

Mr. Kingsmill as the quiet water sediments of a great gulf with the Miocene conglomerates and sandstones of Nanking and elsewhere for its marginal equivalents, appeared to require a different explanation. All loess need not be of river origin; in oscillations of land marine deposits must be carried up to great heights; and, referring to Mr. H. M. Jenkins's determination of the marine origin of the Loess of Belgium, Prof. Jones thought it highly probable that some at least of that in China may have been similarly formed.

Mr. HUGHES said that the author appeared to have grouped together all the superficial deposits of a vast area without explaining very clearly the grounds upon which he identified those deposits at distant points. He did not prove that what he called the shore deposit was marine, or that it was of the same age as the loam which he described, and which Mr. Hughes thought, from the description, was far more likely to be subaerial.

Mr. EVANS and Mr. ETHERIDGE suggested the probability of much of the so-called Loess having been brought down from higher loamy beds, possibly derived from the decomposition of limestone rocks containing sand and clay, and redeposited by the action of rain.

MAY 10, 1871.

Dr. Henry Nyst, of Brussels, was elected a Foreign Member, and Prof. G. Dewalque, of Liège, a Foreign Correspondent of the Society.

The following communications were read:—

1. *On the ANCIENT ROCKS of the ST. DAVID'S PROMONTORY, SOUTH WALES, and their FOSSIL CONTENTS.* By PROFESSOR R. HARKNESS, F.R.S., F.G.S., and HENRY HICKS, Esq. *With Descriptions of the New Species, by H. HICKS, Esq.*

(PLATES XV. & XVI.)

IN an early edition of *Siluria* (1854) there is a figure of a specimen of *Paradoxides Forchhammeri*? Angel., from the black slates of North Wales. In the third edition of the same work (1859) the same figure occurs, with the remark "locality unknown, probably from Pen Morfa, near Tremadoc, North Wales." In this edition there is also a note with reference to the occurrence of this form, stating that "only one species of *Paradoxides* has yet been found in Wales; although the specimen is imperfect, Mr. Salter believes it to be identical with *P. Forchhammeri* of the alum slates of Andrarum in Scania."

In the last edition of *Siluria* (1867) the same figure is named *Paradoxides Hicksii*; its locality is indicated as "near Dolgelly, North Wales;" and it is further stated that "this fossil has been

found both at Dolgelly and in Pembrokeshire, about a hundred feet above the lowest black *Lingula*-slates."

Respecting the discovery of another form, *Paradoxides Davidis*, Salter, in Pembrokeshire, the late Mr. Salter has described this species, and named the locality whence it has been obtained*.

In this memoir a Table is also given of the strata which make up the "*Lingula*-flags in Wales;" and Mr. Salter has described the lower portion of this series as a "thick mass of black shales very uniform in its upper part, but with hard sandstones in the lower, probably accumulated in a deep sea." The fossils of the Lower *Lingula*-flags are stated to be "*Lingulella*, rare, *Olenus*, common, *Agnostus*, common, *Paradoxides Davidis*" †.

Subsequently Mr. Salter, in a communication entitled "On some New Fossils from the *Lingula*-flags of Wales," described and figured several new forms of Trilobites, a *Theca*, and a large Sponge obtained from the dark-coloured rocks of Porth-y-Rhaw by Mr. Hicks ‡.

In this memoir a section is given of the fossiliferous rocks, showing their relation to the purple and green sandstones on which they repose.

In 1865 Mr. Salter alludes to the occurrence of "Some additional Fossils from the *Lingula*-flags;" and a note on the genus *Anopolenus* is appended to this communication by Mr. Hicks §. The lower portion of these *Lingula*-flags affording the additional fossils, and also those previously referred to, were designated by Messrs. Salter and Hicks, in a paper read at the British Association in 1865, the "*Menevian group*."

In 1867 a new form of *Lingulella* (*L. ferruginea*, Salter), from the Lower *Lingula*-flags of St. David's, was described; and the occurrence of a variety of the same, *Lingulella ferruginea*, var. *ovalis*, Hicks, which had been obtained from the underlying red rocks, was alluded to ||.

In this communication of Messrs. Salter and Hicks we have the first indication of the presence of fossils in the purple and green rocks of the St. David's promontory, upon which the Lower *Lingula*-flags are superposed.

In 1868 Messrs. Salter and Hicks gave an abstract having reference to the occurrence of some new fossils from the *Menevian group* (Lower *Lingula*-flags); and in 1869 a detailed description was given of these fossils ¶.

The discovery of fossils in the dark-coloured Lower *Lingula*-flags

* Quart. Journ. Geol. Soc. vol. xix. p. 275.

† This description of the Lower *Lingula*-flags was correct so far as then recognized in North Wales; but it does not include that very important portion at the base, which has since been separated by Messrs. Salter and Hicks, and named the *Menevian group*. *Paradoxides Davidis* belongs to this group, and should not be associated with *Olenus*, the typical genus of the *Lingula*-flags proper.

‡ *Op. cit. suprâ*, vol. xx. p. 233.

§ *Op. cit. suprâ*, vol. xxi. p. 477.

|| *Op. cit. suprâ*, vol. xxiii. p. 339.

¶ *Op. cit. suprâ*, vol. xxiv. p. 519, and xxv. p. 51.

of Pembrokeshire by Mr. Hicks induced other geologists to seek for similar fossils among the equivalents of these rocks in connexion with the Lower Lingula-flags, which repose conformably upon the upper portion of the purple rocks forming the Merionethshire anticlinal.

In reference to the rocks which rest upon the purple strata on the east side of this anticlinal, Mr. Plant communicated a memoir entitled "Notes relating to the Discovery of Primordial Fossils in the Lingula-flags in the neighbourhood of Tyddyngwlad's Silver-lead Mine." An abstract of this was published in the Quart. Journal of the Geol. Soc. in 1866; and the memoir appeared *in extenso* in the Trans. of the Geol. Soc. of Manchester. A list of fossils obtained from the Lower Lingula-flags of this portion of Merionethshire was given by Mr. Plant; and this list exhibits a series having a very intimate relation with that containing the fossils obtained by Mr. Hicks from Porth-y-Rhaw, near St. David's.

The Lower Lingula-flags of the valley of the Mawddach, Merionethshire, are seen occurring between hard dark-grey shale-beds, which afford *Oleni*, and the highest member of the purple rocks of the anticlinal; and the Lower Lingula-flags here are conformable to the deposits above and below them. In their mineral nature they have great affinity to their equivalents near St. David's, consisting of what Mr. Salter termed "sandstones probably accumulated in deep water."

The strata at Porth-y-Rhaw, which are rich in Trilobites, contain no red or purple rocks associated with them, but are grey in colour at their base, being banded by light and dark shades, and black in their upper portion; and it is in the latter that fossils are most abundant.

Beneath the grey beds, and having the same inclination as the Lower Lingula-flags (Menevians) there is, in the St. David's promontory, a great development of rocks, which exhibit red, purple, green, and greenish-grey colours. These rest upon a conglomerate composed of quartz pebbles, of various sizes, cemented together by a reddish or purple sandy matrix.

The beds upon which the conglomerates rest are greenish in colour, and these are supported by rocks of rather peculiar characters.

