found elsewhere, twelve agree so nearly with Carboniferous species as to be only di-

* [This *Spirifer disjunctus* was stated, in the Memoir of Salter and Baily relied upon by Prof. Heer, to have occurred in the Carboniferous strata of that country; but this has since been ascertained by Mr. Etheridge to have been a mistake.]

stinguished from them with great difficulty. For example, the most abundant fern of St. John's, *Pecopteris discrepans*, Daws., is hardly to be distinguished from *Pecopteris lonchitica*, a species which, both in America and in Europe, is abundant in the Carboniferous. In the same manner, *Cordaites Robbii*, Daws., is so near *C. borassifolius*, Sternb., sp., that, according to Dawson, it may often be mistaken for it; and *Asterophyllites parvulus*, Daws., is scarcely distinguishable from *A. delicatulus*, Sternb. (*Bechera*). Therefore the St.-John's flora has in fact the character of the Lower Carboniferous formation, and the only question is whether it does not approach more nearly to the Millstone-grit flora (with which it has five species in common) than to the Ursa stage. By this also it becomes doubtful whether the Catskill and Chemung groups do not belong rather to the Ursa stage than to the Upper Devonian.

In the arctic zone, besides the Bear-Island flora, we may regard the sandstones of Parry Island as belonging to the Ursa stage. In Melville Island also the sandstone lies under the Mountain Limestone; and the *Knorria acicularis*, which is found in it, serves as a point of contact with the Bear-Island flora, and shows that these plants of South Ireland and the Vosges reached as far as 76° N. lat.

If we add the plants of St. John, Kiltorkan, the Vosges, the south Black Forest, and the Verneuilii-shales to those of Bear Island, they yield to the Ursa stage a flora of seventy-seven known species, of which three are common to the Devonian and seven to the Middle Carboniferous. Of the former, however, one, and of the latter three species are doubtful, either in their determination or in their geological position. With the Upper Carboniferous (the Permian) the Ursa stage has not a single well-determined species in common; with the Mountain Limestone it has thirteen species, and with the Millstone-grit twelve; and with the two united, eighteen species. Among these are the most frequent species, such as form the true typical plants of the Lower Carboniferous, namely *Calamites radiatus*, *Lepidodendron Veltheimianum*, *Knorria imbricata*, *Cardiopteris frondosa*, and *C. polymorpha*. One of the most characteristic genera of the Ursa stage is *Cyclostigma*.

The flora of the Mountain Limestone and its equivalents appears to be less rich than that of the Ursa stage; the culmiferous beds, on the contrary, have yielded a large number of plants, as have also the Greywacke and *Posidonomya*-shales of the Harz, Silesia, and Moravia. If we compare the plants from these different places, we find in each a number of peculiar forms, which probably arises from the flora being, as yet, so little known to us; but we find also many species in common, which throughout are the most abundant and consequently the most important of the localities. These are chiefly the typical plants mentioned above. The Millstone-grit flora, when compared with that of tho Ursa stage, is remarkable for the increase in the number of species common to the Coal-measures; among these are species which have a wide range through the formation, such as *Neuropteris Loshii* and *Calamites Suckowii*. The newer Greywacke, also, which forms a passage to the Coal-measures, is distinguished from them by the

character of its flora. Among the ferns, the Pecopterids are wanting or very rare, as they are in all the Lower Carboniferous of Europe; the different forms of Cyclopterids and of the fine-leaved Sphenopterids, on the contrary, are very frequent and characterize the fern-flora of this period. In the Coal-measures, on the contrary, the genera *Neuropteris* and *Pecopteris* (including *Cyatheites* and *Alethopteris*) are developed in a variety of species, and appear everywhere in great abundance. *Lepidodendron* extends through the Lower and Middle Carboniferous, but on the whole is more abundant in the former, while the *Sigillariæ*, which play so important a part in the Coal-measures, are almost entirely wanting in the Lower Carboniferous. In fact, the whole flora of the Lower Carboniferous period must have had a different aspect from that of the Coal-measures, although it consisted of the same families and, in a great measure, of the same genera.

If we now glance once more over the Lower Carboniferous strata of Bear Island, we cannot fail to recognize a striking resemblance between them and the formations of the same age in Europe, especially in the south of Ireland. We may classify them in the following manner.

