EXPLANATION OF PLATE XII.

- FIG. 1. *Corynoides gracilis*. 1a. A specimen natural size. 1b. The distal end magnified 5 diameters. 1c. The proximal end mag. 5 dia.
 FIG. 2. *Dendrograptus ramulus*. 2a. A specimen nat. size. 2b. Part of a branch mag. 5 dia. 2c. Another specimen nat. size.
 FIG. 3. *Graptolithus attenuatus*. 3a. A specimen nat. size. 3b. A portion mag. 5 dia. 3c. Three hydrothecæ mag. 10 dia.
 FIG. 4. *Graptolithus acutus*. 4a. A group nat. size. 4b. Part of a specimen mag. 5 dia.
 FIG. 5. *Diplograptus Etheridgii*. 5a. A specimen nat. size. 5b. and 5c. The distal and proximal ends mag. 5 dia. 5d. Another specimen nat. size. 5e. Part of a specimen collected by the Geol. Surv. of Scotland, enlarged.
 FIG. 6. *Diplograptus penna*. 6a. A specimen nat. size. 6b. and 6c. Portions mag. 5 dia.
 FIG. 7. *Diplograptus pinguis*. 7a. A specimen nat. size.
 FIG. 8. *Diplograptus fimbriatus*. 8a. A specimen nat. size. 8b. and 8c. The distal and proximal ends mag. 5 dia. 8d. Another specimen nat. size.
 FIG. 9. *Diplograptus Hincksii*. 9a. A specimen nat. size. 9b. A portion mag. 5 dia. 9c. An imperfect specimen nat. size. 9d. A young specimen nat. size.
 FIG. 10. *Dicranograptus rectus*. 10a. A specimen nat. size. 10b. Part of a branch mag. 5 dia. 10c. The proximal end mag. 5 dia.

IV.—ON THE RELATIONS OF THE MIDDLE AND UPPER SILURIAN (CLINTON, NIAGARA, AND HELDERBERG) ROCKS OF THE UNITED STATES.

By Professor JAMES HALL, of Albany, U.S.A.

Foreign Member of the Geological Society of London.

IN the general classification of the Palæozoic Rocks of North America, while we have carefully compared and attempted to correlate them with the greater divisions of the Silurian, Devonian, and Carboniferous systems of Great Britain and the continent of Europe, we have still retained the local names of formations, which to a great extent were given in the Geological Survey of New York. These names, like English local names, indicate a locality or region where the strata are well shown, and the characteristic features of the formation better developed than in other places. Several of these local formations have thus been grouped together as representing certain stages in the systems of formations as recognized above.

In this grouping together we have the Medina Sandstone, the Clinton Group, and the Niagara Group as representatives of the Middle Silurian, while we arrange the Water-lime and Lower Helderberg Groups in the Upper Silurian strictly. These two divisions are clearly separated from each other by the *Onondaga Salt Group* as shown in the subjoined diagram (1) thus :

Upper Silurian	{ Lower Helderberg Water-lime. Onondaga Salt Group or Salina formation.
Middle Silurian	{ Niagara Group. Clinton Group. Medina Sandstone.
Lower Silurian	{ Hudson River Group. Trenton Black River } Limestones. Birdseye }

Below these come the well-marked Lower Silurians, the equivalents of the Caradoc and Llandeilo formations.

The geographical distribution of the Middle and Upper Silurian in the United States and Canada is very clearly determined and extremely different in the two divisions. Each one of these divisions has been the subject of long-continued study and careful investigation. Each one of them has furnished materials for a volume of the Palæontology of the State of New York, and it may be said with confidence that there is scarcely a single species common to the two formations. Representative species do occur in the two divisions; and wherever the physical conditions have been similar during the two epochs, the species occurring in those beds bear a close similarity to each other. But the entire assemblage of fossils is so different that from these alone (leaving out of consideration the relative position of the formations), no good Palæontologist would recognize them as the fauna of a single era in geological time.

In a paper read before the American Association for the Advancement of Science in 1870, Mr. A. H. Worthen, the State Geologist of Illinois, proposes to dispense with the subdivisions Niagara and Lower Helderberg Groups, and gives his reasons for regarding them as one and the same, and that the nomenclature of the science is thus unnecessarily burdened with two designations for the same formation. He bases his conclusions upon observations made in the Schoharie valley, where, he asserts, the Lower Helderberg Group rests directly upon the Sandstones of Lower Silurian age, the Hudson River Group.