In many spots they have an aspect which so nearly resembles syenite that it is, at first sight, very difficult to make out their true nature; for they appear to be made up of crystals imbedded in a base of quartz. When, however, these apparent crystals are carefully examined, they are found to be, for the most part, angular fragments of quartz, not possessing the proper crystalline form which this mineral assumes. Some of the fragments have a subangular outline; and a few even manifest a distinctly rounded surface. The matrix in which these fragments are imbedded does not exhibit a crystalline arrangement, and contains a very large proportion of silica as a constituent. The chemical composition of a specimen of these rocks has been kindly determined by Dr. Blyth, of Queen's College, Cork, and is as follows:—

| | |
|----------------------------|------|
| Silica | 78 |
| Alumina..... | 16.5 |
| Lime, soda, and iron | 5.5 |

100

The proportion of silica afforded by the foregoing analysis much exceeds that which is obtained from rocks having a syenitic nature.

These quartziferous rocks form an E.N.E. and W.S.W. course; and near the centre of this ridge is the city of St. David's.

The arrangement of these rocks, which seem to be quartziferous breccias, is rather indistinct. In the immediate neighbourhood of St. David's, and also near Clegyr Bridge, about a mile E. from St. David's, they have associated with them irregular bands of hard greenish-coloured ashy-looking shales, considerably altered in character, but in many instances possessing distinct traces of foliation. Bands of this shale have also been met with in well-sinkings in St. David's*.

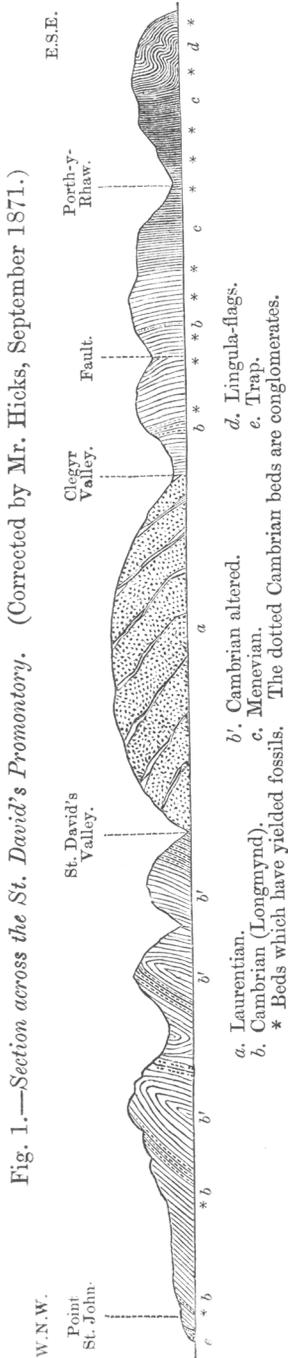
Differences prevail in the characters of the rocks which repose upon the central ridge, those on the S.S.E. side presenting an aspect somewhat different from those on the opposite side. This difference seems to have resulted from faults which have brought various rocks of the purple and green series into contact with the quartziferous breccias.

The quartziferous breccias on the S.S.E. have, for the most part, resting upon them quartz rocks of a greenish-grey colour and compact nature. These possess many of the features of hornstone, and they are intersected by closely approximated joints. They have, however, a distinct S.S.E. dip at a high angle, usually about 80°; and in this position they are well seen in the neighbourhood of Clegyr Bridge, where their strike is parallel to the axis of the quartziferous breccias.

On following the line of strike of the hornstones for a short distance towards the W.S.W., these rocks are found to disappear. At the ruins of Nun's Chapel, about a mile W.S.W. from Clegyr Bridge, the compact quartz rocks are seen; but immediately beyond this all traces of them are lost, and a greenish flaggy sandstone appears at Porth Clais Harbour resting *against* the quartziferous breccias.

The connexion between the quartziferous breccias and the greenish flaggy sandstones at Porth Clais Harbour results from a fault, having a throw-down on the E.S.E. side, by means of which rocks newer than the compact quartz rocks, or hornstones, are brought into contact with the quartziferous breccias. At Porthlisky, a little to the

* Since this paper was read, I have been fortunate enough to find two or three spots in the ridge where the bedding is distinctly shown, and where the shales are seen alternating with the more massive quartziferous beds. The strike of the beds is from N.W. to S.E., and hence quite discordant to the overlying Cambrian series, in which the strike is from N.E. to S.W. This ridge, therefore, must represent a more ancient group of rocks than the Cambrian, occupying a position equivalent to that of the Laurentian group in Canada.—H. HICKS.



W. of Porth Clais, purple sandstones, which will be shown to be higher in the series than the greenish flaggy rocks, strike against the quartziferous breccias, affording further evidence of the occurrence of a fault in this neighbourhood.

It has been stated that at the ruins of Nun's Chapel the compact quartz rocks are in connexion with the quartziferous breccias.

At this locality there are seen resting, apparently conformably, on the compact quartz rocks, conglomerates already referred to as being composed of large and well-rounded masses of quartz imbedded in a purple matrix. These conglomerates, as here seen, are about 30 feet in thickness.

The same conglomerates are well shown near Clegyr Bridge, where they appear to be conformable to the underlying compact quartz rocks, their dip being towards the S.S.E., at about 80°. In this locality the thickness of the conglomerates amounts to about 60 feet.

On the N.N.W. side of the axis of the quartziferous breccias no compact quartz rocks are recognizable; but some fine-grained yellowish beds of a soft and decomposing nature are seen in contact with the quartziferous breccias, and are succeeded by purple conglomerates.

The section on the S.S.E. side of the axis exhibits a good development of greenish flaggy sandstones identical with those alluded to as occurring at Porth Clais Harbour; and these sandstones are conformable to the conglomerates on which they rest. The greenish flaggy sandstones have been worked, especially at Caerfai; and a small quarry of them is also

seen on the E. side of the stream below Clegyr Bridge. These rocks have a thickness of about 400 feet; and on the N.N.W. side of the axis the greenish flaggy sandstones also occur, resting conformably on the conglomerates.

On the S.S.E. side of the ridge the greenish flaggy sandstones have above them red shaly beds, agreeing in their inclination with the strata on which they repose; and these red shaly beds have afforded the earliest traces of organic remains which have been hitherto discovered in the St. David's promontory. These remains consist of *Lingula ferruginea*, Salt., a form previously mentioned, another and larger *Lingulella*, a *Discina*, and a new species of *Leperditia* of considerable size, *L. cambrensis*, Hicks.

These red shales occur on both sides of the quartziferous ridge. They are seen on the N.N.W. side, in Ramsay Sound, where fossils have also been obtained from them near Castell. A small fragment of a Trilobite has likewise been met with in the red shales of this locality; but this fragment was not sufficiently distinct to allow of the form being satisfactorily determined.

On the S.S.E. side of the ridge the fossiliferous shales are seen at Porth Clais Harbour; and in this spot also fossils occur*. They are likewise seen under the ruins of Nun's Chapel, at Rhoscarrylhuyd, and also at Caerfai and Mill. These red fossiliferous shales have a thickness of about 50 feet.