		Bear Island.	South Ireland.	Other localities.
Lower Carboniferous.	III. Millstone-grit stage.	Siliceous schists.	*Posidonomya*-shales and coal.	Culmiferous in Devon; Millstone-grits, Upper Greywacke and *Posidonomya*-shales in the Harz, Silesia, and Moravia.
	II. Mountain-Limestone stage.	*Productus*- and *Spirifer*-limestone.	Limestone formation with *Productus* and *Spirifer*.	Burdie House; Mountain Limestone and shales in Silesia; Hainichen, Ebersdorf, Artinsk, Petrowskaja, &c. in Russia; Parry Island, Spitzbergen.
	I. Ursa stage.	*Cyathophyllum*-limestone.	Carboniferous shale with *Cyathophyllum*.	Barnstaple.
		Sandstones and shales with plants.	Yellow Sandstone with plants.	Greywacke of the Vosges and the southern Black Forest; Marwood plant-bed (?), St. John's, in Canada; Sandstone of Melville Island, Catskill and Chemung?
Doubtful.		Russian-Island Limestone.	Upper Old Red.	
Devonian.		Red shales.	Old Red.	*Cypris*-shales of Saalfeld.

The Coal-measures are wanting in Bear Island, as in Spitzbergen;

but probably the siliceous schists, which are greatly developed in the upper divisions of the Mountain Limestone, represent the Culm or Millstone-grit. The position of the Russian-island limestone, which is widely spread, especially in Spitzbergen, is still doubtful; for determinable fossils are wanting in it; and the classification of the red shales in the Devonian is by no means certain. But although much still remains doubtful, we can see from clearly established facts that a remarkable and analogous development must have taken place in South Ireland and in Bear Island, high up in the north, and in the middle of Europe, in the formation of the rocks as well as in the plants and animals contained in them. Therefore the flora of the Ursa stage is of great significance in the history of the earth, as we shall see still more clearly if we cast a glance at the position which it holds in the order of the earth's development.

In the Silurian and Lower Devonian all the known plants and animals are marine; and it is not until the Middle and Upper Devonian that land-plants, indicating dry land, make their appearance. Yet at present there are only a few localities known to us, which may be designated as Devonian islands: the neighbourhood of Saalfeld, in Thuringia, which belongs to the Upper Devonian, is the only one which has yielded a fairly respectable number of plants; and even these have been found mostly in small fragments, which probably may have been divided into too many species. Towards the end of the Devonian period the dry land increases rapidly in the northern hemisphere; it must have been a time of rising of the bed of the sea. With this great formation of dry land begins a new epoch—the Carboniferous. The first division of this I have called the Ursa stage. With it came in the first rich land-flora, which can be traced in the northern hemisphere, both of the Old and New World, from 47° to 74° and 76° N. lat. Everywhere it exhibits the same character; everywhere appear *Calamites radiatus* (which probably clothed the marshy low country with its long column-like stems), the branching *Lepidodendron*, thickly clothed with leaves, and the curious *Knorria*. Even the *Cyclostigmata*, with which we have become acquainted in Ireland and Bear Island, were probably not wanting in dry-land formations lying between them, and formed part of the woods under whose shade the species of *Cardiopteris* and *Palæopteris* spread out their powerful fronds.

This flora already comprises such a remarkable number of species, many of which appear in such widely distant regions, that it seems to indicate a wide-spread continent which was situated in the temperate as well as in the arctic zone. The coal-lands of Russia reached perhaps as far as Bear Island, the plants of which would then represent the most northern offshoots of the Russian Lower-Carboniferous flora. That the Ursa stage must have belonged to a land of considerable extent is shown by the freshwater animals found in it, the great pond-mussels (*Anodonta*) and the insects (all Neuroptera). They could only have lived in a land large enough to give rise to lakes and rivers.

