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THE GEOLOGICAL SOCIETY.

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W. Salter, Esq., W. Chambers, Esq., C. Buchanan, Esq., and J. C. Cunningham, Esq., were elected Fellows of the Society.

The following communication was read:—

On the Silurian and Associated Rocks in DALECARLIA, *and on the Succession from Lower to Upper Silurian in* SMOLAND, ÖLAND, *and* GOTHLAND, *and in* SCANIA. By Sir RODERICK I. MURCHISON, G.C.S., V.P.G.S. &c.

PLATE I.

HAVING already communicated the additional knowledge I obtained last year (1845), concerning the drift and erratic blocks of Sweden*, I propose in this memoir to give the results of the examination of those palæozoic and associated rocks in several parts of that country which fell under the joint observation of my friend M. de Verneuil and myself during the same period.

Two of the districts under review have not been critically examined since they were described by Hisinger; and his memoirs being in the Swedish language, with which few persons are familiar, and having been written before the palæozoic classification

* See Quarterly Journal of the Geological Society, vol. ii. p. 349.

was established, no apology is required for the present attempt to group correctly all the ancient sedimentary deposits in those tracts, and to show what additions have been made to our knowledge of them by recent researches *.

In a memoir communicated to this Society in the year 1844, and in the first chapter of the work on Russia, I endeavoured, partly by personal exploration, and partly by the inspection of fossils in the Museums of Stockholm and Christiania, to group the palæozoic masses with Lower and Upper Silurian strata. But as an additional survey could not fail materially to improve my acquaintance with these deposits (particularly as I was on the last occasion accompanied by my able associate, M. de Verneuil), I now place the main results of our last tour before British geologists. These results coincide with the general view of the Scandinavian succession which was before propounded, and which is clearly developed near Christiania in Norway. But I have still to describe peculiar features which exhibit, on the one hand, the rupture and isolation of the strata in Dalecarlia and Scania, and on the other, the unbroken and symmetrical succession of the *whole Silurian system* which Scandinavia affords, and which is exhibited in sections proceeding from Smoland on the main land of Sweden, through the great islands of Öland and Gothland.

The sedimentary strata to be described occupy three tracts topographically distinct and distant from each other:—1. Dalecarlia and the adjacent districts in the north; 2. a part of Smoland and the adjacent islands of Öland and Gothland; and 3. Scania, the southernmost part of Sweden.

In all these tracts Silurian rocks abound, and in the northernmost of them (as in Norway) there are also vast thicknesses of Old red sandstone. These deposits (like others which I have previously described in Norway and the western and central parts of Sweden †) are separated from each other by great regions of crystalline rocks, the chief masses of which, as before demonstrated, are of *azoic* characters and of age anterior to the lowest fossiliferous strata.

Not pretending to be able to describe in detail, the various characters of the crystalline rocks in the vast intermediate spaces, I have not attempted to give a coloured map of the districts under

* Professor Eichwald of St. Petersburg visited Gothland about three years ago, but although he has alluded to its organic remains, he has given no sections of the island. In the last summer, and two months before M. de Verneuil and myself went thither, the island was examined in some detail by Col. Helmersen, whose account of it has been communicated to the Imperial Academy of Sciences of St. Petersburg. Whilst this author, the chief fossils of whose collection we examined at St. Petersburg, entertains ideas resembling those we have adopted, in believing the beds to be on the whole equivalents of the Upper Silurian, there is a point of some importance as to the details of succession which will be discussed in the sequel, on which I differ from my distinguished friend and fellow Academician.

† See Quart. Geol. Journ., vol. i. p. 468, and Russia in Europe, vol. i. p. 15.

consideration; and as my sole object at present is correct classification and not topographical accuracy, the precise limits of such deposits are left to be subsequently defined by Swedish observers. At the same time, whilst it is hoped that the accompanying diagrams (see Plate I.) will sufficiently illustrate the chief phænomena and the order of the strata, the reader will do well to refer to Forsell's map of Sweden*.

1. *Dalecarlia and the surrounding country.*

The portion of Dalecarlia in which transition rocks are known to occur (from the descriptions of Hisinger accompanied by a detailed map), includes the extensive parishes of Rättvik, Ore, Orsa, Mora and Sollerön; or in other words, it is the country circumscribed by and in parts extending beyond the Lakes Siljan, Orsa-sjön, Skatunge, Oresjön and Garsjön. These lakes, fed by streams from the higher country, are nothing more than expanded and gently meandering tributaries of the great river Dal-Elv, which flowing from west to east to the south of Fahlun, finds its way, through other and smaller lakes, to the Baltic Sea south of Gefle.

Bounded on the south, the east and the north by regions of gneiss and other slaty crystalline rocks, as well as intercalated granites and greenstones of different dates, the chief palæozoic rocks of this tract of Dalecarlia form merely a ragged belt surrounding a dome of porphyry. Surrounded by the lakes in question, this dome is a nearly circular mass of about twenty English miles in diameter, the inner portion of which has been left blank upon the geological map of Hisinger. From all that we could ascertain by examining its edges, or by information from persons who have penetrated further than ourselves (there being no roads in the greater part of these woodlands), this district is occupied by granitic as well as porphyritic rocks, which, to judge from the evidences that fell under our notice, must all have been erupted, or at all events were thrown up posterior to the deposit of the Silurian strata, and probably after that of the Old red sandstone.

The crystalline central dome-shaped mass rises to about a thousand feet above the sea, and contains some small upland lakes or tarns. On the whole, this tract is geologically analogous to the central masses of the Christiania district already described, wherein porphyritic, hypersthenic and younger granitic rocks have burst through, and dislocated the Silurian strata.

In the Table attached to his Map, Hisinger has correctly represented

* I must here express my great obligations and those of my friend to Baron Berzelius, who not only furnished us with Hisinger's district maps, but also gave us every facility for examining the collections under the superintendence of Professor Mosander and Professor Lovèn, and further made us known to M. Sefström and M. Weggelin. The latter gentleman, who has examined the rocks of Dalecarlia in some detail, gave us some useful notes respecting them.

the presence of three members of the sedimentary deposit, viz. sandstone, lerskiffer (black schist) and limestone, but does not state whether they were accumulated in that ascending order. Indeed, without the knowledge that has since been obtained concerning the true order of these formations in Britain, Russia and other countries, and its application to less disturbed districts of Scandinavia, no one could venture to form even a well-founded conjecture of the Dalecarlian succession. Thus, although the chief members of the lower sedimentary strata are clearly referable by their fossils to portions of the Lower Silurian group, they are here more insulated than in any part of Europe I have examined; no example having yet been detected of more than two contiguous sub-groups whose relations are determinable. After this preliminary notice, I will now briefly describe a few natural sections which indicate these dislocations.

The low country adjacent to the eastern shore of the Lake Siljan is covered with debris (in parts a perfect Os); but a little above the hamlet and post-house of Uitby, and thence ranging along to the farms of Alsarby (see Plate I. fig. 1), courses of limestone and shale (*c*) are exposed on the lane sides and in the farm-yards, the beds being nearly vertical as you ascend the hill, but less highly inclined at a lower level. These strata consist in parts of thin-bedded, earthy limestone with shelly way-boards, in some parts of red and in others of grey colour, in which the large *Orthoceratites duplex* (*O. communis*, His.) and the *O. trochlearis* occur, together with the gigantic *Asaphus tyrannus* (nob.), (*A. Heros*, Dalm.), *A. expansus*, *Orthis calligramma* and other forms. These fossils leave not the slightest doubt that the strata in question are identical with those of the chief limestone at Kinnekulle, which there, as in numerous other tracts, form the central or principal mass of the Lower Silurian group of Sweden. But the relation of this limestone to inferior or superior deposits is invisible; the slope towards the lake being entirely covered up with detritus, whilst between the calcareous ledge of the higher hill of granite (*q*) there is also a rough talus of angular fragments of that rock.

Seeing, however, the vertical and dislocated position of the beds, which here range from N.N.E. to S.S.W., in conformity with the general outline of the shoulders of granitic rock on the east, and further observing that this latter (*q*) is a red unstratified younger granite or granitello, the masses of which *in situ* are visible at a few paces from the limestone, little doubt was entertained, on our very first inspection, that the granite (*q*) had been protruded posterior to the limestone (*c*)—a conclusion to which we were led by all the other sections we made.

In the lower country, extending from Uitby to Rättvik and in the valley to the north, the shale inferior to the limestone is visible, whilst at Rättvik the limestone again crops out. Following the outline of the lake and passing another promontory of granite which cuts off the limestone and here advances nearly to the water, the ground beyond it on the west subsides into the low fertile holm of

Skärberga. The strata on the shore are there seen to consist of the same limestone as that which occurs at Uitby and Rättvik, but the dip is entirely changed. The beds being inclined only 22° to 25° to the N.W., expose in successive ledges a thickness of 40 or 50 feet of limestone; the uppermost being of red and green mottled colours with marlstone, and the central or thicker beds (1 to 2 feet each) of deep red tint. These beds are loaded with gigantic Orthoceratites (*O. duplex*), some of which are more than 3 or 4 feet in length, and with these are associated other fossils, including *Lituites convolvens*, a form well-known in the Lower Silurian rocks of St. Petersburg.

At the adjacent hamlet of Vickarby and between that place and Oya, shale and limestone are to be observed, but not in juxtaposition; the former a black schist (lerskiffer) on the banks of a rivulet north of the road, the latter on the high road to Mora, and about three-quarters of an English mile beyond Vickarby, where a rock similar to that before described, but containing a few fossils, is seen in highly inclined strata, striking east and west, and at only ten paces from the granite from which it dips away rapidly to the S. and S.W.

In all the hilly and rugged tract which intervenes between this spot and Mora nothing is observable save the detritus of granitic and other crystalline rocks; and though faint traces of the Lower Silurian beds are visible near Mora and Vika on the western side of the Lake Siljan, I will at once refer to the natural sections exposed in the isle of Soller, near the western extremity of the lake of that name, as they are among the best which can be observed in this region, for the purpose of developing the relations of the different beds of the Lower Silurian rocks to intrusive granite.

This isle, about a Swedish mile or nearly six English miles in length from S.E. to N.W., consists in its south-eastern part of that variety of granite (composed of greenish-white and pink felspar, mica, quartz and hornblende) which is called "granitello" by the Swedish mineralogist Erdmann. This mass, rising to about 200 feet above the lake, is flanked at lower levels towards the N.W., first by a band of limestone and next by one of sandstone.

The church and chief portion of the village stands on the north-western edge of the granite, and a very little below them, limestone, identical with that of Vickarby and chiefly of a reddish colour, is seen in a sloping plateau inclined to the N.W., W.N.W. and N.N.W. at angles varying from 5° to 14°. This red rock affords the usual Orthoceratites (*O. duplex*); whilst a grey and greenish variety, found at a somewhat lower level, is charged not only with *Orthis regularis* and *O. moneta*, but also with the *Sphæronites aurantium*, a species of Von Buch's family of Cystidea, which at Kinnekulle and elsewhere in Sweden, as at Petersburg, is typical of the Lower Silurian formation.

A single traverse of these strata on one parallel might lead to the belief that the granite was the fundamental rock of the isle, and that next to it in ascending order of age came the great Orthoceratite limestone and Sphæronite beds, and lastly the sandstone, which

lies in the low promontory to the N.W. By passing, however, along the granitic escarpment and by tracing the junction of that rock with the sedimentary strata, we saw that such an interpretation was fallacious.

The dip is there found to vary according to the form of the masses of granite against which the beds of limestone abut; and by following these beds to the N.E. it is at length clearly seen, that the granite has been irregularly thrown up against the edges of different beds of limestone which have been folded and contorted around the intrusive rock in different directions. We also observed, that instead of passing under the sandstone, the limestone was cut off by a line of fault parallel to the granitic scarp, which so ranges athwart the isle as to come up to the limestone on the N.E. shore of the isle. This fault probably ranges downwards into those bituminous schists (lerskiffer) which in so many parts of Sweden lie beneath the Orthoceratite and Sphæronite limestone, and surmount a sandstone which is the fundamental Silurian rock in all other tracts of Sweden where the strata lie undisturbed (the Slepsten or whetstone of Dalecarlia). One or two small quarries of this whetstone are visible in the low grounds, and it is, as elsewhere, a fine-grained whitish and yellowish sandstone with a few flakes and patches of green marl. Though much traversed by diagonal joints, the strata present no other appearance of inclination or disturbance; for the quarries lie at some distance from the granite.

The transverse section (Pl. I. fig. 2) sufficiently explains the relations of the rocks in the isle of Soller. 1st, the sandstone (*a*) is the same which almost invariably underlies the bituminous schists in other provinces of the kingdom; 2nd, the place of the bituminous schists is occupied by a fault, indicated by a line of morass, peat, bog and water; 3rd, the red Orthoceratite limestone and the grey Sphæronite rock (*c* and *c**) really form the uppermost strata of this isle, the granite having been irregularly upheaved through them.

In following the Lower Silurian limestone northwards to Orsa, the red Orthoceratite beds are seen at Watnäs in a vertical and highly elevated position, striking N.E. or N.N.E. and S.S.W. This calcareous ledge, rising out from beneath a gradual slope of detritus towards the lake of Orsa on the west, is succeeded on the east by many rolled fragments of conglomerate and porphyry. On ascending however to the hill top or ridge of the Degeberga, we observed in a rugged mountain road (and for more than an English mile) a succession of peculiar strata whose strike was conformable to that of the Orthoceratite limestone, and also highly inclined (see Plate I. fig. 3).