On the S.S.E. side of the axis, reposing conformably on the fossiliferous red shales, purple sandstones having occasional green bands associated in them occur, somewhat coarse in grain. These purple sandstones are about 1000 feet thick; and hitherto no fossils have been obtained from them. These sandstones are now being largely worked, the stone used in the restoration of the Cathedral of St. David's being obtained from them. They afford large blocks, which dress well.

On the N.N.W. side of the axis the thick purple sandstones are represented by deposits having more varied colours. On the E. side of Ramsay Sound, where the fossiliferous red shales occur, these are seen to be succeeded by greenish sandstones, upon which are rocks reddish in colour passing upwards into a series of purple strata. Greenish sandstones rest upon the purple strata; and above these are purple-coloured beds, having within them red layers. These varied-coloured sandstones represent the thick purple sandstones on the S.S.E. side of the axis; and they are also almost unfossiliferous, so far as present observations go.

The thick purple sandstones of the S.S.E. side of the St. David's promontory have superposed conformably upon them yellowish- and grey-coloured sandstones and shales. In the lower portion of these yellow-coloured rocks there have been found remains of a large and new form of sponge, *Protospongia major*, Hicks. These strata, which have some conglomerate beds associated with them, have also afforded Trilobites, one of which appertains to a new genus, and the other forms are new species. These are *Plutonion Sedgwickii*,

* Davidson on the Earliest British Brachiopoda, Geol. Mag. vol. v. p. 306.

Hicks, *Conocoryphe Lyellii*, Hicks, *Microdiscus sculptus*, Hicks, *Agnostus cambrensis*, Hicks, *Protospongia fenestrata*, Salter, *Theca antiqua*, Hicks, and *Paradoxides Harknessi*, Hicks.

The yellowish-coloured sandstones and shales are well seen on their line of strike in most of the headlands which intervene between Porth Clais Harbour and Caer-bwdy. The principal spot from which fossils have been obtained is the second headland E. of Porth Clais Harbour. The same rocks can be seen also between Folly and Trelerwr. Their thickness amounts to about 150 feet; and on the N.N.W. side of the axis their equivalents occur in a nearly allied form, being yellowish-grey sandstones.

Succeeding these are grey rocks with purple bands, which pass upwards into purple and red sandstones and shales; and from these *Lingulella ferruginea*, var. *ovalis*, *Conocoryphe solvensis*, *Paradoxides Harknessi*, and several of the other species have been obtained between Solva and Whitchurch. The total thickness of the two series on the S.S.E. side of the axis is about 700 feet. On this side of the axis these rocks are intersected by lines of faults, which run parallel to their strike; and one of these extends from the coast a little S. of Folly through Trelerwr. These faults have downthrows on their S.S.E. side, which have reduced very materially the absolute thickness of those rocks on this side the promontory.

On the E. side of Ramsay Sound, and on the N.N.W. side of the axis, the equivalents of the grey and purple sandstones do not seem to have been affected by faults; and here they have a thickness of about 1500 feet.

On this side of the ridge also the grey and purple sandstones have their representatives in the form of grey, purple, and red flaggy beds.

On the S.S.E. side the grey and purple sandstones have, resting conformably upon them, grey grits, which contain *Paradoxides aurora*, Salter, and *Conocoryphe bufo*, Hicks; and these two forms have not, up to the present time, been discovered in strata which underlie or overlie the grey grits. *Agnostus cambrensis* and *Theca antiqua* have also been obtained from these grey beds. These two species also occur in the underlying rocks; but they have not yet been met with in deposits higher than the grey grits. *Discina pileolus*, Hicks, and *Obolella sagittalis*, Salter, are also found in the grey beds. They likewise occur in the underlying purple strata, and they extend upwards through the Menevian group.

Lingulella ferruginea is also found in the grey beds; and this form has the widest range of any of the fossils that have been obtained from the purple and green rocks of the St. David's promontory. It occurs in the lowest fossiliferous zone which has hitherto been discovered, and it extends through the Menevians. *Theca penultima*, Hicks, also occurs in these grey rocks; and this is the lowest horizon from which it has been procured. Its range seems limited, as it has not been met with above the lower portion of the Menevians.

On the N.N.W. side of the axis, on the E. shore of Ramsay

Sound, these grey fossiliferous grits are not seen: a fault having an E.N.E. course has cut through the upper portion of the purple-coloured rocks which support the grey strata. A few beds of these grey grits, however, are seen on the N.N.W. side of this fault, near Ogaf Golhfa, in Whitesand Bay, reposing upon the higher members of the purple flags and sandstones. The order of the rocks from the quartziferous breccias upwards, when not disturbed by faults, is as follows:—

| <i>Lower Cambrian.</i> | | feet. |
|---|--|-------|
| 1. Greenish hornstones on the S.E., and earthy greenstones on the N.W., forming the outermost portions of the so-called Syenitic and Greenstone ridges. | | |
| 2. Conglomerates composed chiefly of well-rounded masses of quartz imbedded in a purple matrix | | 60 |
| 3. Greenish flaggy sandstones | | 460 |
| 4. Red flaggy or shaly beds, affording the earliest traces of organic remains in the St. David's Promontory—namely, <i>Lingulella ferruginea</i> , <i>Leperditia cambrensis</i> , a larger <i>Lingulella</i> , and a <i>Discina</i> | | 50 |
| 5. Purple (sometimes greenish) sandstones | | 1000 |
| 6. Yellowish-grey sandstones, shales, and flags containing the genera <i>Plutonia</i> , <i>Conocoryphe</i> , <i>Microdiscus</i> , <i>Agnostus</i> , <i>Theca</i> , <i>Protospongia</i> , and <i>Paradoxides</i> | | 150 |
| 7. Grey, purple, and red flaggy sandstones, containing most of the above-mentioned genera | | 1500 |
| 8. Grey flaggy beds, containing <i>Paradoxides aurora</i> | | 150 |
| 9. The true beds of the "Menevian Group," richly fossiliferous, and the probable equivalents of the lowest portions of the Primordial Zone of M. Barrande | | 550 |

The discovery of a fauna specially rich in Trilobites among the purple and green rocks and their associated strata of the St. David's promontory affords very important information concerning the earlier forms of life which occur in the old sedimentary deposits of the British Isles. Until the discovery of this fauna, these rocks and their equivalents in North Wales have been looked upon as all but barren in fossils. We have now scattered through about 3000 feet of purple and green strata a *well-marked* series of fossils such as have nowhere else been obtained in the British Isles.

In the Longmynds of Shropshire, consisting of purple and green rocks, which probably represent the rocks having the same colour in the St. David's district, the only evidence of the existence of life during the period of their deposition is in the form of worm-burrows—and in the somewhat indistinct impressions which Mr. Salter regarded as trilobitic, and to which he has given the name *Palæopyge Ramsayi**.

If we assume the purple and green shales and sandstones with their associated quartz rocks of Bray Head, and the drab shales of Carrick McReily, co. Wicklow, to represent the old rocks of the St. David's promontory, they afford only very meagre evidence of the occurrence of life during the period of their deposition, in the form of worm-burrows and tracks and in the very indeterminate fossils which have been referred to the genus *Oldhamia*.

* Quart. Journ. Geol. Soc. vol. xii. p. 249.