It is difficult to decide how long this state of things lasted. Then

the land began once more to sink; and brackish-water formations appear, followed later on by purely marine deposits. The Carboniferous shales and Mountain Limestone cover the former land with its imbedded plants. The great extension of the Mountain Limestone over many parts of Europe and America, and the small number of land formations which it covers, show us that this sinking of the land must have been a general phenomenon. The northern hemisphere must therefore most probably have had quite a different aspect at that time than during the Ursa stage. Then the same phenomenon recommenced as in the beginning of the Carboniferous period. In consequence of an extended rise to the west we obtain the continental formations of the Millstone-grit, which afterwards reached their greatest extent and development in the Coal-measures. During this long lapse of time the flora remained, on the whole, the same. Many of the leading species outlived all the mutations, and show that the whole of the land was never under water, even at the time of the formation of the Mountain Limestone; there always remained enough dry land to support these species of plants, which afterwards extended their range when the land, as in the Millstone-grit, began again to have a greater extension. There can be no doubt that a long period must have elapsed between the beginning of the Ursa stage and the Millstone-grit, and that during these many thousand years the conditions of life of the organic beings must have undergone reiterated changes. It is therefore a very remarkable fact that, in spite of this, so many species lasted through this time and did not undergo any perceptible alteration. The many forms of *Calamites radiatus* which appear in Bear Island are also found in the lowest member of the Lower Carboniferous and in the roofing-slates of Moravia; then the species disappears, nor does any similar form of this type (which Schimper has raised into a separate genus, *Bornia*) extend into the Coal-measures; the same thing takes place in the species of *Knorria* and *Cardiopteris*. These facts tell very decidedly against the continuous and imperceptible transmutation of plant-species. They are the more important, since the plants on Bear Island must clearly have lived under quite different conditions of light than those in the Vosges or in Ireland; for they must have endured a long winter-night. It is indeed remarkable that evergreen trees, such as the *Lepidodendra* must probably have been, and plants with such large leaves as *Cardiopteris frondosa* could have withstood such a long winter-night, even if we take into consideration that the Bear-Island flora consisted almost entirely of vascular Cryptogams, which can better dispense with light than the Phanerogams. Moreover the climate of Bear Island must have been as favourable to the growth of plants as that of Ireland or the Vosges, although that island lies $26\frac{1}{2}^{\circ}$ further north; for the corresponding species are as large and quite as luxuriantly developed, and have even produced more considerable coal-strata than those of lower latitudes in the same period. Warmth, therefore, must at that time have been more equally distributed over the earth, whilst already in the Miocene period a

great difference had begun to arise, which has increased immensely up to the present time. The climate must have been not only more equable, but warmer, as is shown by the coral-banks which were formed at that time in Spitzbergen, as well as by the enormous tree-like Cryptogams and the large-leaved ferns which Bear Island produced.

Appendix.

On Cyclostigma, Lepidodendron, *and* Knorria, *from* Kiltorkan. By Prof. Oswald Heer, F.M.G.S.

[Plate IV.]

(Read January, 10, 1872*.)

1. Cyclostigma kiltorkense, Haught. Ann. & Mag. Nat. Hist. ser. 3, vol. v. p. 444.

Stem clothed with a finely wrinkled bark. It is covered with numerous and very close striæ; and these very fine striæ pass away into spiral lines, and are in some places joined together. When the outer bark is wanting we have only these fine striæ. Such a specimen I received as *C. Griffithi*, Haught.

On the bark there stand in regular rows small round warts, which have a circular depression at the top. These are surrounded by a projecting rim, which is often striated with fine cross lines. Sometimes these warts look like small hollows having a smooth middle part. The warts are about 2 millims. in diameter. They are from 8 to 13 millims. apart, and form highly oblique transverse rows. Pl. IV. fig. 5*a* is a piece of a stem; 5*b* a portion with the wart, magnified.

Branches.—These agree entirely with the stems in the formation of the bark and in the warts. The bark is also wrinkled and covered with very fine and close striæ. The warts are from 6 to 8 millims. apart, and in a branch 13 millims. broad there are two or three in the oblique row (fig. 4, and, a portion enlarged, fig. 4*b*).

As remains of fruit-cones, which Schimper has described as *Lepidostrobus Bailyanus* (Traité de Paléontologie Vegét. ii. p. 71), are often found near the stems of this species, they probably belong to it. In support of this view is the fact that in Bear Island also the cone-scales have been found near the fragments of the stem (see my 'Fossil Flora of Bear Island,' pl. xi. fig. 3*c*). These cones differ from those of *Lepidodendron* in their firm and almost woody base, which is marked with a longitudinal furrow, and in the remarkably long bristle-like front portion.

2. Cyclostigma minutum, Haught. *ibid.* p. 444.

Lepidodendron minutum, Haught. Journ. Geol. Soc. Dublin, vol. i. p. 235.

Lepidodendron, sp., Lyell, Elements of Geol. ed. 6, p. 521, fig. 585.

* See p. 85 of the present volume.