Some of these beds (*x*) are undistinguishable from quartz rocks; others resemble highly crystalline hard red sandstone; others, again, might be mistaken for what would usually have been called grauwacke grits and fine conglomerates, the whole being more or less thin-bedded and containing some strata passing into cherty and flinty masses, and others into hornstone, &c. These highly inclined and altered beds are thrown off by syenitic granite (*q*), which seems to

pass on the north into a porphyry. The natural inference from this section (if it occurred in an undisturbed region) would be that the beds of sandstone and conglomerate were of older date than the fossiliferous Lower Silurian rocks; but subsequent observation rendered this point very doubtful. By following the Orthoceratite Silurian limestone upon its strike to the N.E., it was evident, that upon the shoulder of the Degeberga above Wängsgårde, the porphyry of that mountain (a red felspathic rock) was in absolute contact with the limestone, which is there a thin-bedded rock, having somewhat the aspect of marble, but still offering no very distinct evidence of having been altered. That the strike and inclination of these beds had been deranged and changed by the invasion of the eruptive rock was made more evident, by trending the flank of the headland of porphyry which sweeps eastwards from the valley above the vale of Orsa, where we found that the limestone also changed its direction and wheeled round to the E.N.E., the strata dipping from 50° to 75° to the N.N.W. In one spot, indeed, we observed the edges of the calcareous strata expanded over a width of not less than 250 paces on the slopes of the hill or between the porphyry and the lake; both the red Orthoceratite rock, the gray and green limestone with Lituites and other fossils being exposed. Again, between this spot and the valley of the Ore we saw (near the village of Enon) portions of a black schist charged with Graptolites and a very minute Orthis, which seemed to overlie the limestone, a small advanced promontory of which we detected in a highly inclined position striking across the brook above the bridge from N.N.E. to S.S.W. But on ascending the banks of this stream (which is not marked either in the maps of Forsell or of Hisinger), we looked in vain for any connection of those masses with the great body of Orthoceratite limestone higher up the hill to the south. The stream is seen to run through a gorge of porphyry, the protrusion of which has evidently dismembered the strata. Here, as elsewhere then, we had to decipher the probable original relations of mere detached fragments of the Silurian rocks, and all that we could determine from their character and fossils was, that as a whole they clearly belonged to the Lower Silurian group. We next proceeded along the central dome of eruptive rocks (porphyry in one part and granite or granitello in another) on its northern and eastern faces, first by ascending the Ore Alf from Orsa to Skatunge, and thence by following the road from the latter place to Ore, Osmundsberg, Böda and the waterfall called Styggfors, in order to connect if possible the whetstone and shale of the valley with the well-known horizon of the Orthoceratite limestone*.

Judging from the deep incoherent sands, devoid of nearly all other detritus, which occupy the lower part of the valley, and have the appearance of being nothing more than the disintegration of the whetstone or "Slepsten," that rock may be presumed to form the basis of the lower and undisturbed portion of this tract. For, on

* From the mouth of the river Ore this whetstone is largly exported, being conveyed by the Orsa and Siljan lakes to different parts of Sweden.

proceeding a few miles and ascending to Skatunge, we reached quarries of the whetstone, in one of which the reddish or pinkish variety is obtained, and in the other the usual fine white sandstone. This rock is very irregularly bedded, traversed by innumerable devious joints and affected by slickensides. Though of pinkish and reddish colours, the fine-grained, soft, non-micaceous character of the rock was quite the same as that which characterizes the Lower Silurian sandstone in many parts of Sweden where that rock (as previously shown*) forms the base of the fossiliferous series, like which it is here charged with flakes and spots of whitish and greenish clay, and is occasionally irregularly laminated with white and greenish-white lines.

At Skatunge, or a mile only in advance of those quarries, but at a higher level, the "Slepsten" or fine sandstone is no longer visible, and its place is apparently occupied (see Pl. I. fig. 4) by a red felspathic porphyry (*p*), regularly bedded and jointed, striking east and west (in conformity with the outline of this portion of the porphyritic dome), and dipping 60° to the north. The succession on the dip is obscured for a short distance; but on the grassy slopes and fields below the village calcareous and sandy beds with Orthoceratites and other fossils (*c*) are overlaid by black shale, the whole dipping north and being conformable to the porphyry (*p*), by which they have unquestionably been thrown off.

As if to add to the confusion within the area of dislocation, we observed on the road hard micaceous flagstones, perfectly unlike the soft whetstones described, which the peasants had extracted from the adjacent low hills, where, as in Norway, they are associated with porphyry; and as these rocks were wholly unlike anything seen in the Silurian series of other parts of Scandinavia where the relations are clear, and were undistinguishable from well-known specimens of Old red sandstone in Norway where its position is distinct, we began to infer that these as well as the highly inclined beds of red sandstone and conglomerate seen near Wattnäs (Pl. I. fig. 3) might belong to that formation, to the abundant presence of which in another part of this country I shall presently allude.

But although most of the porphyry of this tract, like the "rhombic porphyry" of Norway, has evidently been protruded after the deposit of the Old red sandstone, it must be observed that near Mora we found a very large rolled block of a hard coarse red conglomerate containing fragments of porphyry, thus showing that there must also have existed a rock of that character which had been consolidated anterior to the accumulation of the Old red sandstone. Some of these porphyries, as in Pl. I. fig. 4, may, therefore, have been formed contemporaneously with the Lower Silurian or protozoic strata†.

* See Quarterly Journal of the Geological Society, vol. i. p. 15; and Russia and the Ural Mountains, vol. i. p. 15 *et seq.*

† According to M. Erdmann of Stockholm, who kindly explained his views to me, there are three chief varieties of porphyry only in Sweden; viz. felspar, hornstone, and jasper porphyry, each of which has been erupted posterior to the primary or azoic rocks.

In travelling from Skatunge to Ore we crossed a tract marked as limestone by Hisinger, but that rock is no way visible from beneath coarse detritus (as far as we could observe), except in the bed of the stream, which at about three English miles east of Skatunge flows from the porphyry dome or plateau into the lake of Skatunge. The bridge by which the road crosses this stream at a spot called Lada-Oken, is arched over upon ledges of red Orthoceratite limestone, which there dip to the N.N.W. at 15°, but on ascending the bed of the rivulet amongst a chaos of fallen trees and rank vegetation, the same beds were found to be completely wrenched round even in a hundred paces, dipping first to the east and afterwards to the E.S.E.

These strata doubtless owe their contortion to the influence of the contiguous porphyry, which a little further east (in the tract called Ruttberge) rises and occupies the surface of the higher grounds in a multitude of small spherical domes. No sooner were we on these hard knolls than we observed their surface to be striated in the manner described in my last communication, and here most unquestionably the direction of the striæ was from N.N.W. to S.S.E., the direction which the great mass of the drift has taken in this part of Sweden.

These rounded porphyry knolls are miniature representations of the entire dome, around which the fragmentary masses of the Lower Silurian rocks can be traced. In one spot we observed (almost in contact with the porphyry) a compact, finely-laminated ironstone, which the peasants had begun to break into, in hopes that it might prove of value; and this rock, in almost horizontal strata, graduated into a hard, flag-like, red, micaceous sandstone*, evidently a portion of the same rock to which I have previously adverted, and which here (as in Norway) seems to be intimately associated with the porphyry, the elevation and outburst of which have also broken up the symmetry of the Silurian deposits.

Leaving the porphyritic dome or plateau with its red sandstone and passing southwards, we found ourselves in an undulating tract, which, extending along the western shores of the lake of Ore (Ore-Sjon) from Furadal by Ore to Dalby, and thence by Osmundsberg to Böda and Rättvik, is usually void of crystalline rocks *in situ*. Wherever the fundamental rock can be discovered beneath the detritus, it consists of Lower Silurian strata, similar, or nearly so, to those on the other sides of the crystalline dome. In these fragmentary masses, however, other links in the chain of a Lower Silurian group are detected, which we had not yet observed in this tract. Thus, at Furadal, at the northern end of the Ore Sjon,

* In the wild forests north of Skatunge inhabited only in summer by shepherds &c., and into which we did not penetrate, we were informed that there was much sandstone as well as limestone. Having cross-questioned the peasants, we clearly ascertained that they perfectly distinguished what they called sandstone (undistinguishable from our Old red) from the "Slepsten" or whetstone which is a Lower Silurian rock; and it is therefore probable that the Old red occupies a large tract to the N.E. of the great porphyry region of Elf Dal, as I shall presently show it does to the west thereof.

which we reached by passing through deep sands (similar to those of the Ore Elf, and probably like them derived from the decomposition of the bottom sandstone or "Slepsten"), we obtained from M. Classen* some specimens of Trinucleus in black schist (one approaching very near to *Trinucleus Caractaci*), as well as other Lower Silurian fossils; but here as elsewhere no connexion between the beds could be detected; the limestones and black schists with Trinucleus being only discernible in fragments which have either been rent asunder by eruptions or buried under superficial detritus.

Further southward, Osmundsberg is an insulated, tabular-crowned hill, rising to the height of 498 feet above the adjacent lake of Ore, or 1272 Swedish feet above the sea, and lies about two or three English miles to the north of Böda†.

When I first cast my eye over this hill (the summit of which is about an English mile in its longest diameter) I thought it must afford some explanation of the relation of the limestone, of which its upper part is composed, to the surrounding lower tract; but even here no clear sections could be obtained, owing to the slopes being covered with detritus. To the west, as well as on the eastern and southern sides of the hill, the limestone presents bold cliffs in which no clear stratification is visible; the hard and crystalline rock conveying the idea that it had been partially affected by heat.

But to whatever extent it has been altered, the limestone is here and there charged with fossils, which when examined left no doubt of its age. Without such search, and judging from its grey colour and resemblance to some of our English mountain limestone, as well as from its profusion of imbedded Encrinites, a field geologist, if brought suddenly to the spot, might well have pronounced it to be of carboniferous age.

The fossils however that we collected at Osmundsberg were all Lower Silurian forms, viz. *Illænus crassicauda*, *Asaphus expansus*, *Orthis parva*, *O. moneta*, *O.* n. sp., *Leptæna sericea* and *L. imbrex*, with some undescribed species, a few corals, and many Encrinites. As the rock in which these fossils occur occupies the summit of a nearly horizontal plateau (see Pl. I. fig. 5), and as the sandstone or whetstone (*a*) is seen, though in fragments only, in the surrounding low country, the inference would clearly be, that if the rolled debris on the slopes of the hill did not obscure a junction, the limestone (*c*) would be seen to repose, as in other parts of Sweden, on black schist with some limestone, and the latter on the light-coloured sandy rock as a base.

That this is the true succession in this region was sustained by the evidences which are afforded in the picturesque gorge of Stygg-fors near Böda, two or three English miles to the south of Osmundsberg (Pl. I. fig. 6). There, one of the branches of a stream which works several small mills, issues from the edge of the plateau

* The director of the iron-works at Furadal.

† The slight descent of the waters from this rocky region of Dalecarlia to the Baltic has been noticed in the memoir previously read upon the superficial accumulations of Sweden (see Quart. Geol. Journ., vol. ii. p. 374).

or dome of eruptive rock (which here has a granitic character) (*q*), and falls over ledges of sandstone (*a*), which although highly altered and quartzose when in contact with the granitic rock, becomes at the distance of a few paces a hard quartzose representative of the light-coloured whetstone, and is overlaid by finely laminated dark gray shale (*b*)*. The shale, which is considerably expanded in this locality and is present in highly inclined strata, contains nodules of argillaceous limestone, and resembles the strata which overlie the Lower Silurian sandstone along the Omberg on the Wettern Lake, formerly described by me†. It may be fairly inferred that these rocks constitute the base of the Lower Silurian group in this tract, because the strata plunging to the south and east are followed in these directions by a considerable breadth of Orthoceratite limestone, which is confluent with the strata before alluded to in the environs of Rättvik, beneath which lie the shale and sandstone, as seen in the bed of the Dragsjon.

On reviewing, then, all the natural evidences which can be collected from this confused and broken district, the geologist who has made himself familiar with the mineral characters, fossils, and order of the strata in other parts of Sweden, necessarily concludes that all the fossiliferous beds which are visible in detached and insulated localities around the dome of erupted rocks above mentioned, or which come out from beneath much crystalline and transported detritus in this part of Dalecarlia, belong to the Lower Silurian group, and are referable in ascending order to the sandstone, bituminous schist, Orthoceratite limestone and Graptolite schist of other parts of the country; the only exceptions being certain sandstones and flagstones, which from evidence, to be given in the sequel, are supposed to belong to the Old red sandstone.

Tract of Porphyry and Old Red Sandstone in Elf Dal and on the lake Wenjan.

If doubts might exist in the tract above described whether the conglomerates, quartzose bands and flagstones which there occur at intervals, may represent the Old red formation, there can be little hesitation in considering the sandstone of the Lake Wenjan, which is intercalated in the adjacent porphyritic country on the west, to be of that age.

But even there misgivings might be entertained (so hidden are the relations), if it were not, that in the adjacent tracts of Norway rocks of precisely the same character overlie true Upper Silurian rocks. Now, throughout Dalecarlia, as in other parts of the main-

* The chief stream at this spot, which issues from the crystalline plateau, is precipitated over a hard siliceo-felspathic rock, of which I did not bring away specimens, and concerning which I have no notes, but my impression is that the mass is an altered sandstone. Rushing through rents in the rock the water cascades into a deep abyss, excavated in black schist with calcareous nodules. We detected no fossils in our visit to this picturesque scene.

† Quarterly Geological Journal, vol. i. p. 477; see also 'Russia,' &c., vol. i. p. 17.

land of Sweden, in which these rocks occur (with the exception of Scania), Lower Silurian rocks only are visible, and the strata which I refer to the Old red sandstone seem, in all these tracts, to have been deposited next in succession without the intervention of the Upper Silurian strata.

