

NO. VII.—THE CARBONIFEROUS LIMESTONES OF SCOTLAND, WITH
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THE productive Coal-measures of Scotland are practically confined to a belt about thirty miles wide, stretching across the Central Lowlands from the Firth of Clyde in a north-easterly direction to the Firth of Forth. On the north-western boundary of this belt they are occasionally found lying more or less conformably on older strata, but are generally cut off by a series of upthrow faults, which run nearly parallel with the Lennox and Ochil Hills. These hills are largely made up of great sheets of andesite of Calciferous Sandstone age, interspersed, especially in the western district, with numerous volcanic necks of the same age—necks which now form prominent features of the landscape, such as Dumbarton Rock, Dumbuck, Dumgoyn, and Dungoil.

The south-western boundary is formed by a remarkable line of faulting which has thrown up the Silurian rocks of Kirkcudbrightshire, and those of the Leadhills and of the Moorfoot and Lammermuir ranges. At many points this fault exhibits a vertical displacement of at least 10,000 to 12,000 feet. Although the coal-fields within those boundaries are now cut up by denudation into a number of separate basins, there can be little doubt that in Carboniferous times they formed one continuous series, probably extending for some distance northward, and overlapping the Old Red Sandstone of the marginal Highlands.

The Carboniferous series as developed in this belt is sub-divided as follows :—

1. Coal-measures :—
 - Upper Red Sandstones.
 - Upper series of Coal-seams.
 - Lower series of Coal-seams.
2. Millstone Grit or “Moorstone” rock.
3. Carboniferous Limestones :—
 - Upper series of Limestones.
 - Coal-measures.
 - Lower series of Limestones.

4. Calciferous Sandstones :—

Shales, Cement-stones, and Sandstones, including the Oil-shale series.

Sandstones, Conglomerates, and Cornstones, merging into Upper Old Red Sandstone.

During the early Carboniferous period the Lowlands of Scotland, together with the greater part of Ireland and of England, formed an area of long continued depression. The English and Irish area was under clear water most of the time, and great beds of limestone were accumulated on the slowly subsiding bottom. This sea became shallower towards the north, and in the Scottish area various successive land-surfaces were formed, which from time to time sank beneath the sea and were covered over with deposits of sand and mud. The beds of limestone formed in Scotland at this time were comparatively thin, from 2 feet to 10 feet being the general limit, although in some exceptional cases a thickness of as much as 100 feet has been attained. Tracing the same beds southward into England and Ireland we find a gradual thinning out of the intervening sandstones and shales, together with a thickening of the limestone seams. In the north of England and in Ireland these seams have become solid beds thousands of feet thick, which are prominently exhibited in the Mountain Limestones of Northumberland. Under these conditions coal-seams were being formed in Scotland at the same time as the beds of limestone were being deposited in England and Ireland. Had the fates seen fit to make Ireland at this period an area of shallow water instead of one of deep water what a difference would it have made in the prosperity and development of that country! Scotland was then the scene of great volcanic activity, and great bodies of lava and of ashes flowed over the country, filling up the seas and estuaries, and forming the interbedded igneous rocks characteristic of the Lower Carboniferous formation.

A careful study of the geological conditions under which the Carboniferous Limestone Measures were deposited is of very great importance in connection with the future working of our coal-fields. According to my calculations more than one-fourth of the coal still remaining to work in Scotland is in the seams to be found in that portion of this series which is concealed under the Millstone Grit and the Coal-measures. In estimating the probabilities of finding workable coal in those concealed

areas a consideration of the geological history is necessary in order to arrive at any satisfactory opinion regarding the condition in which the coal-seams are likely to be found.

A general study of the Carboniferous Limestone coals as found in Scotland shows that the coal-field may be divided into three distinct districts, in each of which the deposition of the seams has been affected by different conditions. There is first a strip from 6 to 10 miles wide running across the country in a north-easterly direction, from about Girvan in Ayrshire to Elie in Fifeshire. On the south-east this district is bounded by the great series of faults throwing in the Southern Silurian uplands. On the north-west it is bounded by a line of faulting which can be traced first along the north-west of the Girvan valley and at the north-west of Patna. The fault disappears below the Coal-measures of Ayrshire, but re-appears again to the north-west of Muirkirk. It there forms the boundary of the Muirkirk and Douglas coal-fields. At Muirkirk the fault throws the Silurians against the Lower Limestones, and to the South of Lesmahagow it throws the Old Red Sandstones against the Upper Limestones. To the east of Lanark the line of faulting becomes obscured, but somewhere in the vicinity of Carnwath it appears to form a junction with another fault running in nearly the same direction from the southern boundary of the Douglas coal-field. The combined faults then continue along the base of the Pentland Hills and form the north-west boundary of the Edinburghshire coal-field. They are seen at Portobello on the shores of the Forth, and again on the Fifeshire coast, where, after passing through Kilconquhar, they form the northern boundary of the St. Monans and Pittenweem coal-basins.

