

of the plant is known in the North Wales Exposure." I am afraid that I cannot agree with this suggestion; on the contrary I think that any conclusion, based on the occurrence of isolated fragments of plant-remains in the Lower Carboniferous rocks might be most misleading, and might result in serious errors in correlation.

Thus in the present instance *A. Vanuxemi* occurs at Meathop and at two horizons in the Shap district in beds which, as I have shown, belong to the C 1 horizon of the Bristol area, while in North Wales abundant remains of this species occur according to Messrs. Hind and Stobbs in S 2, an horizon very much higher in the series; lastly, this species was originally described from the Upper Devonian of New York. After all, this is only in keeping with what we have been led to expect from the study of the relative duration of terrigenous and marine floras and faunas elsewhere, for instance the Laramie and overlying formations in America.

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#### NOTICES OF MEMOIRS.

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PROBLEMS OF THE SOUTH-WESTERN HIGHLANDS OF SCOTLAND. Abstract of the Presidential Address to the Glasgow Geological Society by Professor J. W. GREGORY, D.Sc., F.R.S., F.G.S., January, 1910.

THE Southern Highlands of Scotland consist of a complex series of gneisses, schists, crystalline limestones and quartzites, trending across Scotland approximately from south-west to north-east. These metamorphic rocks are bounded abruptly to the south by the Highland Boundary Fault, which brings them against Upper Palæozoic rocks. Their northern boundary is less regular and is generally the junction with the Moine Gneiss, the rock which occupies so much of the Northern and Central Highlands. The schists and the associated rocks between the Moine Gneiss and the Boundary Fault may be conveniently grouped together, under the name proposed by Sir Archibald Geikie, as the Dalradian System.

The most important difficulty in the interpretation of these rocks is the uncertainty as to which is the upper and which the lower end of the succession. According to Nicol, the southern members are the youngest, and there is a descending series to the north. This view is contradicted by many obvious facts in the field geology; the view is therefore widely held that Nicol's order must be reversed and that the beds on the southern margin are the oldest. The serious difficulty in the second view is that the southern rocks are much less altered than the northern, and this theory therefore involves some measure of selective metamorphism. Several ingenious interpretations have been advanced to overcome this difficulty. The author of the address, however, held that both views as to the order of the succession are correct in parts.

The Dalradian System is intermediate in age between the Torridon Sandstone above and the Caledonian and Lewisian Gneisses below. That it is pre-Torridonian seems to follow from the evidence in Islay and Colonsay; that it is post-Caledonian is shown by its superposition upon the Moine Gneiss in several localities, as north of Ben Lui and in Glen Tilt; in the latter, the evidence collected by Mr. Barrow appears

conclusive that the Dalradians are resting on an eroded surface of the Moine Gneiss. The Dalradian System may be divided into five series as follows:—

- Schiehallion Quartzite Series (including the Boulder Bed).
- Blair Atholl Series (Limestones, black schists and quartzites).
- Ben Lawers Series (Phyllites with some limestones and quartzites).
- Loch Tay Series (Limestones, garnetiferous mica schists and some quartzites).
- Loch Lomond Series (Gneiss, albite schist, etc.).

The most important rock in the lowest series is the Loch Lomond Gneiss, which is well developed in the peninsula of Cowal, on both sides of the northern part of Loch Lomond, and around Loch Katrine. This series consists mainly of coarse, highly inclined sedimentary gneiss and albite schists. This series extends eastward to Loch Voil, where it disappears beneath the rocks of the Loch Tay Series to the north and the overlap of the Ben Ledi and Ben Vane Grits and slates to the south. North of the Loch Lomond Gneiss occurs a series of garnetiferous mica schists associated with limestones and some quartzites. This series can be traced all across the country; it includes the Glen Daruel limestone south of Loch Fyne, and the limestones of Crianlarich, Glen Lyon, and Loch Tay. That they overlie the Loch Lomond Series is well shown north of Loch Voil, and that they rest unconformably on the Moine Gneiss is proved by the evidence north of Ben Lui. The essential member of the Ben Lawers Series is the phyllite of Ardrishaig, the Forest of Mamlorn and Ben Lawers. This phyllite is often intensely crumpled and seamed with innumerable thin quartz veins. It is associated with thin bands of quartzite and quartz-schist. Its superposition on the Loch Tay series appears to be clearly demonstrated from the relations of the two series at Ben Lawers, and still more clearly from the outliers of the Ben Lawers phyllite resting upon garnetiferous mica schists, as at Ben nam Imirean.