The red sandstone in question is separated from the Silurian rocks by a rugged range of porphyry covered with dense woods, whose sides are so loaded with debris, that in a few situations only is the solid rock visible. Of the forty to fifty varieties of porphyries and crystalline rocks (including syenite, syenitic granite, serpentine, &c.) which are worked into ornaments and polished at the works of Elf Dal which we visited, but three or four are taken from rocks *in situ*. These quarries afford the dark and purple porphyries which are so well known over Europe, and of which beautiful monuments occur in the Royal Gardens and public places of Stockholm. We ascended from the valley of the Elf river through heaps of porphyritic detritus, to visit the quarries of Bliberg, which are opened on the southern face of the summit of hills, whose outlines are formed of domes, rising to 700 or 800 feet above the sea. At Bliberg, the porphyry, which is cut down vertically to a depth of about thirty feet, and horizontally for about 100, has a dark purple base filled with small crystals of white felspar, and is traversed by vertical joints, the faces of which strike 10° east of north: these joints are cut by rectangular planes (the beds of the quarrymen) which incline very slightly (5°) to the north. Though the rock is of exceedingly uniform composition at this spot, the very same range of hills a little to the west contains a light red and different porphyry, whilst to the east, at only a very short distance from Bliberg, it passes into the syenite or granitello of Gärberg*.

Thus, in the ridges of the Elf Dal, as in the great dome-shaped mass between the Siljan, Orsa and Skatunge lakes before described, one portion of the same rocks (all erupted posterior to the palæozoic age) is a porphyry, and another a granite. This fact is, indeed, completely in harmony with what was specially alluded to in my memoir on the environs of Christiania, where various kinds of porphyry†, syenite, granite and greenstone, all integral parts of the same

* It is from this rock that the Swedes are now cutting the monument to be erected at Stockholm to the memory of Charles XIV.

† By a letter recently received from my distinguished friend Leopold von Buch, I learn that after a careful analysis, M. Gustaf Rose has determined the peculiar rock of Ringerigge near Christiania, with large rhombic crystals of glassy felspar (the rhomb-porphyr of Von Buch), to be an augite rock. The analyses of this skilful mineralogist, when added to those of Berzelius and others, may doubtless ultimately define the true composition and characters of crystalline rocks, and enable us to group them more precisely than has hitherto been possible in their respective families; but can such nomenclature be shown to have reference to geological relations, by marking distinct eruptive rocks as peculiar to particular æras of disturbance? If certain granites, porphyries and greenstones were (as I believe) erupted at the very same time, and if in the very same ridge all these rocks are so collocated in reference to bedded strata that they must have been erupted simultaneously or nearly so, this distinction of M. Rose, as far as I now understand it, would seem to be rather mineralogical, than historical or geological.

range of hills, have perforated, and in some cases overflowed, both the Silurian rocks and the Old red sandstone of that territory.

In addition to an excursion into Elf Dal, we threaded the porphyry range which separates the Siljan from the Wenjan Lake, passing by the iron forge called Siljan-fors to the glass works of Johannisholm, situated at the south end of the last-mentioned sheet of water.

The sides of this lake, whose length is about seven miles from N.N.W. to S.S.E. and its mean width about a mile and a half, are of no great altitude. The outline on the western shore is however much more pronounced and elevated, and consists either of porphyry, which, as seen in the buttresses near Johannisholm, has a grey felspathic base enclosing small crystals of black hornblende, or else of a red porphyry with greenish and grey crystals. This latter rock, like the red porphyry alluded to near Skatunge, is as regularly stratified and jointed as any sedimentary rock, its strike being nearly north and south, and the beds either vertical or dipping at 70° to the west.

Enclosed between these porphyry ridges on the west side of the lake and those of Siljan-fors, which range up to Elf Dal, is a considerable breadth of sandstone, which, from its characters and intimate association with the porphyry, is, I have no doubt, of the same age as the rocks at Ringerigge near Christiania, and the equivalent of the Old red sandstone of Britain*. This sandstone, which constitutes in fact the western bank of the lake, is there dislocated and piled up in the remarkable manner described in a previous memoir. The rock is with difficulty observed as a solid mass *in situ*; but from the points at which we detected it, as well as from information we received from the Magister Westrom, that the rock is extensively quarried at Wenjan, it would appear that throughout a great space it is nearly horizontal.

That such is the position of the fundamental rock might, indeed, also be inferred from the fact, that throughout the space of the few miles which we travelled amid its numerous and colossal angular fragments the sandstone exhibited no varieties, all the specimens being referable to the same stratum; whereas, if the beds had been inclined, we ought to have met with conglomerates, flagstones and thick-bedded hard sandstones, &c., similar to the succession which the formation presents in Norway, portions of which rocks I have already adverted to as occurring in the district east of Mora†. Here the sandstone is uniformly a finely laminated, slightly micaceous hard rock, and is for the most part of mottled light red and grey, red, green and yellow colours. In short, it is undistinguishable from some well-known forms of the British Old red sandstone, like which,

* These relations having been incorrectly expressed in a woodcut published in the first volume of the Quarterly Journal of the Geological Society, the reader is referred to the second volume of that work, Part ii. p. 71, and to 'Russia in Europe and the Ural Mountains,' vol. i. p 13.

† See a further account of these angular blocks, Quart. Journ. Geol. Soc., vol. ii. p. 374.

the fine lamination of its alternating laminæ of different colours is a striking character, when exposed in the vertical edges of the joints or backs of the stone, whilst a transverse blow sometimes gives a conchoidal fracture, in which no lamination is visible. Besides these more compact beds, others which are more micaceous split into flagstones and expose ripple-marked surfaces. Now, whilst this rock cannot be distinguished from the Old red sandstone of Great Britain and Norway, and is here, as in the latter country, encased between masses of porphyry, it is wholly unlike any member of the Silurian rocks of Scandinavia, and is in every respect dissimilar, since the latter consist of soft non-micaceous fucoid sandstone and arkose, which form, as I have shown, the fundamental deposit of the protozoic series of Scandinavia. My belief is, that whenever the north of Sweden shall be correctly explored, this Old red sandstone will be found to have a very considerable extension; for I was informed that the rock extended for many miles (forty to fifty miles English) northwards from Wenjan into tracts where there are no roads, and where, in fact, owing to impassable forests, the country can only be examined by ascending the streams and lakes.

How far the sandstones which exist in large expanses in the region immediately to the north of Dalecarlia may be of this age I am not prepared to say, but the Lower Silurian rocks, including vast sheets of red Orthoceratite limestone, are largely expanded around Ostersund*, and as these are surrounded by vast breadths of red sandstone, also associated with porphyry, I am disposed to believe that the relations must there be the same as those in Dalecarlia; a suggestion, it is right to state, which could not have been ventured upon if I had not previously made myself acquainted with the precise relations of the Silurian and Old red formations of Norway in their normal positions.

Before dismissing the consideration of the Old red sandstone of the north of Sweden, I may allude to the red sandstone and conglomerate of Gefle, which we examined on our return from Dalecarlia to Stockholm. Occurring on the south bank of the river at Gefle, in a width of about one and a half English mile, this rock ranges from the sea on the N.E. to the lake called Storsjon on the S.W., or along a space of about twenty English miles. In that low country, no part of which rises much above the sea, and which is to a great extent either covered by detritus of rocks or by rich clay

* A knowledge of this fact I owe to M. Henry Gahn, a young Swedish geologist, with whom we fell in on his return from Ostersund, as we were proceeding from Furadal by Dalfors and Alfta to Gefle. In respect to the region which lies to the W. and N.W. of Dalecarlia, I learnt from M. Erdmann, that red sandstone, associated with porphyries, ranges along the mountains which form the banks of the Western Dal Elf to Hormundsjon, and which in the hills between Tisjon and Arefors trend from N.N.W. to S.S.E., and are consequently parallel to the band of Wenjan. Red sandstone occurs also largely in the mountain of Stadjan, and much higher up this drainage and 3904 feet above the sea, where it is said to alternate with schist or slaty clay, and is highly indurated near its contact with the greenstone of Idresjon. The northern boundaries of this sandstone are unknown.

and loam, this sandstone is nowhere (as far as we could ascertain) exposed as a solid rock *in situ*; but being found at intervals, and exclusively along the zone defined, in large untravelled, angular slabs and broken fragments, the rock is extensively quarried both for millstones and building-stone, and was largely used for the latter purpose in constructing the base of the royal palace at Stockholm.

Whether this slightly micaceous reddish and pinkish sandstone be referable to the Old red (Devonian) system or to the Lower Silurian, I am not prepared to decide. If time had permitted, the question indeed might possibly have been determined by a visit to the islands off Gefle, where there are limestones with Lower Silurian fossils, and where it is possible that the relation of the sandstone to such fossiliferous strata may be determined. In the meantime, knowing that all this country is very little elevated above the sea, and that ancient gneiss or azoic rock appears in numerous promontories all around, and further, seeing that several varieties of this sandstone had much more the characters of an arkose, or rock regenerated from the gneiss, than any portion of the Old red sandstone properly so called, I am at present rather disposed to believe that it will be found to be of Lower Silurian age.

Mines.—In taking leave of Dalecarlia and Helsingland, it may be expected that I should allude to the several mining points which we visited, viz. Fahlun, Bisberg and Danemora, and which lie between those northern tracts and the country of Upsala and Stockholm.

As however the first and last of these mines, the one famous for its copper ores, the other for its magnetic ores, have been described in detail by other authors, I can scarcely pretend to offer much that is new respecting places at which we only remained a very short time. Still I may state that both these mines appeared to me to occur in crystalline rocks more ancient than the Silurian system.

At Fahlun, the gneiss, or rather mica schist, and its associated quartzose and felspathic rocks, are so traversed by veins, the surface is so strewed over with loose blocks (adverted to in my last communication), and the mounds of refuse materials are so large, that, independent of mining statistics and details, and the occurrence of some beautiful minerals, there is little to interest the geologist.

At Danemora (though surrounded by ancient granitic gneiss) the prevailing rock in which the magnetic iron occurs is a quartzose felspathic rock, which the Swedes term Helle-flinte. M. Erdmann's analysis has proved that it contains at least 10 per cent. more silica than compact felspar rock, being composed of 70 per cent. of silica, the remainder consisting of alumina, with some soda, and about $\frac{1}{2}$ per cent. of lime. That author, who is disposed to think that some of the Swedish iron ore lies in beds, admits that it here occurs as a sort of vein of irregular form, but contends that as it occupies troughs, and has always been found to be based on schists, it cannot (like the magnetic iron of the Ural Mountains, described in the work on Russia) be considered as pertaining to the class of eruptive rocks.

In these splendid open mines or quarries, which have been worked for 400 years, and into which the workmen are seen descending in

buckets to depths of 80 and 100 fathoms, nothing is to be observed that can authorize the separation of the rocks in which they occur from the primary or azoic class. At the same time it must be stated, that crystalline white limestone, partially used as a flux, folds over here and there in the irregular contortions of the mass, and seemed to me *to be cut by the veins* of magnetic iron, some of which are ninety feet wide. These iron masses vary, containing from 40 to 80 per cent. of the metal. The chief vein has a devious direction from N.N.E. to S.S.W., and hades 70° to the W.N.W.*

The mines of Bisberg near Säter occur in what M. Erdmann terms a mica schist composed chiefly of quartz and mica, though much felspar rock also appears. Judging from the splendid open cuttings or chasms from whence the magnetic iron has been extracted, and also from the appearance of laminæ of deposit in the ore, my first impression was that the ore laid in beds which strike with the strata from N.E. to S.W., and dip to the S.S.E. at 80°. But after all it seemed impracticable by slight observation to determine that these are true beds of ore; for in following the mass underground (which we did not), it may, I apprehend, be found to traverse the strata in a slightly oblique direction. At all events, judging from the ancient walls of the rock alone from whence the ore has been extracted, I came to the conclusion that, although more or less parallel to the highly inclined strata of mica schist, it must be considered a true vein. In fact, besides crystals of calc spar, hornblende, quartz and other minerals, films of earthy serpentine and finely polished slickensides occur upon the walls of the parent rock from whence the iron ore has been extracted (some of these masses being charged with magnetic iron), thus leaving little doubt that here, at all events, the metalliferous matter has resulted from an action of an eruptive nature, which had penetrated the body of the rock, chiefly indeed between its laminæ of deposit, but long after its original formation. In short, I completely agree with Baron Berzelius, that however much some of the Swedish metalliferous products may at first sight appear to lie in beds, they all belong to true veins.

2. *Coast of Smoland, and Isles of Öland and Gothland.*

The large and fertile islands of Öland and Gothland, which lie to the east of the province of Sweden, called Smoland, have long been known to consist chiefly of ancient or transition limestones. In a former memoir, as well as in the work on Russia, I have endeavoured to show, that whilst Öland, lying near to the mainland, is composed of sandstone, schist and Orthoceratite limestone (*i. e.* of the same Lower Silurian strata known in other portions of Sweden), Gothland, situated nearly in the middle of the Baltic Sea, is a true Upper Silurian deposit. This conclusion was indeed arrived at solely by the inspection of the fossils and the evidences given in the

* So powerful is the magnetic attraction, that my compass was here carried round 35° to the west.

works of Hisinger, as the localities had not yet been visited by English, French or German geologists. The first addition we were enabled to make to our previous knowledge of these tracts was by discovering along a large portion of the coast of Smoland, extending from the north of Monsteras to the south of Calmar, a light-coloured, whitish sandstone, precisely similar to that which I have previously described in the contiguous provinces of the mainland (Kinnekulle, Lügnos, &c.), and this sandstone, lying upon azoic and granitic rocks, is surmounted by black aluminous schist and Orthoceratite limestone. The tract of Smoland occupied by this lowest bed of the Silurian system of Sweden, is so low, and has so few natural features which can expose the subsoil, that the sandstone itself is not, I believe, to be seen *in situ* at more than one locality.