In the district between those boundaries the coal-seams of the Carboniferous Limestone series have attained their greatest development.

The number of workable seams, and the total aggregate thickness at various points, are as follows:—

	Number of seams.	Thickness in feet.
Girvan, - - - - -	6	31
Patna, - - - - -	2	17
Mansfield (New Cumnock), - -	5	37
Muirkirk, . - - - -	8	47

	Number of seams.	Thickness in feet.
Glenbuck, - - - - -	7	35
Coalburn, - - - - -	8	37
Ponfeigh (Douglas), - - - - -	14	57
Edinburghshire, - - - - -	34	95
Pittenweem, - - - - -	9	40

This shows an average thickness throughout the district of 45 feet of coal.

The remainder of the Scottish area may be divided into two districts by a line running in a north-westerly direction from Carluke to about Kirkintilloch.

In the south-western district, embracing North Ayrshire, Renfrewshire, and portions of Lanarkshire and Dumbartonshire, the coal-seams are very poorly developed. Large areas, such as those at East Kilbride and at Auchenheth, contain only 2 feet or 3 feet of workable coal. In the Paisley and Hurler area a maximum thickness of 16 feet is found; to the west of Glasgow, at Garscube, there is about 12 feet of coal. At Dalry the coal is only about 6 feet thick, and further south, by Stewarton and Loudoun, the coal-seams are either absent or very thin and unworkable. Even allowing for the thicker seams at Garscube and Hurler, the average aggregate thickness throughout does not exceed 5 feet or 6 feet.

In the north-eastern district, including the eastern portion of Lanarkshire, with Stirlingshire and Fifeshire, the coal-seams are generally better developed than in the south-western district.

The number of seams, and the total aggregate thickness at various points in this district, are as follows:—

	Number of seams.	Thickness in feet.
Kirkintilloch, - - - - -	5	10
Denny, - - - - -	2	6
Bannockburn, - - - - -	5	13
Bo'ness, - - - - -	8	30
Fifeshire, - - - - -	12	46

This shows an average thickness of only 21 feet, as compared with 45 feet in the first district. It is also to be noted that there is a progressive thickening of the coals going from west to east.

The coal areas outside of those three districts are of comparatively little importance.

Scattered throughout the Silurian area to the south-west of the great boundary fault there are numerous outliers of Carboniferous Limestone, together with some areas containing Coal-measures and Permian Sandstones. There is no doubt that the Carboniferous Limestone series once extended over the greater part of the south-west of Scotland, but the conditions under which it was there deposited were not favourable to the formation of coal-seams.

On the north-eastern margin of the coal-field the conditions are somewhat different from those prevailing on the south-west. Although, as already mentioned, the actual boundary is mostly formed by a series of faults, still the general succession of the beds can be traced downward as we proceed to the north-west from the coal-field.

The lower division of the Carboniferous Limestone series is found in contact with the shales, cement-stones and igneous rocks of the Upper Calciferous, and this series again is lying more or less conformably on the Lower Calciferous and Upper Old Red Sandstones. How far the coals of the Carboniferous series originally extended over the older measures it is impossible to say. It is just possible that they may have extended to the edge of the metamorphic schists of the Highlands. If this is a correct assumption, then the area which has been denuded of thousands of feet of coal-bearing strata is greater than the whole area of the coal-fields which are left. It is more than probable that the most of this area was beyond the limits of the Carboniferous sea, but however that may be, if the coals were once there they are gone now, and there is not very much to be gained by speculations on the subject.

A very important factor in causing the difference between the coal-beds of the western and eastern areas of the Carboniferous Limestone series was undoubtedly the great volcanic activity which had its main centre in the district between Dumbarton and Campsie during Calciferous Sandstone times.

The great sheets of lava which were poured forth at this time, and which now form such prominent features of the landscape in Renfrewshire and Dumbartonshire, must have had a profound influence in altering the conditions of the early Carboniferous sea or lake. The volcanic centre would also be subject to many local depressions and elevations even after the active eruptions had ceased. An evidence of this local irregularity is found in the

district of Possil, Kirkintilloch, and Cumbernauld, where it is almost impossible to establish an exact correlation between the various seams. Again, at Kilsyth we find four seams of ironstone, but in the Denny coal-field, three miles distant, there are only two seams of ironstone, and these cannot be correlated with any of the Kilsyth seams. Most of the Kilsyth coal-seams have disappeared altogether at Denny, but some of them come in again further east at Bannockburn. The beds of Kilsyth and Bannockburn appear to overlap and dovetail into one another in the neighbourhood of Denny.