There is one very prominent feature about the palæontology of the ancient rocks of St. David's: this is the occurrence of four distinct species of the genus *Paradoxides*; and this feature contrasts very strongly with the entire absence of the genus *Olenus* from these rocks.

On a comparison of the palæontology of the St. David's rocks with those of the continent of Europe and of America, which seem to occupy nearly the same horizon, we have like features, to a very great extent, presenting themselves.

The lower fossiliferous horizon of Sweden, the Alum-shales, has been divided by Angelin into two groups. The lowest of these, "Regio B," contains forms of *Paradoxides*, among which we learn that Dr. Otto Torell has recognized two species that are St.-David's forms, viz. *P. Davidis* and *P. Hicksii*. The upper portion of the Alum-shales of Sweden, "Regio A" of Angelin, contains several forms of *Oleni*; and from this portion of the series the genus *Paradoxides* seems to be absent.

The deposits upon which the Alum-shales of Sweden rest, the "Fucoidal Sandstones," contain within them purple beds; and from these we have reason to believe that evidence of life has been obtained by Dr. Otto Torell in the form of an *Obolella*. In Sweden the genus *Paradoxides* is found accompanied by *Conocoryphe* (*Conocephalites*); and Trilobites of this genus are also found associated with *Paradoxides* in the St. David's promontory.

Regio B of Angelin is represented by the dark-coloured rocks of Porth-y-Rhaw; and below these are strata which seem to be the equivalents of the Fucoidal Sandstones of Sweden, yielding an extensive series of fossils.

In N. Wales, on the E. and N.E. side of the Merionethshire anticlinal, Regio B is also represented, and is succeeded by the equivalents of Regio A, which, in the form of a thick series of dark-coloured sandstones and shales (*Lingula*-flags), contain several species of the genus *Olenus*.

In Bohemia, the primordial zone of Barrande, as shown by its fossil contents, is very near to the horizon of the Menevian group as exhibited in Wales. Trilobites appertaining to the genera *Paradoxides*, *Conocoryphe*, *Ellipsocephalus*, *Sao*, and *Agnostus* occur; but no traces of the genus *Olenus* have been obtained from the Bohemian primordial rocks.

In Bavaria, Sir R. I. Murchison states that, in the neighbourhood of Hof, the primordial zone, "which consists of black siliceous slate, above 50 feet thick, contains Trilobites, which have been determined by Barrande to belong to *Conocoryphe* and *Olenus*;" and in a letter from M. Barrande to Sir Roderick it is said that "with these primordial Trilobites are also associated two or three forms which everywhere characterize the second Silurian fauna (*Llandeillo* and *Caradoc*), i. e. *Calymene* and *Cheirurus*!"*

With reference to the fauna of the primordial zone of Hof, Barrande has remarked on the absence of the genus *Paradoxides* there-

* Quart. Journ. Geol. Soc. vol. xix. p. 362; Siluria, 4th edit. p. 374.

from. He regards the fossils which occur in these primordial rocks as being of a later age than those found in the primordial zone of Bohemia; and he looks upon them as representing a period between the first and second faunas of Bohemia*.

This fauna of Hof has no analogy with the ancient fauna of the St. David's promontory. It is altogether much higher in position, and connects the upper portion of the Lingula-flags of Wales, not only with the succeeding Tremadoc rocks, but also with higher members of the Silurian series.

The occurrence of rocks which appertain to the primordial zone of Barrande, in Spain, has been referred to by Sir R. I. Murchison †.

The arrangement of these Spanish representatives of the primordial zone has been given in detail by M. Casiano de Prado ‡.

The fauna of the Spanish primordial rocks, which has been obtained from a thin series of red limestones, has been described by Barrande. Among the fossils which it affords are seven Trilobites, referable to the genera *Paradoxides*, *Arionellus*, *Conocephalites*, and *Agnostus*. The genus *Paradoxides* is represented by *P. pradoanus*, a form which seems to occur only in Spain. The species of *Arionellus* is *A. ceticephalus*, Barr., which is a form found in the primordial rocks of Bohemia. There are three species of *Conocephalites* among the Spanish representatives of the primordial zone, of which two are Bohemian, viz. *C. coronatus* and *C. Sulzeri*; and one form, *C. Ribeiro*, Barr., has not yet been obtained elsewhere. Two species of the genus *Agnostus* are also met with in the Spanish primordial rocks. These several Trilobites have been obtained from deposits which lie north of Scabero, and of Bonar, in the province of Leon.

Sir R. I. Murchison also states that MM. de Verneuil and Louis Lartet have discovered a "primordial" Silurian range with the same species of Trilobites near Daroca. They also found it in various parts of the Silurian strata which extend from Daroca to Moncayo §.

The occurrence of fossils, of a type allied to those which are obtained from the rocks of St. David's, has been recognized in several localities in North America. Mr. Salter has mentioned *Paradoxides Harlani*, Green, as occurring in great quantities in Massachusetts. *P. Bennetti*, Salter, is found in hard, fine-grained, flinty shales at Branch, in the promontory between St. Mary's and Placentia Bays, Newfoundland; and Mr. Salter alludes to the occurrence of *Conocephalites antiquatus*, Salter, as a form which was exhibited at the Great Exhibition, 1851, and which was obtained from a boulder of brown sandstone in Georgia ||.

Dr. Dale Owen has mentioned the occurrence in Wisconsin of several forms of *Dikelocephalus*, with species of *Conocephalites*, *Ari-*

* Faune Silurienne des Environs de Hof, December 1868.

† Siluria, 4th edit. p. 416.

‡ Bull. Soc. Géol. France, 1860, vol. xvii. p. 516 *et seq.*

§ Siluria, 4th edit. p. 416.

|| "Fossils of the Lingula-flags or Primordial Zone," Quart. Journ. Geol. Soc. vol. xv. p. 551 *et seq.*

onellus, and *Lonchocephalus*, in the equivalents of the Potsdam sandstone. The genus *Paradoxides* however, does not, seem to be represented in this fauna*.

A species of *Paradoxides*, which appears to be identical with a form occurring in Bohemia and Thuringia, *P. spinosus*, Boeck, has been met with in altered argillaceous sandstones in a quarry in Quincy, south of Boston, in eastern Massachusetts †.

In Canada, at Point Lévis, on the banks of the St. Lawrence, a fauna, possessing a character nearly allied to that mentioned by Dr. D. Owen as occurring in Wisconsin, is seen. Among the thirty-six forms of Crustacea which this fauna affords are two forms of *Ari-onellus*, one of *Conocephalites*, and five of *Dikelocephalus*. These are associated with fifty-five species of Mollusca, four of Radiata, and forty-two forms of Graptolites, the latter being generically and, in most instances, specifically identical with those of the Skiddaw slates ‡.

The fossils of Point Lévis occur in limestone conglomerates and in interstratified slates. These rocks appertain to the Quebec group, and represent in this part of North America the calciferous sand-rock §.

In Vermont, as seen at Swanton Falls, the Potsdam sandstones are exhibited in the form of dolomites and red sand-rocks. The lower portion of these afford *Conocephalites Adamsi*, Bill.; and from the higher strata *C. Teneri*, Bill., *Paradoxides Thompsoni*, Hall, *P. vermontiana*, Hall, and three species of brachiopods are obtained ||. Strata of the same age, and affording the same forms of *Paradoxides*, occur on the coast of Labrador, on the north-west side of the Straits of Belle Isle. Here *Conocephalites*, with two forms of *Bathycirus*, three of *Salteria*, and several brachiopods are found associated ¶.