The inhabitants of the district have, indeed, no reason to go to the expense of excavating quarries; for, with the exception of a few *osar* containing water-worn northern detritus, nearly the whole surface of the country, along a distance of many miles, is strewed over by large angular fragments of the sandstone, affording ample materials for working into millstones, building-stone, &c. As this sandstone is identical with that which partly occupies the western shores of the Isle of Öland, and as the mainland, extending to the west, the north and the south, consists of gneiss and ancient granitic rocks, there can be no doubt that all this sandstone of the low seaward promontories of Smoland is merely dislocated and broken up *in situ*, and was formerly in connection with a similar rock in Öland; the narrow channel between that island and the mainland having since been excavated in this deposit. (See Pl. I. fig. 7, *a*).

On reaching the port of Calmar, we were prevented by a violent storm from reaching Öland, where it had been our intention to inspect the exact relations of the sandstone and the overlying schist, which is largely used for the extraction of alum, as well as the Orthoceratite limestone, which is extensively quarried and exported both for lime and as an ornamental marble. These rocks (all slightly inclined to the E.S.E.) having however been correctly laid down by Hisinger in a geological map, accompanied by an account of the order of superposition, and the fossils having been examined by us in numerous collections, we felt less regret in not having been able to accomplish our object. In fact, the succession in Öland is so symmetrical and unbroken, and its limestone is so clearly of Lower Silurian age, that no doubts can be entertained concerning it. This rock contains the *Orthis calligramma* and *Illænus crassicauda*, both of which typify the Lower Silurian rocks of Scandinavia, Russia and England, together with *Orthis moneta*, *Asaphus expansus*, the well-known *Orthoceratites duplex* or *communis*, *O. trochlearis*, with the Cystidea, *Echino-sphærites pomum*, *E. aurantium* and the *Sycocystites granatum* (V. Buch); all these species characterize rocks of the same Lower Silurian age in various parts of Sweden and the Baltic provinces of Russia, and have nowhere yet been found in Upper Silurian strata.

Öland exhibits, in fact, the same normal ascending succession of

nasteries of the once-flourishing Hanseatic city of Wisby, stand upon different ledges of the rock. They there constitute an undercliff, the site having evidently been chosen on account of numerous springs of pure water which flow out upon the subjacent shale. The Wisby limestone is, for the most part, a grey subcrystalline mass passing in numerous points into marble†, in which abundance of Upper Silurian corals are visible; but with the exception of corals and encrinite stems, which occur profusely, other fossils in good preservation are less frequently obtained in the limestone than in the argillaceous way-boards and underlying nodular shale.

In order to convey a just idea of the structure of the northern division of Gothland, I have prepared two diagrams. The first of these (Pl. I. fig. 8) is a sectional view of the coast extending from Hög Klint to Lummelund, as seen from the cliff, which is vertical and higher than in any other part of the island. The second (fig. 9) is the detailed section of the same High Cliff, or Hög Klint. The lowest beds (*e*, fig. 9), extending to the water's edge, consist of dark grey shales, from thirty to forty feet in thickness, with nodules of limestone, and perfectly resemble the Wenlock shale of Britain. In these the *Terebratula plicatella* and *T. prisca* are very abundant, together with *Leptæna depressa*, *Spirifer cardiospermiformis*, *Orthis elegantula*, Dalm., a *Leptæna* approaching to *L. sericea*, and many well-known Wenlock species, both of shells and corals, including in the latter a multitude of Cyclolites.

The next strata (*f*), forming a projecting ledge midway in the cliffs, are reddish encrinital limestones, in beds three or four feet thick, very much resembling certain red and pink varieties, worked for marble along the Wenlock edge; these beds graduate upwards into the uppermost mass (*f**), a hard grey limestone containing large irregular concretions, like the ball-stones of Wenlock and Dudley, which, as in England, descend into and apparently cut out the bedded rock.

From the angular masses of limestone which had fallen on the beach below, we collected, in addition to the fossils above-named, the following corals: *Catenipora escharoides*, *Favosites Gothlandica* (most abundant), *Stromatopora concentrica*, *Cystiphyllum helianthoides*, *Porites pyriformis*, &c., together with *Euomphalus funatus*, *E. alatus*, and two or three species of Crinoidea, &c. These fossils (the same group occur at Cappelhamn and at Lummelund on the

† The limestones of Gothland have served in ancient time for the construction of the numerous beautiful Gothic churches with which the island abounds, and many of the porticos of these churches exhibit varieties of marble which have been formed into slender pillars and highly wrought and elaborate capitals. An archæologist would indeed reap a rich harvest in spending a summer month or two in Gothland, where not only amid the magnificent monastic ruins of its capital, Wisby, but also in many of its striking parish churches, he would find some fine types of early Norman and mediæval architecture, all easily accessible, and for the examination of which the kind and hospitable Governor, General von Hohenhausen, the Baron Fock, the intelligent English Vice Consul, M. Enequist, the Magister Söderberg, the Countess Schærer, and others I could gratefully refer to, would afford him every facility.

north) would be quite enough to fix the age of these rocks as being the same as the limestones of Wenlock and Dudley. The collection in the town of Wisby is indeed so amply supplied with fossils from the surrounding localities as to render quite certain the identification of the limestone and shale of the north of Gothland with the Wenlock limestone and shale of England. In short, I doubt if in any other quarter of the globe two synchronous deposits can be found, which, 900 miles apart in a straight line, are so closely assimilated as the Wenlock and Wisby limestones, both by mineral characters and fossil contents.

Thus, among the Wisby Encrinites is the remarkable *Hypanthocrinites decorus*; among the Trilobites, the *Calymene Blumenbachii*; among the Orthoceratites, the *Orthoceratites annulatus* and *O. ibex*; and among the Euomphali, the *E. rugosus* (*E. catenulatus*, Dalm.), together with the *Pentamerus galeatus*, *Atrypa tumida*, and numerous other shells, whereof a list is annexed, which are typical Wenlock forms.

On the east coast of the northern part of Gothland we visited the bay and port of Slite with its promontories and islands, where the same rock is burnt for lime, and whence it is largely exported. This rock, nearly as white as chalk when viewed at a distance, exhibits in its interior very much the same general appearance as certain varieties of the Wenlock limestone of England, wherein concretions or "ball-stones" of greenish, greyish and pinkish colours, and loaded with corals, encrinites, &c., are irregularly wrapped round by partings or way-boards of greenish or ash-coloured shale.

It is on the western shore of the fine land-locked bay of Slite, that portions of this rock stand out in those grotesque masses of limestone which were rudely figured by Linnæus in the description of his tour in Gothland. These rocks of Länna are in fact dismantled portions of former hard coralline reefs, the earthy and softer portions of which have been worn and washed away. The highest of these masses may be from thirty to forty feet high, and they consist of the small concretionary, coralline, marble-like limestone of pinkish and grey colours, each great mass being, in fact, a huge ball-stone traversed by irregular lines of fracture, and presenting in one point of view the appearance given in the drawing (Pl. I. fig. 10).

Whilst however not a shadow of doubt could exist (even before our visit) respecting the age of the great mass of limestone and shale of the north of Gothland, the interesting point before alluded to remained to be determined, namely whether the southern and south-eastern portions of the island that terminate in the rocky promontory of Hoburg might not (as I had supposed) be referred to a still higher member of the Silurian system, and be in fact the equivalent of the Ludlow formation of Britain. To answer this question, M. de Verneuil and myself, escorted by Baron Fock, travelled from Wisby to Mount Hoburg and the adjacent tracts.

The general results of our survey are explained in the diagram (Pl. I. fig. 11); though it must be understood that this section, extending over a distance of about fifty miles in a very flat region, is

clear at certain points only, the most remarkable of these being at Hög Klint, Klinte Berg, and from Grötlingbo to Mount Hoburg.

To the south of Hög Klint and along its inland continuation, called Tofta, the surface of the ground, *i.e.* the limestone (*f*) (much obscured by northern drift and local calcareous detritus), declines gradually to the south into the depressions of Sandviken or Vestergärn and the bay of Klinte. At the latter place, the low country extends for some distance eastwards and E.N.E. into the island, and by numerous wells sunk for water, as well as by the heavy surface-soil, the substratum of this valley is known to be a greenish grey shale, very similar to the shale both above and below the Wenlock limestone in England.

This central Gothland shale (*g* of section) more resembles the Lower Ludlow rock than the Wenlock shale; since by certain sinkings it has been found to contain argillaceous flagstones. These shale-beds are distinctly overlaid by a bold ledge of limestone, Klinte Berg, which presents an escarpment sixty or seventy feet high above the plain, and trending from W.S.W. to E.N.E. At Djupviken on the coast, where the shale crops out from beneath the limestone, it is found to contain the *Calymene Blumenbachii* and several very minute Trilobites, with *Terebratula prisca*, *Leptæna depressa*, *Delthyris cardiospermiformis*, *Delthyris* or *Spirifer crispus*, *Atrypa tumida*, and Orthoceratites.

The overlying limestone (*h* of section, fig. 11) (and we examined its summit and sides transversely for two or three English miles) is at least sixty feet thick, and contains in its central and massive parts abundance of Pentameri (the *Gypidia conchidium* of Hisinger), associated with *Terebratula Wilsoni*, *Terebratula prisca* or *affinis*, and numerous corals, including *Catenipora escharoides* and others, of which the *Favosites Gothlandica* and the *Porites pyriformis* constitute entire reefs. The uppermost stage of this limestone is a perfect congeries of Encrinites, the large stems of which are occasionally very striking. This succession presents, then, a decided distinction between the beds of Klinte and those of Wisby and Hög Klint, where the encrinite band specially occupies the lower part of the limestone (see fig. 9).

As a local distinction between the limestones of Wisby and Klinteberg it may be noted, that the uppermost ledge of the latter is made up of Encrinites in flagstones, whilst in the sections near Wisby (fig. 9) these fossils abound in the lowest strata of the limestone.

Although the strata are here what would be called horizontal, they appeared to me to hang slightly to the S.S.E., and the form of the escarpment, which runs E.N.E., transversely to the longitudinal axis of the island, together with the gentle slope of the land southwards from the summit of this escarpment, favour this view.

We had not time at our disposal to visit the adjacent islands of the Great and Little Charles (Stora and Lilla Karlsö), which lie off this western shore of Gothland; but we saw their bluff escarpments sufficiently well in a bright autumnal day, to perceive that each of their summits consisted of tabular limestone reposing on shale like the rocks of Klinteberg on the main island.

Now, if it be asked, whether the limestone of Klinteberg can be separated, as in the general section, fig. 11, from that of Wisby and Hög Klint, I reply, that in the absence of positive proof of superposition in this flat region, I have only ventured to do so from the preceding and following balance of evidence.

Whilst, as already stated, the surface of the limestone of Wisby and Hög Klint declines gradually to the south, and apparently passes under the shale and limestone of Klinteberg, distinct proofs will presently be given of a positive succession to younger strata in the southern and south-eastern parts of the island. My belief therefore, as drawn from this analogy, is, that the limestone of Klinteberg (*g*) and its underlying shale (*h*) stand in the place of the Aymestry limestone and its underlying British stratum, the Lower Ludlow rock.

This suggestion is sustained by the collocation in the Klinteberg of abundant Pentameri, very closely allied to *P. Knightii*, with *Terebratula Wilsoni*, fossils which have not been observed in the northern masses of limestone. Moreover, we found in the shale at Klinte (or at Djupviken near it) the *Orthoceras Ludense* and *O. annulatum*, both of which species in England are chiefly found in the shale beneath the Aymestry limestone. These, with other Orthoceratites peculiarly characteristic of the Lower Ludlow rock of England, occur also at Grogarn and Kathamarsvik on the eastern or opposite side of the island in this parallel. These zoological facts, combined with the lithological changes above-stated, induce me therefore to repose confidence in the belief that the strata are arranged in an ascending series from N.W. to S.E.

But besides these fossils, so typical of the Aymestry and Lower Ludlow rocks, there are, it must be admitted, other shells, such as the *Leptæna depressa*, *Terebratula plicatella*, and numerous corals, which are identical with those of the northern or Wisby limestone. Such however is the case in England also, there being very few Aymestry or Lower Ludlow fossils which have not been detected in the Wenlock formation of Siluria.

On the whole therefore I think that the Klinteberg strata are on the parallel of the central and lower parts of the Ludlow rocks.

Passing from the environs of Klinte southwards to Burge, we next travelled over a flat tract covered with detritus and osar; but having reached Grötlingbo, we found solid strata at the surface of a plateau about seventy feet above the sea. Here, at all events, it was at once evident, from the lithological aspect of the rocks alone, that we had reached a formation essentially different from any which we had seen in the northern and central parts of the island. (See Pl. I. fig. 11, *i*.) In the common to the south of the church of Grötlingbo, quarries have been pretty extensively opened in the rock, which unlike the crystalline limestone of the north is a peculiar sandy calcareous grit, with beds and inosculating courses of a white pisolite, in parts a perfect oolite, and these beds graduate downwards into strata of very fine-grained, finely laminated and slightly calcareous earthy sandstone, having a yellowish exterior and a bluish nucleus, the beds of which thicken downwards.

In these strata, particularly in the sandy limestone and oolite, we speedily procured numerous specimens of the shell figured by Hisinger as the *Avicula retroflexa*, and repeated by me in the 'Silurian System.' It was the occurrence of this fossil which formerly led me to suppose that the southern end of Gothland would be found to differ from the mass of the island, and would eventually be placed in the parallel of the Ludlow rock, in which that striking shell occurs in England. When we fairly determined on the spot, that this species of Avicula was undistinguishable from that of Britain, and further saw that it was here, as in England, associated with the spinose *Leptæna lata* or *Chonetes sarcinulata*, a fossil never found in any inferior Silurian strata, whether in Northern Gothland or in England, and also that these shells were mixed with other forms of Avicula, Cypricardia and Turritella equally unknown in the northern limestones of Gothland, but strikingly representing the collocation of shells of the Upper Ludlow of England, there was no longer any doubt that we had pursued an ascending section from the north, and were now fairly amid the equivalents of the Ludlow rocks of England. Among the other Ludlow rock fossils, Mr. Sowerby has since my return to England identified the *Terebratula pulchra*, *Cypricardia retusa*, *Pleurotomaria articulata* and *Turbo corallii* of Grötlingbo with species of the Upper Ludlow rock. We here also found fragments of Trilobites and a small Battus or Agnostus, identical with the *A. tuberculatus* published in the 'Silurian System' from the Downton Castle building-stone of the Ludlow rock*.