The Blair Atholl Series consists of the Blair Atholl Limestones, the black or graphitic schists and some interbedded quartzites, which are often of considerable thickness and form a large part of the Highland Quartzite. To separate them from the succeeding quartzite, it is proposed to call them the Cammock Hill Quartzite, from a locality where they are well exposed near Pitlochry.

The uppermost member of the Dalradian System is the Schiehallion Quartzite with the boulder bed at its base. It rests unconformably upon the Blair Atholl Series. Parts of the quartzite are quite unfoliated and remain as granular feldspathic quartzites, in which the feldspar grains have not been sheared or crushed.

According to this arrangement, the five series of the main Dalradian sequence occur in succession from south to north, and the oldest members are the most altered and highly crystalline.

Along the southern margin of the Dalradian schists there is a series of slates and grits, which are not foliated, and strikingly resemble ordinary Palæozoic slates and quartzites. The slates are worked at Luss and Aberfoil. The field relations of these Aberfoil Slates and

Ben Ledi Grits can be most easily explained by their unconformable deposition on the southern edge of the Dalradian rocks.

There has been assumed a transition from the Ben Ledi Grits to the intensely altered gneissic grits belonging to the Loch Lomond series, but the evidence for this passage is not convincing. The southernmost part of these comparatively unaltered rocks include cherts and shales which are marked on the Survey Maps as 'Silurian(?)'.<sup>1</sup> The exact age of these beds is doubtful. They may be Upper Dalradian and correspond to the great unconformity at the base of the Schiehallion Quartzites, or, as is more probable, they may be post-Dalradian in age.

The relations of the Dalradian Schists is suggested as follows:—

Eozoic.	{	Algonkian . . .	Torridon Sandstone.
		Dalradian.	
		Caledonian . . .	Moine Gneiss and associated schists.
		Lewisian . . .	Fundamental Gneiss.

The classification suggested in the address adopts Nicol's succession in part, as it accepts the Aberfoil and Ben Ledi Series as younger than the Loch Lomond Gneiss against which they rest; and it is consistent with the less altered condition of the southern rocks and the steady diminution in the metamorphism of the rest of the series going northward, as for example, from the Loch Lomond Gneiss to the Loch Awe Grits, and from the garnetiferous mica schists of the Loch Tay Series to the black schists and unfoliated quartzites near Blair Atholl.

The evidence in some points of this succession is still incomplete, especially as regards some of the rocks nearest Glasgow. The special problems on which further research would be most useful were therefore mentioned, in the hope that the members of the Glasgow Geological Society would investigate them.

The subject is of interest from its bearing upon the early geological history and geography of North-Western Europe. The structure of Western Europe has been dominated by the formation of three great mountain systems, each due to pressure usually from the south, and each having its younger rocks exposed mainly on the northern flanks of the chain. The youngest is the Alpine System, formed mainly in Upper Cainozoic times, and including the Pyrenees, Alps, Carpathians, etc. A somewhat similar mountain system, of which fragments remain in Southern Ireland, Devonshire, Brittany and Germany had been formed in Upper Palæozoic times; from its analogy with the Altai Mountains of Asia, Suess has called its mountains the European Altaids. Still earlier, in later Archean times, there was formed the first of these European mountain systems, of which fragments occur in Northern Ireland, the Grampians, and Scandinavia. There are many interesting analogies between these old Grampians and the later Altaids and Alps. The old mountain system to which the Grampians belonged probably extended far westward into the North Atlantic and to its influence may be attributed the desert climate of Scotland during the deposition of the Torridon Sandstone.

<sup>1</sup> By kind permission of Dr. Home it was announced during the address that Dr. Hinde has recently identified Radiolaria in the cherts of this series.