The Potsdam sandstones are represented in the north-west portion of Newfoundland. The strata here, which have been termed by the late Mr. Jukes the Lower Slate formation, consist of the Signal-hill sandstones and the St. John's slate (Report on the Geology of Newfoundland).

From the slates on the west side of St. Mary's Bay Mr. C. Bennett obtained *Paradoxides Bennetti*, Salter, a form before alluded to.

Dr. Dawson refers to the occurrence of a rich primordial fauna in New Brunswick. It affords fourteen species of *Conocephalites*, two of *Paradoxides*, one of *Microdiscus*, and two of *Agnostus*, associated with six forms of Brachiopoda **.

* Geology of Wisconsin, vol. i. p. 72.

† H. D. Rogers, Geol. of Pennsylvania, vol. ii. pl. 11, p. 816.

‡ Sir W. E. Logan's Report on the Geology of Canada, 1863, p. 232.

§ Professor Dana, in the last edition of the 'Manual of American Geology' (1870), p. 171, unites the Potsdam sandstone and the calciferous sand-rock into one group, placing them at the base of the Silurian, and designating the epoch of their deposition as the "Potsdam or primordial period."

|| Report, p. 811.

¶ Report, p. 866.

** Acadian Geology, 2nd edit. p. 641.

With reference to the distribution in time of the earlier genera of Trilobites, it would appear that the genus *Olenus* is represented in Britain and Europe by twenty species, which are confined to the horizon of the Lingula-flags, but not occurring so low as the Menevian group, and by two species which, in Wales, are found in the higher horizon of the Tremadoc slates. In America there are four forms of this genus, and these are found in positions higher than any of the Old-World species; and the American forms are distinct from those of Britain and Sweden. Three of these species occur in the Quebec series; and one *O. undulostriatus*, Hall, has been obtained from the Hudson-river group.

Of the genus *Conocoryphe* (*Conocephalites*) there appear to have been found in the Potsdam sandstone of America twenty-six species; and if to them we add the fourteen forms obtained by Dr. Dawson from New Brunswick, forty species of this genus seem to occur in the New World, all being low down in the primordial rocks. There is one form not included in this number, which appears to be common to Britain and Texas, *C. depressa*, Salter; and this, in Wales, makes its appearance in the Tremadoc slates; and in America another form, *C. Zenkeri*, Bill., is found in the Quebec group.

In the Old World eighteen species of the genus *Conocoryphe* occur among the representatives of the Lingula-flags and the underlying deposits, and four forms make their appearance in the Tremadoc slates.

In America this genus does not range so high as the genus *Olenus*; and in the same country it has been met with in a lower horizon than *Olenus*.

Of the genus *Microdiscus* one form is mentioned by Dr. Dawson as occurring in the primordial rocks of New Brunswick, and one form appears also in the Quebec group.

Wales affords two species of this genus, one of which is found in the Menevian series, and the other in the purple rocks of St. David's. This genus also ranges higher in America than in the Old World.

As regards *Arionellus*, four species have been recognized in the Potsdam sandstone of America, and two have been obtained from the Quebec group. In Britain, and on the continent of Europe, three forms occur; and these are found low down among the earlier rocks.

This genus also appears in a higher horizon in America than in the eastern hemisphere.

Of the genus *Dikelocephalus* there are in the Potsdam sandstone of America twelve forms; and in the Quebec group thirteen species occur. In Britain, which seems to be the only country where this genus occurs in the Old World, there are four forms; and these have a limited range, three being confined to the Upper Lingula-flags, and one to the Tremadoc slates.

Here, again, we have a genus which is represented in a higher position in America than in Britain.

The genus *Paradoxides* is represented in America by six species; and these all appear to occur in the lower portion of the primordial zone. Of these species it seems probable that *P. Thompsoni* and *P. vermontianus*, which Mr. Billings has referred to a new genus, *Olenellus*, occur in a position higher than the forms from Massachusetts; and as regards *P. macrocephalus*, Emmons, its position seems to be doubtful*. The Old World affords, including the new species alluded to in this communication as occurring in the purple and green rocks of St. David's, twenty forms; and these are all very low down in the earliest fossil-bearing rocks of Britain and Europe.

The genus *Anopolenus*, very nearly allied to *Paradoxides*, affords two species only; and these have hitherto only been found in the dark-coloured rocks above the purple and green strata of St. David's; and the same remark applies also to *Erinnys* and *Holocephalina*, a species of each of which occurs in the same rocks.

As regards the thickness of the strata external to the British isles which afford the earlier forms of Trilobites, this, in Europe, contrasts very strongly with what our own country exhibits.

In Sweden, the strata representing the ancient fossiliferous rocks of St. David's are very thin, if we regard them as included in Angelin's "Regio B." It is, however, by no means improbable that in this country the underlying "fucoid sandstones" represent the lowest series of the fossiliferous rocks of South Wales.

In Bohemia, the primordial zone of Barrande, "Etage C," has a thickness of about 1200 feet.

The thickness of this zone in Spain seems to be very small. There are two bands representing the primordial rocks in that country. One has a thickness of about 40 metres, that of Sabero; and the other seems to have a like thickness. They may, however, be the same band repeated by a fault.

In America the Potsdam sandstones, or their representatives, have very variable thickness. In some spots they are not more than 20 feet in depth, while in other localities they are said to attain to several thousand feet of thickness.

In Wales, if we assume the strata to which the term *Lingula*-flags has been applied, and those which in South Wales occur in a lower horizon, to represent the Potsdam sandstones, then we attain to a thickness much exceeding even the most extensive development of these sandstones, since the *Lingula*-flags would afford us about 6000 feet of strata where they are best developed, to which we have to add from 3000 to 4000 feet for the St. David's rocks in which fossils occur, as shown by the labours of Mr. Hicks.

List of Memoirs published since 1862 on the Rocks of the St. David's Promontory, and on their representatives in North Wales.

1. Salter, Quart. Journ. Geological Society, Feb. 1863.
2. Hicks, Trans. of the Geol. Soc. of Liverpool, Dec. 1863.
3. Salter, Quart. Journ. Geol. Soc. 1864.

* The form *P. asaphoides*, Emmons, seems to be an *Olenus*.

4. Salter & Hicks, Report Brit. Assoc. 1865.
5. Salter & Hicks, Quart. Journ. Geol. Soc. 1865.
6. Plant, Quart. Journ. Geol. Soc., and Trans. Geol. Soc. Manchester, 1866.
7. Salter & Hicks, Report Brit. Assoc. 1866.
8. Salter & Hicks, Quart. Journ. Geol. Soc. 1867.
9. T. Belt, Geol. Magazine, 1867.
10. Davidson, Geol. Magazine, 1868.
11. Hicks, Report Brit. Assoc. 1868.
12. Salter & Hicks, Quart. Journ. Geol. Soc. 1869.

DESCRIPTIONS of NEW SPECIES of FOSSILS from the LONGMYND ROCKS of St. DAVID'S. By HENRY HICKS, Esq.