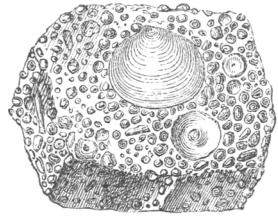
In this district we soon indeed obtained positive proof, that the beds dip to the south, though the inclination is so slight that no indication of it can be detected in a single locality.

The quarries of Grötlingbo, where the peculiar shelly oolite and sandstone occur, are, as before said, about seventy feet above the sea; but on descending from them and passing southwards for four English miles along the marine bay called Bursvik, the same beds of calc grit, oolite, pisolite and sandstone (containing the very same shells) are next detected, close to the little port of Bursvik, at a height of not more than twenty feet above the sea; whilst near the promontory of Hoburg, a few miles further south, they are actually on a level with the water. The diagram (fig. 11) explains therefore, by stratigraphical evidence, that the Upper Silurian oolite and sandstone (*i*) dip away from the great masses of limestone and shale (*e*, *f*, *g*, *h*), of which the central and northern portions of the island are composed, and distinctly pass under the limestone of Hoburg (*k*).

These quarries at Bursvik and Mount Hoburg have been long opened, and they are the only valuable sources in the island for the extraction of free-stone, which is available for building and roofing purposes and for whetstones. This fine and slightly calcareous psammite is as greedy of water as portions of the Ludlow rock, like which it increases astonishingly in weight upon exposure to

* This crustacean, I would here observe, is distinct from the *A. pisiformis* of the Lower Silurian rocks.

moisture, as formerly pointed out by Linnæus, when he spoke of the *Conchistriati* and *Entrochi* of this locality. In the quarries of Bursvik the best sandstones are separated from each other by thin courses of shale, and though they here and there present casts of shells, it is chiefly in the overlying or pisolitic bed that these occur; viz. *Cypricardia retroflexa*, *C. reticulata*, *Leptæna lata*, with a beautiful *Lucina*, which seems to have escaped the vigilance of Hisinger, and which we willingly dedicate to that persevering Swedish geologist, who is entitled to much commendation for his various works, geological and palæontological (*Lucina Hisingeri*, Murch. and De Vern.).



Lucina Hisingeri.

LUCINA? HISINGERI: *a smooth lenticular shell, with the apex inclined rather forward and slightly curved.* It is a matter of regret that neither the inner surface nor the hinge has been seen, consequently the genus is doubtful.

Between Grötlingbo and Bursvik the sandstone and oolite are not overlaid by any rock, and with the exception of a few large northern blocks and some blown sand, which partially obscure the surface, this barren and treeless district is characterized by its stone walls of sandstone and its pisolitic oolite.

This external aspect might well indeed have led to a geological mistake; for anyone who did not examine the fossils and had not learnt their position in the palæozoic series by comparison with the structure of other countries, might naturally have referred these strata to the oolitic series. The coarser oolite or pisolite of South Gothland is, in fact, scarcely distinguishable from the pea-grit of the inferior oolite of Cheltenham, and the finer-grained rock is mineralogically the same as numerous specimens of the middle and upper oolites of Britain, or of the tertiary oolites of Styria.

This error was committed by Hisinger, in his general map of Sweden*, and the same author having published a true Jurassic or Lias Ammonite as pertaining to this district, the erroneous view was for a time entertained by other European authors.

With respect to this Ammonite, we were informed by the best authorities in Stockholm that it was not found in any stratum of

* Hisinger's petrographical map of Gothland, on the contrary, conveys an opposite view, viz. that the limestone is the same from north to south, and directly overlies the sandstone of Bursvik and Grötlingbo. The latter was therefore considered by that author to be the fundamental rock of the island, instead of being the uppermost as here represented.

Gothland; but whether transported thither, or simply misplaced and mislabelled in a museum, it must, after the preceding description, be obvious to every geologist that no such fossil can have had a place in the rocks charged with the true Upper Silurian forms which are found throughout the southern mass of Gothland, extending from Bursvik on the north to Hoburg Point on the south.

Hoburg Head, though not the *mountain* spoken of by Linnæus (for it seemed to us at no point to exceed 200 feet in height), is still a bluff bold headland, particularly when viewed on its southern and western faces, which are washed by the sea†.

Its lower strata, as represented in the diagram (Pl. I. fig. 12, *i*), consist of the sandstone above-described, only visible at low tides in the form of flag and tile-stones; the lower beds of sandstone rising to the north being only apparent a little to the north of the Hoburg Head, where they are quarried. The next stratum (*i**) is a small concretionary limestone, representing in a very coarse form the pisolite and oolite of Bursvik and Grötlingbo, and containing some of the same fossils. The rock marked (*k*) is a mass of coralline limestone, a perfect breccia or plexus of corals with earthy partings forty feet thick: among other shells we found in it the *Avicula retroflexa* of the inferior pisolite also in this band. The next stratum (*k**) is an encrinite limestone forty feet thick, with few or no corals. This uppermost stratum is a hard marble of red, greenish or greyish and white colours.

The limestone of Hoburg, which unquestionably overlies the sandstone and pisolite of Grötlingbo and Bursvik (fig. 11) as seen in various hills of this southern peninsula in the parishes of Vamlingbo and Sundre, certainly contains two or three species of shells and numerous corals identical with those of the north of Gothland. But the great mass of the Wenlock shells are no longer found in it, their place being taken by other species; whilst the corals *Catenipora escharoides* and *C. labyrinthica*, so characteristic of the inferior strata, no longer appear. It is also to be observed, that in addition to the Ludlow fossils‡ above-mentioned, we here find the *Leptæna Fischeri* (nob.), a species belonging to the unquestionably Devonian system of Russia.

Considering then the order of succession and the fossiliferous contents of this southern promontory of Sweden, I must beg to differ from those who have previously visited it, including my distinguished associate in the Imperial Academy of Sciences of St. Petersburg, Colonel Helmersen, who preceded us in our last summer's survey. Seeing that the limestone of Hoburg Head was very full of certain species of Upper Silurian corals, and even contained two or three species of shells similar to those of the central and northern parts of this island, he, in common with previous authors, concluded,—1st, that the chief calcareous mass of the island is everywhere identical;

† It has a fine cavern on one of its northern faces.

‡ A specimen of *Homalonotus* has also been found in the Hoburg promontory, and is to be seen at Copenhagen.

and 2ndly, that the sandstone of South Gothland underlying such limestone, was necessarily the oldest rock in the island. When however the limestones of North and South Gothland are closely compared, the essential distinctions both in fossils and superposition above-described, fortify me in the belief, that Hoburg is unquestionably of younger age than the north-western and central masses of the island.

In every section in the northern part of the island, whether on the coast or in the interior, the great limestone, as already explained, rests on shale charged with Wenlock shale fossils, whilst the limestone of Hoburg stands at once upon pisolite, oolite and sandstone, containing a group of Ludlow rock fossils which have nowhere been found beneath the Wenlock limestone. Thus stratigraphical, lithological and zoological evidences combine to support my view. Again, if the sandstone and oolite were so low in the series as Hisinger and Helmersen suppose, why should we have no traces of such rocks and fossils in that part of the series in other parts of Scandinavia?

At Kinnekulle and all other places, whether in Sweden or in Norway, where an ascending series can be continuously observed, the Lower Silurian limestones, wherever I have seen them, are covered by great thicknesses of Graptolite shale; but nowhere is there a trace in that horizon of oolites and peculiar calc grits and sandstones similar, either in lithological or zoological aspect, to those of the south of Gothland. The truth then seems to be, that this being the only tract in the Swedish kingdom where an ascending series is traceable so far upwards as to pass gradually from rocks loaded with Wenlock fossils into others in which Ludlow forms predominate, we might reasonably look for a peculiar *facies* of the rocks. An oolitic structure having long been known in some of the carboniferous limestones of England*, and having since been shown to exist in the Devonian rocks of Russia, we now simply extend the demonstration downwards, and indicate that similar arrangements of calcareous particles took place in the Upper Silurian strata as in succeeding periods; the fact is however interesting as indicating the most ancient oolites hitherto known, and may eventually be of value in leading to the establishment of just theories respecting the origin of certain inorganic phænomena.

Should the preceding view of the succession in Gothland be sustained, it would appear that in the northern and central parts of the island, where the limestone and shale have the same characters and the same relations to each other as in the typical districts of the Wenlock limestone of England, a striking identity or similarity of fossils is coexistent in the two countries; whilst in the southern extremity, where the higher strata assume in part a different lithological structure and are terminated upwards by much purer calcareous masses than at Ludlow, we are presented both with some remarkable species hitherto only found in that formation in England, and with

* See 'Silurian System,' p. 120, for a description of the oolite of the Clee Hills.

a few species common to other limestone tracts of the island, associated with a few forms undistinguishable from Devonian types.

Thus Colonel Helmersen discovered two specimens of the *Calceola sandalina*, a shell hitherto exclusively found in the Eifel and Devonian limestones. This fossil was found on the south-eastern shore in the limestones of Lansberg, which though somewhat to the N.E. of Grötlingbo, probably belong to the same overlying group as the remaining portion of the south of the island. At that point the higher plateau extending from the shore towards the interior (across which we walked), resembles a shingle beach chiefly made up of loose corallines, but beneath these loose fossils lies a blue-hearted, sandy, thin-bedded limestone, which considerably resembles the forest marble of the British oolite; whilst the inland cliff overhanging taluses of gravel and detritus, to which I have alluded in a previous memoir, is a hard breccia-like agglomerate with few traces of bedding.

In a region so flat and so obscured in many parts by drift and local detritus, it is truly no easy matter either physically to connect or to dissociate the portions of the island in the manner attempted in the ideal general section (fig. 11); for corals reappear everywhere in the limestones; and the coast cliffs, which are so bold and striking from the south of Lummelund to the Hög Klint (see figs. 8 and 9), there subside into broken taluses which slope down into bogs, morasses and lakes, it being at certain points only—those especially to which I have alluded—that any clear order of superposition can be traced. I trust, however, that the evidences elicited along the east coast are sufficient to demonstrate, that the lowest stratum in the island is the Wenlock shale, and that the highest is a sandy and calcareous equivalent of the Upper Ludlow rock, with indications of a passage into the Devonian group.

I subjoin to this description a list of the Upper Silurian fossils of Gothland. The list however includes only the shells, Encrinites and Trilobites; the corals, which are very numerous, being under examination by Mr. Lonsdale. These it is intended to publish in a separate memoir; and the argument will be found greatly strengthened when their additional evidence is produced. The species in this list marked with an asterisk (*) have been determined by Mr. Sowerby from specimens brought away: the others were identified on the island by M. de Verneuil.

It is necessary to observe that the localities Hög Klint, Paper Mill and Wisby, may all be considered synonymous with North Gothland; Klinte and Djupviken are in Central Gothland; and Grötlingbo, Bursvik and Hoburg in South Gothland.

List of Upper Silurian Shells, Crustacea and Encrinites of Gothland.

Name and author.	Place. This refers to the Specimens in the Table only.	Situation in the series given in the 'Silurian System.'							
		Upper Ludlow.	Aymestry.	Lower Ludlow.	Wenlock limestone.	Wenlock shale.	Lower Silurian.	Russia.	
Actinocrinites moniliformis, *Miller*	Hoburg ... Bursvik ...	...	...	...	+				
Cypanthocrinites decorus .	N. Gothland..	...	...	...	+				
Terebratula semisulcata, *Dalm.*	N. Gothland.								
—— pulchra, *Sil. Syst*....	Grötlingbo ...	+							
—— plicatella, *Dalm.* (lacunosa, *Sil. Syst.*) .	Hoburg ... Hög Klint .	+	...	+	+	...	...	+	
—— reticularis, *Linn.*, T. affinis, M. C.	Grötlingbo . Klinte	+	+	+	+	+	+	+	
—— cuneata, *Dalm.*	N. Gothland..	...	...	...	+				
—— Wilsoni, M. C. ...	Klinte ..... N. Gothland	...	+	+	+	...	...	+	
—— marginalis, *Dalm.* (imbricata, *Sil. Syst.*)	N. Gothland...	...	...	...	+	+			
—— canaliculata, *Dalm.* .	N. Gothland.								
Pentamerus conchidium *Dalm.*	Klinte	...	+ ?	+ ?	+ ?	...	...	+	P. K nightii Sil. Syst.
—— galeatus, *Dalm.*.....	N. Gothland..	...	...	+	+	+	...	+	
——? (Atrypa) didyma (*Dalm.* Ter.)	N. Gothland..	+	+	+	+	...	...	+	
Pyrtæna baltica, *Dalm.* ...	S. Gothland.								
pirifer? ptychodes.....	S. Gothland ?.	+							
—— ? trapezoidalis.....		...	+	+	+	+	...	+ ?	
—— ? Pisum	N. Gothland..	...	...	...	...	+			
—— crispus ?.....	Grötlingbo ...	+	+	...	+	+			
—— caudatus	N. Gothland.								
—— cardiospermiformis *Dalm.*, Ter. biloba., *Lin.*	N. & S. Gothland	...	...	...	+	+			
—— radiatus (lineatus, *Martin*)	N. Gothland..	...	...	+	+	+	+	+	
—— sulcatus, *His.*	N. Gothland.								
—— octoplicatus	N. Gothland..	...	...	...	+				
Atrypa? tumida, *Dalm.*, tenuistriata, *Sil. Syst.*	Klinte ..... N. Gothland	...	...	...	+	+	...	+	
—— prunum, *Wahlenb*....	N. Gothland..								
Orthis pecten, *His.* non *Linn.* nec *Sil. Syst*....	Grötlingbo.								
Carried forward		6	6	8	16	9	2	9	