Having, during the last thirty years, been familiar with the Schoharie valley and its tributary valleys, and having made sections of the strata at more than twenty different points, I am compelled to say that I have nowhere witnessed the phenomenon asserted by Mr. Worthen. Everywhere, and unmistakably too, the lowest member of the Lower Helderberg Group is separated from the sandstone of Lower Silurian age by *two* or *three* distinct and well-marked members of the series. In order to show the true relation of the rocks of the Schoharie valley, I present the following section, which may be verified in numerous localities in the Schoharie and Kobel's Kill valleys.

	{	Oriskany Sandstone.
Lower Helderberg Group		Upper Pentamerus Limestone.
		Shaly Limestone.
		Lower Pentamerus Limestone.
		Tentaculite Limestone.
		Water-lime Formation.
		Coralline Limestone.
		Green Shales with Iron Pyrites.
LOWER SILURIAN		Sandstones of the Hudson River Group.

Here it will be distinctly observed that the lower member of the Lower Helderberg Group is separated from the sandstones of the Lower Silurian system by an impure Magnesian Limestone, which, though usually destitute of fossils, contains in some localities great abundance of that remarkable Crustacean the *Eurypterus*, and more rarely its allied form *Pterygotus*. The Coralline Limestone, as its name indicates, contains numerous corals, among which are *Halysites*

catenulatus, *Favosites Niagarensis*, etc., and Brachiopoda of several genera. Two or three species of Trilobites also occur in the same rock.

The green shale with iron pyrites has a thickness of thirty or forty feet, and, so far as known, is destitute of fossils. The proportion and amount of iron pyrites is very great, and near the base of this bed there is often a distinct layer of iron pyrites, which has, to some extent, been mined for economic uses. This feature is of interest mainly in connexion with some suggestions I propose to make regarding the characteristics of this part of the formation in its western extension.

Without occupying the time of the Association with details of observations and sections at numerous points, I propose to present a corresponding section at a point about sixty or seventy miles west of the Schoharie valley, where the preceding section may be verified.

We have still the same general features of country, and the greater geological divisions are well marked.

Lower Helderberg Group	<div style="display: inline-block; vertical-align: middle;"> <div style="display: inline-block; vertical-align: middle; font-size: 2em;">{</div> <div style="display: inline-block; vertical-align: middle;"> Oriskany Sandstone. Shaly and Lower Pentamerus Limestone. Tentaculite Limestone. Water-lime Formation. Red and Grey Marls of the Onondaga Salt Group. </div> </div>
Niagara Group	Coralline Limestone.
Clinton Group	Green Shales and Beds of Red Hematite.
Medina Sandstone	Red and Grey Sandstone.

At a point one hundred miles further west we have the following section :

Upper Silurian	<div style="display: inline-block; vertical-align: middle;"> <div style="display: inline-block; vertical-align: middle; font-size: 2em;">{</div> <div style="display: inline-block; vertical-align: middle;"> Oriskany Sandstone. Water-lime Group. Onondaga Salt Group. </div> </div>
Middle Silurian	<div style="display: inline-block; vertical-align: middle;"> <div style="display: inline-block; vertical-align: middle; font-size: 2em;">{</div> <div style="display: inline-block; vertical-align: middle;"> Niagara Group. Clinton Group. Medina Sandstone. </div> </div>
Lower Silurian	Hudson River Group.

At this point every vestige of the Lower Helderberg Group has disappeared, and the Water-lime and Onondaga Salt Group have become developed to a thickness of more than one thousand feet. The Niagara Group in its divisions of Shale and Limestone, and with its characteristic fossils, is a well-marked feature. The Clinton Group, with its abundant iron ores, has reached its maximum thickness to the east of this point, and in the neighbourhood of the second section.

Still following these formations to the westward, we obtain everywhere for several hundred miles essentially the same order of succession, with the absence of the Oriskany Sandstone. This is shown upon the geological map, and the formation may be traced through Western New York, Ohio, Canada, the Islands of Lake Huron, Wisconsin, Illinois, Iowa, and Missouri. Nowhere in this direction till we reach the Mississippi in the southern part of Missouri and Illinois, do we find the least evidence of the limestones or of the fossils of the Lower Helderberg Group.

Now, returning again to our point of departure in the Schoharie

valley, we can trace the Lower Helderberg group of beds to the east and south everywhere underlaid by the Water-lime formation. The blue line marked upon the map indicates the geographical extension of the formation, which is everywhere marked by its characteristic fossils, and everywhere resting on the Water-lime beds, through all its meanderings caused by the plications of the strata through south-eastern New York, Pennsylvania, and Maryland.