PLUTONIA SEDGWICKII, Hicks. Pl. XV. figs. 1-8.

A large Trilobite having affinities with *Paradoxides* and *Anopolenus* in the form of its glabella, but differing from them in having the whole of its surface covered with coarse tubercles or spines. No perfect specimens have been found, but numerous fragments, including glabella, cheeks, head-spines, and portions of the thorax. These, however, show a form nearly equal to *Parad. Davidis* in size; and it is therefore, next to that species, the largest Trilobite discovered in British Cambrian rocks. The head is semicircular, with a wide margin and tolerably long posterior spines. The glabella is large, strongly convex, wider than the cheeks, and reaches anteriorly to the frontal margin; it has three complete transverse lobes, and one incomplete lobe on either side, and is widest across the anterior lobe. Cheeks triangular. Eyes large, extending from near the anterior furrows of the glabella to about half of the length of the cheeks. The thoracic segments show also a strongly tubercular surface. The axis is wide and slightly convex. Pleuræ long and deeply grooved, and with the spines bent backwards.

Locality.—Headland near Nun's well, St. David's.

PARADOXIDES HARKNESSI, Hicks. Pl. XV. figs. 9-11.

Of this species the head and some fragments only have been found; but these show a species entirely distinct from any previously discovered in Britain, although resembling the Bohemian species *P. rugulosus*. The eyes reach the whole length of the cheeks, and are strongly raised at each extremity. The glabella is large, reaches far forwards, and is indented by three complete furrows, and two incomplete ones on either side.

Locality.—Headland near Nun's Well, St. David's, and on road-side between Solva and Whitchurch.

CONOCORYPHE LYELLII, Hicks. Pl. XVI. figs. 1-7.

An exceedingly well-defined species, and the earliest known of the genus. It occurs tolerably plentifully, and in a well-preserved state. Ovate in form, surface generally raised, and more or less convex. Length from $1\frac{1}{2}$ to 2 inches, breadth from 1 to $1\frac{1}{2}$ inch.

Head strongly marginate, semicircular, and with a smooth surface; angles produced into short spines, directed backwards. Glabella parabolic and convex, and indented by three very distinct lateral furrows which reach about one-third of the distance across. Cheeks wider than the glabella, and raised. Eyes situated at about one-third of the distance across from the glabella, and connected with the glabella by very strongly marked ocular ridges. The facial sutures run outwards and forwards above the eyes, and backwards below the eyes to the posterior margin, a little to the inner side of the spinous angles. Thorax consisting of fourteen segments; the axis is convex and tapers gradually towards the tail. Pleuræ less than half as long again as the rings of the axis, grooved deeply, and bent backwards from the fulcrum, which is situated about midway. Tail semicircular, with a tapering, strongly raised axis of four segments; limb marked with four distinct ribs. This species approaches nearer to *C. applanata* than to any other Cambrian species, but is of larger size, has the eyes placed much nearer the glabella, has shorter pleuræ, and a more strongly ribbed tail.

Locality.—A headland near Nun's Well, St. David's.

CONOCORYPHE SOLVENSIS, Hicks. Pl. XVI. fig. 8.

The head and a few thoracic segments only have been found; but these are sufficient to mark a new species, resembling in some respects the Bohemian species *C. coronata*. The head is semicircular, tubercular all over, and strongly marginate. Glabella small, reaching less than two thirds of the distance forwards, narrow anteriorly, and indented by three lateral furrows. A strongly raised boss occupies the place anterior to the glabella, and reaches from it to the margin, but is separated at the base from the glabella by a deep furrow. Cheeks more strongly convex than the glabella, and about twice as wide; the cheeks are wider than in *C. coronata*; and it seems altogether a wider form.

Locality.—Road-side between Solva and Whitchurch, St. David's.

MICRODISCUS SCULPTUS, Hicks. Pl. XVI. figs. 9 and 10.

Differs from *Microdiscus punctatus*, the only other species found in Britain, by having the lobes of the tail distinctly ribbed and not punctated; is about equal to it in size.

Locality.—Headland near Nun's Well, St. David's.

AGNOSTUS CAMBRENSIS, Hicks. Pl. XVI. figs. 11 and 12.

About one fourth of an inch long, and convex. Head longer than wide, and straight on the sides. Glabella occupying more than a third of the width, and divided at its anterior third by a transverse furrow. Tail nearly of the same shape as the head, with a wide axis centrally raised and indented by three furrows on each side.

Locality.—Headland near Nun's Well, St. David's.

THECA ANTIQUA, Hicks. Pl. XVI. fig. 13.

About $\frac{2}{3}$ of an inch long; surface not corrugated, and extremity

rather blunt. Differs from *Theca penultima* and *Theca corrugata* in having a smooth surface, and from *Theca stiletto* in being a larger and wider form, and with a blunt extremity.

LINGULELLA PRIMÆVA, Hicks. Pl. XV. figs. 13, 14.

Half an inch in length and about $\frac{1}{4}$ of an inch in width. Some of the valves show a tolerably convex form, and are marked with concentric lines of growth; most, however, are much compressed and drawn out of form by the cleavage which has affected the beds in which they occur. It is altogether a much larger species than *Lingulella ferruginea*, which also is found in the same beds. It is moderately plentiful in the red beds at the base of the purple sandstones at Caerfai, Nun's Well, and Porth Clais harbour, on the coast to the south of St. David's; but as the beds in each case are much cleaved, good specimens are seldom found.

LEPERDITIA? CAMBRENSIS, Hicks. Pl. XV. figs. 15-17.

Valves about $\frac{1}{4}$ of an inch long, by about $\frac{1}{8}$ of an inch in width. Some of the specimens show a reticulated ornamentation entirely distinct from the ordinary lines of growth in a *Lingulella*, which makes it probable that they belong to the genus *Leperditia*. In other respects the characters are rather indistinct; and though specimens are very plentiful in the red beds along with *Lingulella primæva*, the cleavage has so affected them that it becomes difficult to recognize their true form, or to note any special characters.

PROTOSPONGIA? MAJOR, Hicks. Pl. XVI. figs. 14-18.

The specimens figured under this name I have possibly incorrectly referred to the genus *Protospongia*; but as they approach nearer in character to that genus than to any other yet described from the earlier rocks, I may be pardoned for doing so in preference to making a new genus, where the nature of the fossil is so indistinct. The specimens, however, have very definite characters, and are entirely distinct from those markings so common in the Cambrian rocks, and usually classed together as worm-tracks. In many cases the lines cross each other at sharp angles; at other times a branching appearance is given; nearly all appear as if two flattened fibres were joined together longitudinally, one being wider than the other. At present only a few associated beds, almost immediately below those containing *Plutonia Sedgwickii*, have yielded these fossils; but in them the markings are very plentiful, covering, indeed, almost the whole surface of the beds. One specimen, however (fig. 18), was discovered by me some time since in the "Menevian group." Fig. 19 represents *Protospongia? flabella*, Hicks, a Menevian species, but placed here for comparison; it certainly in some characters resembles *Protospongia? major*, and is most likely connected with it generically. Fig. 20 represents *P. fenestrata*, Salter, also a Menevian species, and the first described of the genus. In this species the

fibres do not show the longitudinal lines always present in *Protospongia major*, nor are they flattened; but in this specimen the fibres are much larger than in the one figured by Mr. Salter in Quart. Journ. Geol. Soc. vol. xx. pl. xiii.