Upper Silurian Shells, Crustacea, &c. of Gothland (continued)

Name and author.	Place. This refers to the Specimens in the Table only.	Situation in the series given in the 'Silurian System.' Upper Ludlow.	Aymestry.	Lower Ludlow.	Wenlock limestone.	Wenlock shale.	Lower Silurian.	Russia.	
Brought forward.....		6	6	8	16	9	2	9	
Orthis demissa? *His.*? ...	Hoburg.								
—— elegantula (canalis, *Sil. Syst.*)	Grötlingbo . Hög Klint .	...	...	...	+	+	+	+	Very rare in Gothland.
—— calligramma (callactis, β. *Sil. Syst.*) ...	Paper Mill . N. Gothland	...	...	...	...	...	+	+	
—— sp. nov.?	Grötlingbo.								
Leptæna euglypha	Grötlingbo? N. Gothland	...	...	+	+	+	+	+	
—— depressa.....	Hoburg ... N. Gothland	...	...	+	+	+	+	+	
—— sericea	Hög Klint ...	...	...	...	...	...	+	+	
—— Lepisma.....	N. Gothland...	...	...	+	...	+			
—— Fischeri	Grötlingbo ...	...	...	...	...	...	...	+	Devonian of Russia.
—— lata (Chonetes sarcinulata, *De Kon.*) ...	Grötlingbo ...	+	+	...	...	...	...	+	
Calceola sandalina (Devonian).....	Lansberg ... S. Gothland	...	...	...	...	...	...	+	Devonian, Eif N.E. Russia, and Devonshi
Cypricardia retusa?	Grötlingbo ...	+	+?	+					
—— carpomorphus, *Dal.* cymbæformis, *Sil. Syst.*	Grötlingbo ...	+							
Tellina prisca (Lucina?)..	N. Gothland.								
Lucina Hisingeri, n. s. ...	Bursvik.								
—— sinuata, n. s.	Hoburg.								
Avicula retroflexa	Hoburg ... Grötlingbo .	+	...	+					
—— reticulata.....		...	+	+	+	...	...	+	
—— small do.?.....	Grötlingbo.								
—— aptera, n. s.?	Grötlingbo.								
Euomphalus discors.....	N. Gothland...	...	...	...	+				
—— rugosus	N. Gothland...	...	...	...	+				
—— funatus	Hög Klint . N. Gothland	...	+	+	+	+	+		
—— sculptus?	N. Gothland...	...	+	+	+				
—— carinatus	N. Gothland...	...	+	...	+	+			
—— alatus, *Sil. Syst.* ..	Hög Klint ...	...	...	...	...	+			
Turritella obsoleta?	Grötlingbo ...	+							
Murchisonia corallii	Grötlingbo ...	+	+						
Turbo corallii	Grötlingbo ...	+	+						
Orthoceras ludense (communis, *Wahl.*) ...	N. and Cent. Gothland ...	...	...	+	...	...	...	+	
—— regulare.....	N. and Cent. Gothland ...	...	...	...	...	...	...	+	
Carried forward.....		13	14	17	25	16	8	20	

Upper Silurian Shells, Crustacea, &c. of Gothland (continued)

Name and author.	Place. This refers to the Specimens in the Table only.	Situation in the series given in the 'Silurian System.' Upper Ludlow.	Aymestry.	Lower Ludlow.	Wenlock limestone.	Wenlock shale.	Lower Silurian.	Russia.	
Brought forward.....		13	14	17	25	16	8	20	
Orthoceras imbricatum, *Wahl.*	N. and Cent. Gothland ...	...	...	...	...	...	...	+	
—— angulatum, *His.* (virgatum, *Sil. Syst.*) .	N. and Cent. Gothland ...	+	+	+	...	+	...	+	
—— undulatum, *His.* (annulatum, M. C.) ...	N. and Cent. Gothland ...	...	...	+	+	+	+	+	
—— trochleare, *His.* ...	N. and Cent. Gothland ...	...	...	...	+				
—— Ibex.....	N. and Cent. Gothland ...	+	...	+	...	...	...	+	
Cytherina Baltica, *Dalm.*	N. Gothland.								
Agnostus ?	Grötlingbo.								
—— tuberculatus, South Gothland (*De Vern.*)									
Calymene Rowii ? *Green.*..	Grötlingbo.								
—— bellatula, *His.*	N. Gothland...	...	...	...	...	...	...	+	Mus. Geol. S Dudley ?
—— Blumenbachii var. pulchella, *His.*	Djupviken ...	...	+	+	+				
—— concinna	Djupviken.								
—— punctata, *Brong.* non *Murch.*	N. Gothland...	...	...	...	...	...	...	+	Mus. Geol. S Dudley.
Asaphus subcaudatus ? ...	Grötlingbo ...	+	+						
—— caudatus? var. small.	Djupviken ...	...	+	+	+	+			
Homalonotus ? (of Hoburg)		+							
Cornulites serpularius ...	N. Gothland...	...	...	...	+				
		17	18	22	30	19	9	26	

General Summary.

Upper Silurian species (British)	46	
... ... (Russian)	17	
		— 63
Lower Silurian species (British).....		9
		—
Total Silurian.....		72
Devonian species		2
		—

In concluding this sketch of the islands of Gothland and Öland I may be permitted to say, that in a region where the strata deviate so very slightly from horizontality, there can be no surer indications of the general strike or direction, than the geographical outlines of the rock-masses and the successive outcrops on a great scale of their different beds. Thus, we see that the major axes of both islands* are nearly parallel and trend from N.N.E. to S.S.W.; a direction which coincides with the prevalent strike of rocks of similar age in Norway and Sweden, and is to a great extent that which prevails in the Silurian and older strata of Britain.

In Öland the low sandstone or base rock is only visible in the cliffs on the shore of the N.W. face of the island; it then disappears under the alum shale near Borgholm, and is no longer traceable along the western shore between that point and its southern extremity; whilst according to Hisinger the alum shale vanishes in its turn near the southern extremity; the extreme headland being exclusively occupied by the Orthoceratite limestone. These facts show, that whilst the island extends from N.N.E. and S.S.W., its strata subside obliquely to its general outline, and hence that their true strike is probably somewhat nearer to N.E. and S.W. and their inclination on the whole to the S.E. or S.S.E.†

Assuming that the Orthoceratite limestone of Öland was succeeded by schists with Graptolites (as it is in many parts of the mainland of Sweden), there are fair grounds for supposing, that the channel of the Baltic which separates Öland from Gothland has been excavated in that soft deposit which would be represented by the letter (*d*) in the general ascending section. Extending thence our view to Gothland, we perceive that its boldest and highest cliffs (forming its north-western shores) are very nearly parallel to the axis of Öland and consist of Wenlock limestone resting upon shale; and that these rocks occupying a great area in the northern part of the island, are succeeded by younger strata representing on the whole the Ludlow formation. An ascending order from N.N.W. to S.S.E. prevails therefore in the Upper Silurian of Gothland as in the Lower Silurian of Öland, and the inferences I have drawn from the positive evidences of fossils and lithological changes in Gothland, are sustained by the analogy of the physical arrangements of the inferior strata in Öland which contain well-known Lower Silurian types.

This view is, indeed, quite in accordance with an opinion I have for some time entertained‡, that the Baltic Sea may be considered a great Silurian trough, the lower rocks of which occupy both the Russian and Swedish mainlands, whilst the true Upper Silurian strata

* See any geographical map; or the general geological map in the work, 'Russia and the Ural Mountains.'

† In referring to Forsell's map of Sweden, it will be seen that it is precisely along the bluff cliff coast, *i. e.* the N.N.W. part of the island, that the sea is deepest, and the shore most swept of detritus, and that where the coast is lower and shelves away into sandy and gravelly bays (as around most of the remainder of the island), detrital accumulations are greater and the soundings shallower. This fact seems to strengthen the view of a geological succession from older and more elevated strata on the north and N.N.W., to younger on the south and S.S.E.

‡ See Russia and the Ural Mountains, vol. i. pp. 18*, 35*.

are only to be found in islands nearer the centre of such trough, as in Gothland on the one hand and in Oesel on the other.

Whether these Ludlow or uppermost Silurian strata ever extended upwards into others which fully represented the Devonian system, in that space now occupied by the wide sea between the Swedish island of Gothland and the Russian island of Oesel, can of course be only conjectured; but the indication of the presence of two or three Devonian species of shells and a profusion of corals common to Upper Silurian and Devonian in the southern and S.E. parts of Gothland seem to favour this hypothesis, which becomes more probable when we know that vast territories of Russia are composed of true Devonian rocks.

3. *Palæozoic Rocks of Scania.*

In the appendix to the work on Russia and the Ural Mountains (p. 646) geologists were informed, that although researches had led me to believe that the chief masses of the palæozoic strata of the continent of Sweden (certainly all those which at that time had fallen under my survey), were of Lower Silurian age, there were strong reasons to suppose, particularly from the researches of Professor Forchhammer, that patches of Upper Silurian also existed both at Aalleberg in West Gothland and in Scania. It was then stated, that this point would, if possible, be cleared up by personal observations in the course of last summer. In reference to Scania, M. de Verneuil and myself travelled from Carlscrona to Christianstad; and thence passing to Andrarum, well-known for its alum slates and their fossils, we made a transverse section across the country by Öfved's Kloster to Lund.

Owing to the flat and very slightly undulating nature of the country, the highest points of which are not 300 feet above the sea, and to wide-spreading masses of superficial clay covered with erratic blocks, &c., the succession of the strata is obscurely seen. But, whilst the relations of the different masses of any one system, such as the Silurian, are difficultly traceable, there is no tract in Sweden in which such a variety of sedimentary deposits occur. Besides the ancient granitic and slaty rocks, Scania contains both Lower and Upper Silurian strata; there are also lignite or coal deposits with many plants (which have been referred to the oolitic series as well as to the Wealden and the greensand); numerous patches of chalk occur charged with beautifully preserved fossils; and lastly, besides northern drift and erratic blocks, this district is of deep geological interest as exhibiting in its terrestrial and modern strata abundant remains of extinct animals commingled with some which now exist. In short, just as Scania first presents the aspect of Denmark, to the traveller proceeding from the north, in its people, architecture, flat surface and deep soil, so by its overlying secondary and recent deposits, it is naturally linked on to the great continent to the south of it, with which, as stated in a preceding memoir, it must have been united, when Sweden and Northern Scandinavia were to a great extent submarine and subjected to very different conditions.

4. *Silurian Rocks of Scania.*

The lowest Silurian rock of Scania, as in other parts of Sweden, is a sandstone. In parts north of Andrarum, referred to by Professor Forchhammer, it is seen in contact with the granitic and gneissose rocks, on which it rests; an order which is also exposed in the adjacent isle of Bornholm, described by that author. In our traverse from Andrarum to Lund, we could only detect this sandstone appearing at one or two spots, without visible relations to any other rock. At Andrarum, however, we were abundantly satisfied with the fine exposure of the next overlying band or alum slate*, which is there a jet-black, finely laminated schist, wholly devoid of slaty cleavage and disposed in horizontal beds. Being largely charged with sulphuret of iron, these schists are broken up for the extraction of alum. Some of the beds are slightly calcareous, and contain at intervals concretions both large and small of an earthy dark limestone, which are occasionally not less than three feet in diameter and of flattened cheese-like forms. Where this concretionary action has taken place, the pyrites is often collected into groups of crystals.

The most abundant fossils are the *Olenus paradoxides* and the *Battus pisiformis*; the latter being the same species which occurs in the British Lower Silurian rocks, whilst the former occurs in the alum slates of Kinnekulle and other parts of Sweden.

The section, Pl. I. fig. 13, explains the general relations visible in passing across this tract from east to west.

Traversing the country westwards from Andrarum through Vallarum and Fremminge, over undulating plains and low plateaus covered with detritus and boulders, it was only at rare intervals, and in a ravine or two, that we could detect the outcrop of other members of Silurian rocks; but whenever they did appear it was in the form of shale and schist, occasionally with Graptolites, but without limestone. In fact, we were assured by Professor Forchhammer, and M. Marklin of Upsala, who have sedulously examined this country, that the great limestone, with remains of Asaphus and Orthoceratites, so abundant in all other parts of Sweden where Lower Silurian rocks occur, has no existence either in Scania or in the island of Bornholm; the whole of the lower group being there represented by sandstone and schists, the latter containing some traces of black limestone. These schists however, though not divided by the Orthoceratite limestone (which appears to have thinned out), are characterized in their upper part by Graptolites, and in their lower by Trilobites, Agnostus, &c. At length we emerged from the monotonous region of mud (derived from the decomposition of these Lower Silurian schists), and at Bielo-gåard we fell in with the first limestone visible. From the aspect of this rock and its imbedded fossils, it was evident that we had reached a true Upper Silurian rock, since it contained forms of Avicula, Spirifer and serpuline

* As there is no cleavage in these rocks, the term "alum schists" or "alum flags" would be a more correct term than "alum slate."

bodies, with fragments of Orthoceratites and many true Upper Silurian corals, *Favosites* (*Calamopora*) *Gothlandica*, *F. polymorpha*, *Aulopora serpens*, with many fragments of Encrinites, &c.