A study of the Calciferous Sandstone series between Lesmahagow and Carnwath shows that there also the bottom on which both this series and the Carboniferous Limestone were deposited was subject to local movements. Ample evidence of this is found in the frequent overlaps. For instance, at Auchenheath the Calciferous Sandstones are either absent or almost entirely covered by the Carboniferous Limestones which overlap them, and are found resting directly on the Old Red Sandstone. To the east of Lanark the upper group of the Calciferous Sandstone overlaps the lower group and rests on the Old Red Sandstones. Many similar instances might also be given.

Going further east beyond the probable area of the volcanic disturbance much greater regularity is found. There is little difficulty in tracing the correspondence between the coal-seams of East Stirlingshire, Linlithgowshire, and Fifeshire, and, as already shown, the thickness of the coal is much greater.

The importance of these observations with relation to the study of the concealed areas of Carboniferous Limestone coal is obvious. We have seen how the coal-field may be divided into three separate districts. In the first, the total thickness of coal varies from 15 to 95 feet, with an average thickness of 45 feet. Wherever these coals pass below the newer formations in that district they may therefore be followed with some reasonable hope of finding workable seams of considerable thickness.

In the second district, that forming the western division of the coal-field, the geological conditions seem to point to considerable irregularity, and the coal-seams are generally few and thin. This indicates that there is much more uncertainty as to the conditions which may exist under the newer measures, and that although

attempts will undoubtedly be made to exploit the coal-seams, those attempts will be somewhat speculative. It is a question of great geological and economic interest as to how far the unfavourable conditions of the west have extended into the Carboniferous Limestone series lying below the Upper Coal-measures of the Lanarkshire basin.

The somewhat arbitrary division line running from Carluke to Kirkintilloch would pass through near Cambusnethan, Bellshill, and Coatbridge, approximately parallel with the course of the River Clyde. This would indicate that the whole of the Clydesdale basin is to be included in the non-productive area, but that the Carboniferous Limestone coals underlying the Airdrie, Slamannan, and Shotts district belong to the third or eastern division. Throughout the whole of this third district, including also Alloa and Fifeshire, the seams may not in the aggregate reach so great a thickness as in the first district, but they are almost sure to be found in a workable condition, and sufficiently regular to justify their exploitation. If the local circumstances are properly taken account of, sinkings to the lower seams may therefore be prosecuted with every hope of success. Before passing from this subject it is worthy of observation that the lower section of the coals of the Coal-measures, *i.e.*, the Drumgray coals and the underlying seams, are very poorly developed throughout the second district, both in Ayrshire and Lanarkshire; but they are found of considerable thickness in the first and third districts.

It is an interesting speculation as to why there should be so great a difference in the character of the coal-seams on the two sides of the line of faulting which form the north-west boundary of the first district. This fault, which, at Girvan on the one hand and Muirkirk on the other, is of sufficient size to throw the Silurians in direct contact with the Carboniferous Rocks, appears to pass through the central basin of Ayrshire without affecting the Upper Coal-measures. If this observation is correct it would apparently indicate that the fault was in existence during the deposition of the Carboniferous Limestone series, so that while a coal-seam may have been in course of formation on the south-east side of the fault on the north-west, the conditions were unfavourable for the formation of coal-seams. While this theory may not meet all the facts of the case it is difficult to see how else

the deposition of coal-seams could have been affected by the presence of a fault.

The Officers of the Geological Survey seem to have adopted the same line of reasoning regarding the fault which forms the division line between the coal-fields and the Southern Silurian uplands, as is shown by the following quotation (Explanation to sheet xv., p. 32):—

“We find that in ascending the Nith valley the Carboniferous Limestone series, which is so well developed in the Thornhill basin, thins out towards the north, until along the south-eastern borders of the Sanquhar coal-fields it disappears altogether, and the overlying Coal-measures come to rest directly on the Lower Silurian rocks. No Carboniferous Limestone beds re-appear until we reach the great fault, immediately on the north side of which they come in in force. It is difficult to understand how this should have happened, unless on the supposition that, at the time when the Carboniferous Limestone series was in the act of deposition, the line of fault was represented at the surface by a steep bank shelving to the north, which formed the limit of the limestone series on that side, but which, as the whole region continued to sink, was gradually buried under the continuous sheet of Coal-measures which stretched through the Sanquhar valley northward into Ayrshire.”