EXPLANATION OF PLATES XV. AND XVI.

(*Illustrative of Fossils from the Longmynd Rocks of St. David's.*)

PLATE XV.

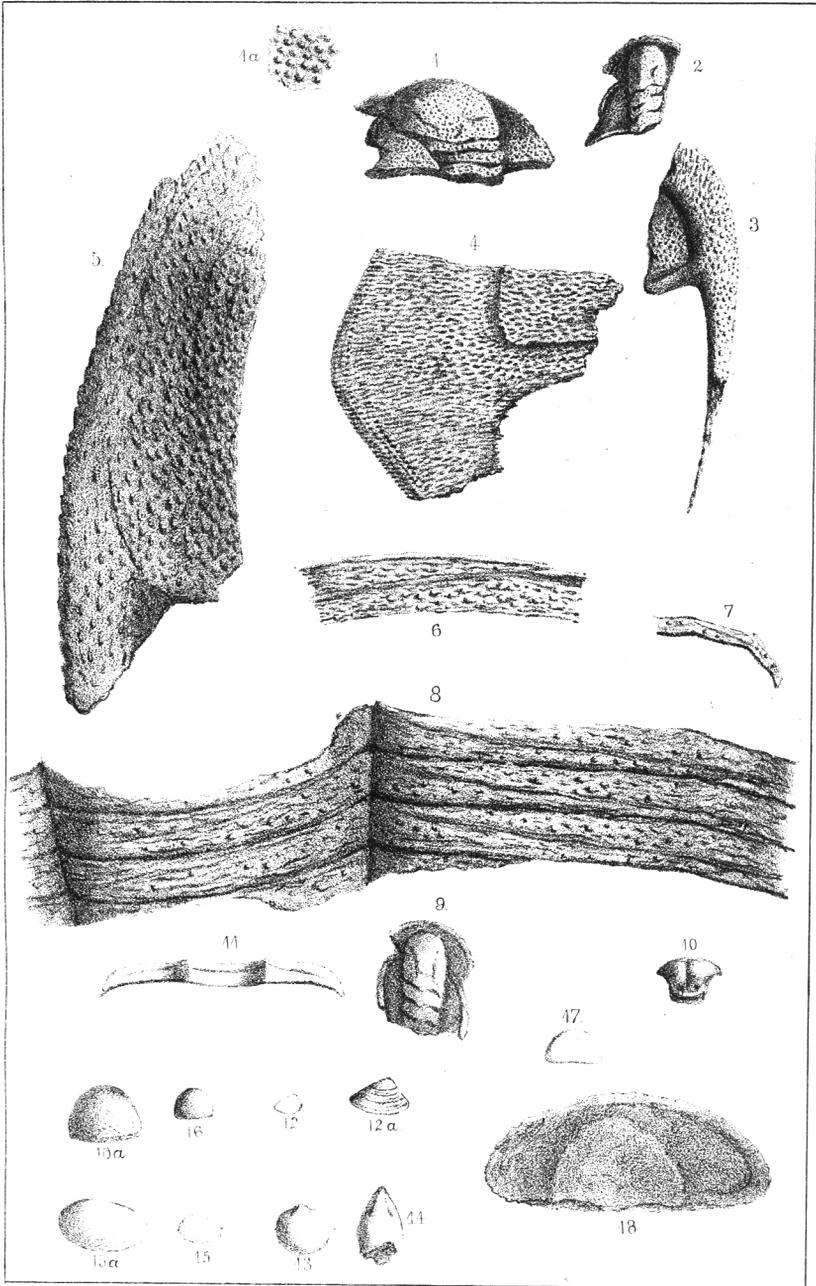
- Fig. 1. Head of *Plutonia Sedgwickii*, Hicks.
1 a. Portion of the same, magnified.
2. Head (small) of *Plutonia Sedgwickii*.
3. Free cheek of *P. Sedgwickii*.
4. The same, large size.
5. Margin of the head of a large specimen of *P. Sedgwickii*.
6, 7, 8. Pleuræ and part of the axis of *P. Sedgwickii*.
9. *Paradorides Harknessi*, Hicks, head of.
10. ———, labrum.
11. ———, a thoracic segment.
12. *Discina pileolus*? Hicks, from the red rocks at the base of the purple sandstones.
12 a. ———, magnified.
13 and 14. *Lingulella primæva*, Hicks.
15, 16, 17. *Leperditia? cambrensis*, Hicks.
15 a, 16 a, 17 a. ———, magnified.
18. Part of the head of a Trilobite from a bed at the base of the purple rocks, about 3000 feet below the "Menevian group."

PLATE XVI.

- Fig. 1-4. *Conocoryphe Lyellii*, Hicks.
5-7. ———, narrower form.
8. ——— *solvensis*, Hicks, head of.
9. *Microdiscus sculptus*, Hicks.
9 a. ———, magnified.
10. ———, tail of.
10 a. ——— tail of, magnified.
11. *Agnostus cambrensis*, Hicks, head of.
11 a. ———, head of, magnified.
12. ———, tail of.
12 a. ———, tail of, magnified.
13. *Theca antiqua*, Hicks.
14-17. *Protospongia? major*, Hicks, from the Longmynd Rocks, St. David's.
18. ———, from the "Menevian Group," St. David's.
19. *Protospongia? flabella*, Hicks, from the "Menevian Group," St. David's.
19 a. ———, portion magnified. St. David's.
20. ——— *fenestrata*, Salter, from the "Menevian Group," St. David's.

DISCUSSION.