This rock is an earthy, flat-bedded, grey limestone, with light grey shale, and is very slightly inclined. It is, in fact, a portion of the rock which has been worked in old quarries through the drift clay of the adjacent low plateau (Kärsbye and Skärtofta). It is in some places an absolute coral reef, loaded with many characteristic Wenlock species. In descending along the course of a little streamlet which runs from the western side of this plateau into the lake of Vomb (Vombsjon), we found the above-mentioned limestone surmounted by grey and greenish shale and hard flag-like limestone, with fragments of Trilobites, an elongated Avicula, Orthoceratites, Tentaculites, and a small Battus, (*Agnostus*) the very same species as that which occurs in the uppermost Silurian rocks of England and Gothland (see (*i*, *j*.) of Gothland, Pl. I. fig. 11 and 12). These earthy, flag-like limestones, of compact character and flat conchoidal fracture, and which are not burnt for lime, are called "Ahlsten" by the peasants, and are clearly distinguished by them from the true limestone, or "Kalksten."

The succeeding and apparently overlying rock (though no absolute junction was detected by us) is a reddish, earthy, finely micaceous sandstone, laminated with purple streaks, small quarries of which have been opened on the left bank of the little brook which works the Skärtofta mill. Though at a low level where we examined it, this rock rises into woodlands from 100 to 200 feet above the level of the adjacent lake, where it affords a fine building-stone, and in the village of Öfved Kloster it is penetrated by a red, earthy porphyry. (See Pl. I. fig. 13. p. *.)

From its red colour and association with porphyry, Professor Forchhammer was at first disposed to consider it as a representative of the Old red sandstone. After an inspection, however, of the casts of fossils which it contains in several localities, particularly to the north of our line of section, and which were submitted to us by Professor Forchhammer, I have little doubt that this sandstone must be classed as an Upper Silurian rock, of about the same age as the Upper Ludlow rocks of England; since it contains forms of Cypricardia and Avicula, with Turritellæ and the *Leptæna lata*, which cannot be distinguished from English species of that age (see also *i*, *j* in the Gothland section, Pl. I. fig. 11).

In the neighbourhood of the Ring Lake to the north of our line of section (Ringsjon), these uppermost Silurian strata further contain the *Avicula retroflexa* and the *Cytherina Baltica* of Gothland; and as in that latitude there are also black shale and limestone with Lower Silurian fossils, there can be no doubt, that there also both Upper and Lower Silurian strata exist, though I cannot define their boundaries. It is also worthy of remark, that although the true lower Orthoceratite limestone has not been detected in Scania, the *Asaphus expansus*, one of the most characteristic species of that age, is found whenever small bands of limestone of black colour are

prevalent, and thus, however the lower calcareous zone may be attenuated in reference to other districts, and however visible in patches only on the surface of this low country, the Silurian series of Scania maintains, through certain typical shells, its continental and general divisions of Upper and Lower.

To the west of Öfved Kloster the Upper Silurian rocks above-described are bounded by a depression occupied by the Vombsjon and other sheets of water, with intermediate tracts of loose sand, which depression is flanked on the west by a low ridge of granitic rocks that ranges from N.N.W. to S.S.E., *i. e.* from Hardeberga on the N.N.W. by Romele Klinte to near Skärby. This granitic ridge thus forms an axis which separates the depression with its lakes, and all the low Silurian tracts on the east, from the country of Malmoe and Lund on the west. To whatever extent covered by clay, sand, detrital matter and boulders, this latter district is presumed from certain outcrops to belong essentially to the Cretaceous series.

Though it formed no part of our object to examine in detail the secondary rocks of Scania, we should certainly (had the season not been so far advanced) have visited the coast sections to the north of Lund, where lignite coal with many fossil plants occur (notably at Höganaes), as also the patch of sandstone at Hör, or Hoer, which is loaded with fossil plants, and which, as described by Professor Nilsson, is considered by most geologists, including Professor Forchhammer, to belong to the Jurassic series, and to be possibly of the same age as the coaly strata of the eastern moorlands of Yorkshire. Nilsson is indeed of opinion that some of these plants (the most abundant of which are the *Nilssonia elongata* and *N. brevifolia* with several species of Pterophyllus) are identical with species from the Yorkshire Oolite.

But this point requires further examination, since M. Ad. Brongniart and Dr. Mantell have suggested, that the plants of Scania may belong to the Wealden formation*, and the presence of animal remains will doubtless be required before the question can be satisfactorily settled. However this may be, true chalk and cretaceous rocks are visible as detached masses in many parts of Scania, and many of their fossils have been described by Nilsson.

I may here observe that at Christianstadt we were delighted to inspect some very rich collections of fossils obtained by M. Malm from various patches of chalk adherent to the crystalline rocks around that place. This ardent young collector asserts that he has found about 300 distinct species, and nearly 200 more than have been published by Professor Nilsson.

* In his work, the 'Medals of Creation,' p. 125, Dr. Mantell, referring to the plants of Hoer, states that their general analogy to those of the Wealden led M. Ad. Brongniart to suppose that the plants in question may belong to that formation, and that M. Nilsson himself, when in England, identified some of his species with undescribed forms collected by Dr. Mantell at Tilgate.

It seems indeed to be the prevalent opinion, that the terrestrial flora which prevailed during the Jurassic series is pretty nearly the same as that which occurs in the Wealden and lower greensand deposits. Hence no safe inference can be drawn concerning the age of Hoer from an examination of the plants alone.

If among these we recognised several of our characteristic British species, we were indeed much struck with the profusion of new forms. This fact is the more remarkable considering the very small areas occupied by the chalk in Scania in reference to its enormous development in Britain, Russia, and other countries.

To the overlying erratic and modern deposits of Scania I have adverted in a former communication.

Conclusion.

In terminating this memoir, I have to remark, that the examination of certain districts of Scandinavia, made during last summer in company with M. de Verneuil, has substantiated the conclusions at which I had previously arrived by visits to other tracts of that region, and by an inspection of many collections, that the Silurian system is there most clearly separated into Upper and Lower groups, and cannot usually be further subdivided.

In Norway the Lower Silurian rocks are chiefly schists and black limestones; in large tracts of Sweden they are more expanded, and with a sandstone base containing no fossils except fucoids, and with the same alum-bearing schists as in Norway, the overlying calcareous matter expands into masses of considerable thickness, laden with Orthoceratites and Trilobites, and surmounted by black Graptolite schists.

In Russia the lower member of these strata consists of soft shales with a few fucoids only (a mere unconsolidated mudstone), which is overlaid by a sandstone and grit, sometimes a conglomerate, containing the peculiar shells Ungulites or Oboli with a few Orbiculæ. These beds, the lowest containing fucoids only, as in Sweden, and the next having small horny bivalves, are surmounted by thick beds of earthy limestone not harder than our most slightly coherent secondary strata, in which a great mass of fossils are distributed, many of them, particularly the Orthidæ with simple plaits, being typical of Lower Silurian strata in different parts of the world.

Now, with this variation in mineral characters, or in other words, with this change of the original condition of the deposit, we are presented in each region with local peculiarities of zoological development. Certain genera, and even the same species of Trilobites, Orthidæ and Orthoceratites, are indeed common to the lower group of each of these northern kingdoms; but a species which is common in the one is often very rare in the other, and each district has a greater or less number of fossils peculiar to it.

If even then within the limits of the tracts around the Baltic, where no contemporaneous eruptive operations have interfered with the deposits of this age, we find that the contents of rocks (precisely on the same parallel) vary considerably in their zoological contents, we might expect that the Lower Silurian type of Great Britain and Ireland should vary according to the conditions of deposit in districts remote from each other even in our own islands, concerning which it must not be forgotten, that the thick marine

sediments of those periods alternate frequently with various eruptions of igneously formed matter.

Comparing the lowest sedimentary masses of Russia and Scandinavia containing organic life, wherein no contemporaneous eruptive matter has been deposited, and those of Great Britain in which such matter abounds, and taking into consideration the great diversity of their lithological characters, it seems indeed to be truly remarkable, not that many species should be respectively peculiar to each country, but that so many highly characteristic groups of fossils of that early age should have co-existed in Russia, Scandinavia, North America and Britain.

Geologists have long ago admitted that the presence of certain Brachiopoda afford one of the surest base-lines for the identification of distant deposits; and knowing as I do that amid the numerous forms in the lower limestone of St. Petersburg there is no one more abundant than the *Orthis calligramma*, and that this form is also equally typical of the Lower Silurian simple-plaited Orthidæ, and that it is indeed this very species and its congeners which most abound in the Snowdon slates, I adhere to the opinions expressed in the anniversary discourse addressed to the Geological Society in 1843, and reiterated after much further observation in the work upon Russia, that there is no fossiliferous stratum of higher antiquity than the published Lower Silurian type, whether the appeal be made to Scandinavia, to Russia, or to America.

I have indeed in a former memoir given the chief results of a comparison of the most ancient fossils in these different countries, and have shown to the Society, that over tracts much larger than the British Isles, there is a strong and positive coincidence in all these strata (however different in mineral sturcture), which, reposing on crystalline rocks void of organic remains, constitute, in my opinion, the first recognizable chapter in the history of primæval life;—that period, in short, in which the strata are traceable downwards into beds charged with fucoids only, and which followed upwards abound in these former, which characterize the typical Lower Silurian rocks of Britain and other regions.

And here I would observe, that every year of additional researches, even in our own country, has led to the confirmation of this view. In the Lower Silurian rocks of Scandinavia and Russia, for example, in which calcareous matter abounds, those earliest crinoids, the Cystidea, occur in myriads; and if a geologist, arguing on negative evidence, had been disposed to consider the Lower Northern group as distinct from the Lower British group, he might have dwelt on these and other apparent zoological exceptions; and in addition to Lower Silurian he might have instituted a "Petropolitan system." But the researches of our Government geologists under Sir H. De la Beche have found these very Cystidea in a mass of rock in Pembrokeshire, formerly described by myself as Lower Silurian *. By the labours of other officers of the same corps, I am informed that these fossils have been

* Whilst this memoir is going through the press, Professor E. Forbes has shown to me specimens of Cystidea and Illænus in the limestones of Bala, associated with typical forms of Orthis, Trinucleus, &c. of the Lower Silurian rocks.

also found in the S.E. of Ireland, in strata which by their place in the series, and by other associated fossils, are also considered to be true Lower Silurian.

Now, whilst the Cystidea occur in thick clusters in the north of Europe, where peculiar calcareous conditions abound, they are comparatively rare in our schistose, muddy deposits of the same age. So is it with the genus *Illænus*, of which *I. crassicauda* is the type, which swarms in the Lower Silurian of the Baltic provinces of Russia, but which is not so abundant in Scandinavia where the conditions change, and which only occurs as a rare fossil in British rocks of the same age.

If indeed the presence of a few peculiar fossils in certain tracts were to be admitted as the test of the individuality or isolation of the stratum in which they occur, then truly may many new names be proposed for the protozoic group. On this principle, the lower black schist and limestone of Scandinavia, containing some organic remains specifically unknown in England, might be termed the Odinian group, in honour of the mythic deity of the early inhabitants; whilst in the new continent, the strata which (as Mr. Lyell believes) occupy the same horizon, might from their geological outcrop be named Canadian. But these local appellations, whether Petropolitan, Odinian or Canadian, are, after all, nothing but the already typified Lower Silurian strata, which in several regions have been seen to repose on masses in which no signs of animal life have been discovered.

For the above reasons, and others cited in my previous works, particularly in the first chapter on Russia, I am of opinion that Professor Sedgwick's recent proposal to establish a Cambrian group*, as distinguished from the Lower Silurian, cannot be sustained, and that the attempt to introduce such a group, as founded on observations in tracts often replete with igneous rocks both contemporaneous and posterior, and which has been subjected to so many dislocations, will, if intended for general use, necessarily lead to much confusion, particularly among foreign geologists. Such a question must, I apprehend, be definitively settled by appealing to countries like Scandinavia, Russia and America, where the very rocks in question are spread over enormous horizontal areas, or in slightly inclined and undisturbed positions, without the trace of contemporaneous disturbances of the sea in which their remains were entombed, and where the strata, the lowest in position which contain organic remains, can be actually seen to repose on pre-existing mineral masses void of such remains.

It is not by finding, after several years of elaborate research, a few undescribed and rare British palæozoic forms, that the age of rocks can be determined. The true tests are order of superposition and the common or prevalent fossil types; for if amid forms peculiar to one or two localities, the prevailing typical shells of a previously named group should occur in lower or thicker strata; or if the band in question can be followed into other tracts where the usual types abound, the point is determined.

Objecting therefore entirely to this proposal, because I now know

* See Quart. Geol. Journ. Vol. ii. p. 130.

that some of the lowest fossiliferous strata of North Wales are charged with shells which are well-known types of the Lower Silurian strata in Britain, Scandinavia and Russia, I object quite as strongly to another suggestion of Professor Sedgwick, that the Wenlock formation may perhaps be merged into the Lower Silurian. This suggestion however is only sustained on the ground that a few species of fossils are found to pass relatively upwards or downwards between the Wenlock shale and the upper beds of the Lower Silurian group as hitherto defined. This fact was to a certain extent known to me when I published the 'Silurian System.' I then knew (as may be seen in my tables) that certain species ran from the lower group even high into the upper *; and subsequent researches of others have, I admit, extended the phænomenon. Without an acquaintance with this fact, I should, indeed, have been most unfortunate in the selection of the name "Silurian," as embracing the lower and upper groups in one system of deposit. The question then really is, whether after types have been recognized, and after they have been applied and found to hold good over large regions of the globe, it is permissible to make changes of geological demarcation founded on the observation of certain slaty districts of Britain, where I venture to say the palæozoic order could never have been worked out had not the clear Silurian types been previously established;—tracts, also, in which little or no continuous limestone occurs, and where the whole of the Silurian series assumes to a great extent a common impress.