The Coralline Limestone can be traced southward for fifty miles along the Hudson River valley, but is lost to observation near the southern limits of the State, and I do not know that the same or equivalent formation has been recognized in Pennsylvania or Maryland. In some parts of Maryland at least the Water-lime rests on shales of the Clinton Group.

Returning again to the point of first starting, we are not able to take up a continuous line of outcrop; but the Lower Helderberg group has been determined by Sir William Logan in the neighbourhood of Montreal. It is largely developed at Gaspé and other places in Canada, and apparently constitutes the main feature in the Limestone formation of this age, so clearly drawn out on the great map of Sir W. E. Logan.

Not being personally familiar with this area of country, I am of course unable to enter into the details regarding the individual members of the series; but I believe that throughout this great extent the Niagara group, as known in New York and Canada West, has scarcely any existence.

Whatever Upper Silurian fossils there may be which are not strictly referable to the Lower Helderberg Group are from beds distinctly separable from it, and lying at a lower horizon. I say this of my own personal knowledge, having critically examined the collections of the Geological Survey of Canada made near Montreal, and at Gaspé and elsewhere.

So far, therefore, we find both the physical fact of super-position and the evidence of fossils coinciding to prove the Lower Helderberg group a distinct and overlying formation to the Niagara group, and separated from it by the Onondaga Salt group and Water-lime formation, wherever these latter formations exist.

It is claimed, however, that in southern Illinois, Missouri, and in Tennessee the Niagara and Lower Helderberg groups are physically and zoologically inseparable. Having seen these formations in Missouri, I am prepared to assert and to prove that the Lower Helderberg and Niagara formations are both physically and by their fossil contents distinguishable the one from the other.

With the localities in Tennessee I am not so familiar; but from the examination of large collection of fossils collected in that region, and from the sections given by Prof. Safford, I believe the formations to be quite distinct. It happens, however, from the thinning out of the Salt Group, and Water-lime formations, that the disputed groups of strata do come in contact; and the facts which would prove a lapse of time between the ending of the one and the beginning of the other have not yet been observed, or if observed, have not received that consideration to which they are entitled.

While therefore the actual physical and zoological distinction can be traced in a westerly direction for more than twelve hundred miles, and in a north-easterly direction for six or eight hundred miles, and for an equal distance in a southerly and south-westerly direction, I can scarcely suppose that the few facts observed within limited areas, and not yet submitted to the test of comparison, will change the views of geologists upon the distinctive character of these formations.

In bringing this brief *résumé* before the Geological Section of the British Association, I have indulged in the hope that the facts might be of some use in a comparison with British Middle and Upper Silurian formations, which can be so clearly recognized in Canada and the United States.

V.—NOTE ON THE MIDFORD SANDS.

By H. B. WOODWARD, F.G.S.,
Of the Geological Survey of England and Wales.

THE term "Midford Sands" suggested by Professor Phillips¹ for the Sands which occur between the Inferior Oolite and the Upper Lias Clay, gives us a very happy name, and one that has been long wanted for these beds; for hitherto although they have been called by many names, not one has been generally adopted. They were first discovered and studied, so Professor Phillips tells us, by William Smith, in the picturesque cliff which overhung his house at Tucking Mill, near Midford—a little hamlet about three miles south of Bath, and situated in one of those delightful valleys formed by the river Avon and its tributaries. The deposit was called by him "Sand of the Inferior Oolite," and so it was known until Dr. Wright in 1856² called the classification into question on palæontological grounds, and maintained that the fossil evidence indicated that the Sands belonged rather to the Lias than to the Inferior Oolite. He gave them the name of "Upper Lias Sands," by which they have since been usually designated. The classification of Dr. Wright has, however, been objected to, and it may therefore be interesting briefly to review some of the opinions in regard to this question, stating also that most recently given by Professor Phillips.

Dr. Wright pointed out that wherever the Sands are well exposed (and he gave sections in Gloucestershire and Dorsetshire), they are overlain by a brown iron-shot marly limestone containing "an immense quantity of individuals of several species of Ammonites, Nautili and Belemnites, with a few shells of other Mollusca," and he maintained that this "Cephalopoda Bed" in its organic remains belonged rather to the Lias than to the Oolite formation. The Sands below he found to pass insensibly into the clays of the Upper Lias.

Mr. Moore,³ however, has disputed these conclusions. He remarks

¹ *Geology of Oxford and the Valley of the Thames*, p. 109.

² *Quart. Journ. Geol. Soc.*, vol. xii., p. 292.

³ On the Middle and Upper Lias of the South-west of England. *Proc. Somerset Arch. and Nat. Hist. Soc.*, vol. xiii., 1865-6.