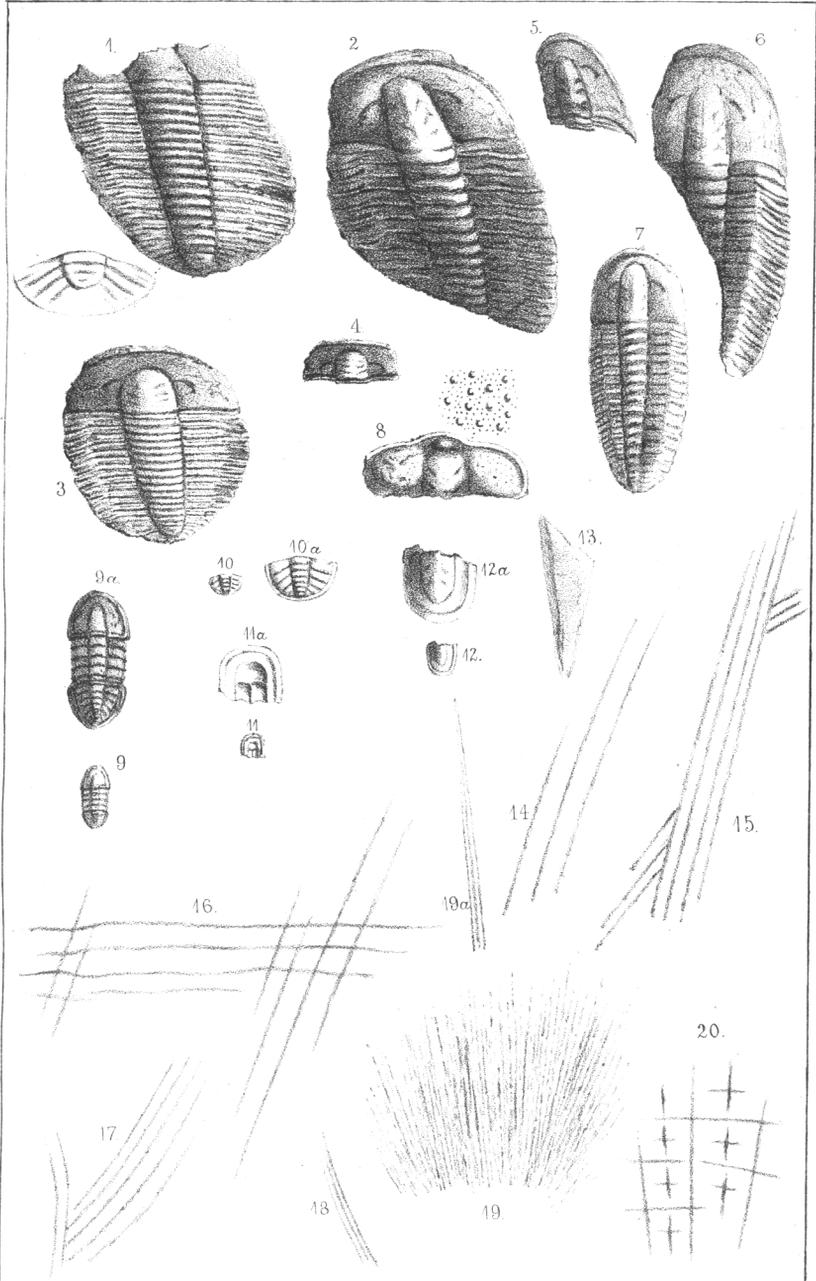
Mr. HUGHES bore testimony to the admirable work done by Mr. Hicks, who had, almost unaided, worked out the geology of that district. Allowing that many subdivisions and new specific names had with great advantage been introduced into petrology, he de-



G.R. DeWilde del et lith.

Mintern Bros imp.

LOWER CAMBRIAN FOSSILS FROM ST. DAVID'S.



G.R. De Witte del et lith.

Mintem Bros imp.

LOWER CAMBRIAN FOSSILS FROM ST. DAVID'S.

fended the Survey nomenclature by reference to the then received definition of Syenite and Greenstone, terms still imperfectly understood and applicable to the main mass of the rocks in question, though possibly subsequent closer examination and new sections may have rendered some modification of the boundary line desirable. He was prepared to allow the metamorphic origin of all rocks of the classes under consideration, but did not think there was sufficient evidence to show that the divisional planes in the Syenite and Greenstone of St. David's were due to original stratification; but they might correspond rather to the great joints of most granites. Mr. Hughes pointed out that the conglomerate contained fragments of the hornstone and quartz of this older series, which he considered was probably part of an old ridge or shoal, possibly of Laurentian, but certainly of Pre-Cambrian age, and thought that there were slight differences in the lithological character of the beds on either side, such as might be explained on this supposition. He agreed with Prof. Ramsay in thinking that there was evidence of the proximity of land in early Cambrian times, but was not prepared to refer these red rocks to inland seas or lakes as opposed to open sea; the whole seemed rather the deposit of an open sea encroaching during submergence. He did not attach very much importance to the restriction of genera to limited horizons in these older rocks of St. David's; for, as it was reserved for Mr. Hicks to discover these fossils after so many other observers had examined the district, he anticipated that further researches must certainly result in finding links which will connect together more closely beds the stratigraphical relations of which seem to indicate so clearly an unbroken though varying series.

Mr. GWYN JEFFREYS had been struck by the intercalation of non-fossiliferous beds from time to time among the fossiliferous beds described in the paper. Beds now in course of formation contained also very few, if any, organisms, apparently in consequence of the great deposits of mud brought down by rivers and redeposited in certain parts of the sea-bed. That this was the case had been proved by recent dredging-operations both in the Atlantic, off the coast of Spain, and in the Mediterranean.

Mr. BOYD DAWKINS called attention to the extension of the Mollusca, Annulosa, and Mollusca, deep down in the Cambrian rocks, and yet without any trace of their convergence. The origin of life might be as far removed from that period as was the Cambrian from the present time. The difference in the colours of the rocks he was inclined to refer to the different degrees of oxidation of the iron they contained, which might supervene in a comparatively short time.

The Rev. W. S. SYMONDS had, in visiting the spot, been much struck by the rocks, at that time termed Syenite, which he believed might be an extension of those on the Carnarvonshire peninsula, and which he thought supported the whole series of the Cambrian rocks, so that they might after all be the Laurentian, the same as

those of Sutherlandshire and Assynt. If this were the case the nomenclature of the Geological Survey would have to be altered, and the rocks of Pistyl and Holyhead no longer termed metamorphosed Cambrian rocks, but Laurentian.

Mr. HICKS, in reply, stated that the quartziferous breccias forming the central ridge contained so many rolled pebbles, and were, moreover, in places so distinctly bedded, that there could be no doubt of their being sedimentary. Other beds, described as Greenstone in the maps of the Geological Survey, were also distinctly laminated. The non-occurrence of fossils in the more sandy beds he attributed to their having been deposited in very shallow water. The fossils occurred principally in fine-grained beds of a flaggy nature.

2. *On the AGE of the NUBIAN SANDSTONE.* By RALPH TATE, Esq.,
Assoc. Linn. Soc., F.G.S.

MR. BAUERMAN, in a recent number of the *Quarterly Journal of this Society* (vol. xxv. p. 27), has discussed at some length the opinions advanced respecting the age of the sandstone strata underlying the Cretaceous limestones, and resting upon the granitic and schistose rocks, in Sinai. These rocks belong to the same series of sandstones described by Russegger as occurring in Egypt, Nubia, and Arabia Petræa, under the name of "Nubian Sandstone."

Though the facts that I have the honour to submit to the Society may be stated in a few words, yet it seems desirable to recapitulate briefly the views that have been advanced as to the period of deposition of the strata in question, the better to explain away those inferences which are so much at variance with my own.

In the first place, it appears, from the circumstance of the Nubian Sandstone being overlain conformably by approximately horizontal strata of Cretaceous age, that this formation has been regarded, in the absence of palæontological evidence to the contrary, as forming part of the Mesozoic group of rocks. Thus Russegger colours and describes it as Lower Cretaceous in his maps; and Bauerman, guided by the lithological similarity of its strata to the Lower New Red Sandstone about Chester, has placed it on the horizon of the Trias; whilst Figari Bey seems to have regarded the tripartite arrangement and lithological features of the series as sufficient tests by which to assign the whole to the Trias, "taking the limestone as representing the Muschelkalk, although the evidence for this determination (other than lithological character) is not very clear"*.

In the second place, the fossils which have been obtained from the limestone separating the sandstone into two great masses are, for the most part, fragmentary, in bad condition, or otherwise undeterminable. Hence the palæontological evidence is of a most con-

* Bauerman, *loc. cit.* p. 27.