Looking to his native hills as he may well do with pride, because he has so well unravelled their intricate relations, Professor Sedgwick would seem to suggest, that the Upper Silurian group should be exclusively confined to the equivalents of the Ludlow rocks as developed in the coarse slates of Westmoreland, &c. But although this may be a good local division in the Lake country, it would, I must say, be utterly valueless if tested in the region of Siluria (where the rocks are unaltered and not in a slaty condition), and if possible, still more so when applied to the Upper Silurian strata of Norway and Sweden.

The Wenlock limestone is, I assert, the true and only definable centre of that which I have designated "Upper Silurian," and extensive European researches, and comparisons with America made by native authors as well as by Mr. Lyell, have confirmed me in this view, to which I hold as an essential and fundamental point in sustaining the Silurian classification. If we deprive the Upper Silurian group of the Wenlock division, and reduce it to the Ludlow rocks, it becomes in many tracts of the globe a mere shred or wayboard, though it be a rock of great thickness in Westmoreland†.

* About 5 per cent. of the Silurian species were then shown to be common to Lower and Upper Silurian rocks.

† I may here state, that I have twice traversed Westmoreland and the adjacent country since the publication of the 'Silurian System.' The first visit was made before the memoirs of Mr. James Marshall, Mr. Sharpe and Professor Sedgwick brought the strata there into accordance with different members of the Silurian

If on the contrary, we continue to unite the Ludlow and Wenlock as originally proposed, by calling it Upper Silurian, we have a group, which, however the fossils of its lowest part or the Wenlock shale occasionally graduate into the subjacent strata, is, on the whole, as clearly separated from that beneath it (whether in the Siluria of the British Isles, the continent of Northern Europe, or in North America) as any two groups belonging to the same series which geologists have attempted to define in rocks of secondary or tertiary age.

It has been stated by Professor Sedgwick, that "beautiful as the sequence of Siluria is, it is not the true mineral type, either for England, Wales or Ireland." Let me here say that I never proposed it as a general mineral type, but simply as a good fossiliferous type of rocks of that age. Few persons, on the contrary, could I think have laboured harder than I myself did to afford evidence of the great lithological differences which are observable even within the Silurian region, by the comparisons I then instituted between the slaty Silurian groups of West Shropshire, Montgomery, Brecon, Caermarthen and Pembroke, and their calcareous equivalents in other parts of Shropshire, and in Radnorshire, Herefordshire, &c. But what I did contend for, and what I think European and American researches have confirmed, was, that in selecting as types those tracts, which, void of contemporaneous igneous rocks and slaty cleavage, were full of calcareous matter, and consequently of fossils, and in running them out into countries where such calcareous matter thinned out, and with it many of the fossils, and where strata precisely of the same age assumed a slaty cleavage, and were associated with igneous rocks, I enabled others who might follow me to estimate mineral conditions at their true value.

Whilst I thus indicated to geologists who might explore those tracts in which strata of like age occurred, that they must not expect to find elsewhere Aymestry, Wenlock, Woolhope and Llandeilo limestones exactly in the order in which they occurred in my typical districts, I stated emphatically, that what I expected to result from extended inquiries in Europe, would be the confirmation of the existence of *two* united natural groups; the quantity, variety and identity of species in each being regulated by the varied mineral character or conditions of the deposits in the different countries appealed to. This appeal having now been made, my surprise is, first, that notwithstanding numerous diversities in lithological structure, so many typical forms should appear in synchronous palæozoic strata in very distant kingdoms; and secondly, that there should even be, as far as Europe is concerned, such occasional striking coincidences of mineral succession;—in a word, that flaggy and thin-bedded limestones should appear at great distances from England on the horizon of the Ludlow rocks,—that

system, and I then observed to Mr. Marshall, who accompanied me from Coniston to Ulverstone, that there could be no sort of doubt that the Coniston limestone represented a part of the Lower Silurian, whilst on the whole the Kendal and overlying schistose series represented the Upper Silurian group. In fact, I urged Mr. James Marshall to publish a memoir on his Coniston band.

great coral reefs and masses of limestone should be found on the parallel of Wenlock and Dudley—that a band of limestone with *Pentamerus lævis* should turn up in Scandinavia, Russia, and even in America, at precisely the same horizon as the little band of Horderly and Woolhope in England—and that copious lower limestones should represent those courses which at Llandeilo and other parts of England and Wales are interpolated in the schists, sandstones and slaty rocks of Britain.

In speaking of the lithological characters of these lower rocks, Professor Sedgwick further expresses his belief, that "as a general rule, all limestone bands *below* the carboniferous series are mere local phænomena appearing at intervals, which are perfectly irregular in countries remote from one another. This remark is meant to include Devonian limestone, and all Silurian limestone both upper and lower *." But this observation is surely as applicable to the limestones *above* the carboniferous. There are essential distinctions between the strata of the Permian age in Russia and those of Western Europe. The dark lias shale of our countries is a solid, light-coloured limestone in the Alps and Carpathians. The middle and lower oolites of the south of England are represented by sandstones and shales in Yorkshire. Even the white chalk, which is the most persistent perhaps of all the secondary deposits of Western Europe, assumes an arenaceous and quartzose type in Eastern Germany, and is unknown in the cretaceous strata of America and Hindostan.

Again, if we ascend into the tertiary series, we find the dense clay of London represented by a white shelly limestone at Paris, and the blue marls and sands of the sub-Apennines, the north of Italy, and the basin of the Danube, become fine oolitic limestones in Lower Styria. Having examined a very large portion of Europe, I contend, that there are no secondary, and certainly no tertiary limestones which exhibit a greater persistency when followed to distant tracts, than the limestone of Wenlock and Dudley as developed in the islands of the Baltic, at a distance of near 1000 miles from the typical English formation. Hence I maintain that the original grouping of the strata by reference to such typical limestones, is a better principle of classification than one founded on the slaty and argillaceous constitution of strata of the same age in other British districts since referred to.

In the same memoir in which the changes or modifications are suggested which have thus led me to express my opinion on the subject, Professor Sedgwick states, that near Builth the lower flagstones there visible, which contain the *Asaphus Buchii*, lie a very little below the Wenlock shale.

If from mentioning this circumstance (which is indicated in my original sections) the object be to infer that the Caradoc sandstone is not a constant stratum between the Wenlock shale and the Llandeilo flags, it is merely the re-announcement of a fact which I have not only long ago admitted, but which I wish to be generally understood. I have indeed specially shown, at first in the year

* Quart. Geol. Journ. Vol. ii. p. 127.

1835*, and afterwards in the 'Silurian System' itself, that the so-called "Llandeilo flags" (those in the very environs of Llandeilo) consist of various bands of limestone interstratified with sands and shales, which in reference to the upper strata exhibit in that tract only a very thin course of sandstone, representing the great Caradoc band of Shropshire. That which is thick in one place thins out in another. In one tract, shale, flagstone and calcareous courses prevail; in another, sandstone and sandy limestone; in a third, shale and slaty rocks; but all these, I contend, are characterized by the same group of fossils, viz. *Asaphus tyrannus*, *A. Buchii*, *Trinuclei* of various species, *Illænus crassicauda*?, and above all by the simple-plaited Orthidæ, *Orthis Actoniæ*, *O. flabellulum*, *O. lata*, &c., of which *O.* (*callactis*) *calligramma* is the type†. In short, the protozoic group, as subsequently worked out, has now been proved to be nothing more than Lower Silurian‡.

The list given by Professor Sedgwick of fossils common to the Wenlock and Llandeilo rocks in those tracts where no intervening sandstone occurs, may perhaps lead inexperienced observers to think that there is no longer a true distinction between these formations; but in the localities to which he appeals, few of the Lower Silurian fossils, except such as are common to great portions of the Silurian system, and have a very wide geographical distribution (such as *Calymene Blumenbachii*, *Leptæna depressa* and *L. euglypha*, &c.), run up into the Wenlock limestone, whilst the presence in that rock of a single species of those simple-plaited Orthidæ which appear in such millions of individuals in the Lower Silurian, is, when it does occur, a very rare phænomenon, either in the British Isles or Scandinavia§.

If we confine our reasoning to Britain alone, and take the common and characteristic typical shells, there can I think be no better proof that the Lower Silurian is well separated from the Upper,

* Phil. Mag. June, 1835.

† As other explorers will doubtless visit the very instructive tract of Corndon and Shelve to the south of Shrewsbury, which I have described in some detail (with all its igneous rocks, both contemporaneous and intrusive), they will there see a very instructive epitome of what I consider to be a group analogous to many tracts in Cambria, or North Wales. The great mass of the Lower Silurian rocks, as shown by my sections (Sil. Syst. pl. 32. figs. 1 and 2), terminate downwards in the copious sandstones and quartz rocks of the Stiper stones, and upwards in flagstones containing *Asaphus Buchii*, which in their turn are surmounted by Wenlock shale; thus presenting, though on a much clearer and grander scale, the same succession as at Builth. Here therefore if "Llandeilo flags" are to be alone recognised by their containing *Asaphus Buchii*, they may, according to my own published sections, be said to overlie Caradoc sandstone. But as mineral constants are unknown, so at Llandeilo the alternating lower fossiliferous series of sandstones and limestones is separated from the upper group by quartz or sandstone. It is to the "Lower Silurian" fossil types only that I appeal.

‡ We have yet to be made acquainted with those forms announced by Professor Sedgwick to distinguish his Protozoic Cambrian from my Protozoic Lower Silurian (as published).

§ Amidst a profusion of Upper Silurian shells, one simple-plaited Orthis (a variety of *Orthis calligramma*) was found by myself in the lowest shale (Wenlock) of Gothland, and of this species one or two individuals only were detected.

than that which was afforded in the work which established the Silurian system. We there find, that out of the twenty-five species of Orthidæ (including in that number four forms doubtfully referred to Spirifers) one species only, the *Orthis canalis*, had been then observed by myself to pass up into the Wenlock formation; whilst after years of assiduous labour, Professor Sedgwick and Mr. Salter add but one other species, the *Orthis lata*, which also rises from the one group into the other. The occurrence of *Trinucleus Caractaci* in the Wenlock shale, and of *Calymene Blumenbachii* in the Caradoc sandstone, does not invalidate the fact, that the one crustacean occurs in myriads in the Lower and most rarely in the inferior part only of the Upper, and the other abundantly in the Upper group and very seldom in the higher part of the Lower; whilst among the thirty-eight species of Trilobites published in the 'Silurian System,' nineteen are still recognised as exclusively Upper Silurian, and fifteen or sixteen as Lower Silurian forms.

I must also dissent from the plan whereby Professor Sedgwick strengthens his conclusions, by excluding corals from his calculations, "as being too widely spread," for by the valuable labours of my friend Mr. Lonsdale, I have shown (and the demonstration has never been invalidated) that by far the greater number of the Silurian zoophytes are confined to the Upper Silurian, and that whilst eight or nine species only descend into the Lower stage, the latter contains some species which have never yet been detected in the Upper. Nor can Crinoidea be considered too imperfect to be of value in establishing a classification. The beautiful forms of *Actinocrinites moniliformis*, *Hypanthocrinites decorus*, the five species of *Cyathocrinites*, and other species of the Dudley limestone both published and unpublished (all generally recognised as true Upper Silurian types), have nowhere been found in the Lower Silurian strata, whilst on the contrary in Russia, Scandinavia and Britain, the Cystidea form a typical Lower Silurian group representing the Crinoidea, and not met with in the Upper group.

But if by such striking evidence, as well as by the absence of vertebrata, the Lower Silurian may generally be well separated from the Upper, I am far from denying that among the 500 Silurian species alluded to by Professor Sedgwick, a few (more even than he has mentioned) may not pass from the one group to the other. Since Mr. W. Smith established his succession of the Oolitic series of England, a number of fossils ten times greater, I will venture to say, has been found to be common to his widely-honoured groups, than by the incessant researches of a number of the best geologists in England, in Siluria, and Wales, have been shown to be common to my Upper and Lower groups; but such a reason has not been deemed sufficient to induce us to change the classification established by the Father of English secondary geology. So far from regretting that multiplied observations subsequent to my own have brought out the fact (which will be rendered more striking when the results of the Geological Survey of Great Britain are published), that a few more species are common to the Lower and Upper Silurian than

I could make myself acquainted with, I rejoice in such discoveries, because they still better *link the two groups together in one indissoluble natural system.* At the same time, referring my readers to the introductory chapters of the work on Russia, and requesting them also to consult the tabular lists of the Upper and Lower Silurian fossils of Scandinavia, I beg them to remark, that whilst some typical species of those regions are omitted, or have not yet been detected in England, they have been found on the same geological horizon in North America. It is from a combination of all these facts, that although when I published the 'Silurian System' I thought and hoped that there might be found a different group of animal life in the western and northern regions of Wales and in those tracts occupied by the so-called "Cambrian rocks," which, without critical examination on my own part, I left to be decided by the researches of Professor Sedgwick, I now repeat that an appeal both to those tracts as well as to other regions of the globe since I addressed the Society to that effect from the Chair, has sustained the conclusion, that the fossiliferous portion of the system alluded to in my work as Cambrian, is at length shown to be inseparable from the Lower Silurian type; and that whilst this group passes stratigraphically and zoologically into the Upper Silurian, the latter is characterized by many typical and peculiar fossils.

Admitting that "organic changes are the surest guides in making out the history of successive changes on the surface of the globe," Professor Sedgwick says that "they form a part only of our evidence, and that the great physical groups of deposits, however rude or mechanical, are historical monuments of perhaps equal importance in obtaining any true and intelligible record of past events*." Now, if by this it is meant, that without duly noting all the synchronous and posterior eruptions by which the surface of the earth has been modified, as well as the density of marine sediments in one region and their tenuity in another, no geological description of a given region can be complete, every one must subscribe to the position. But, on the other hand, I maintain, that if thick accumulations replete with igneous rocks and dislocations, do not contain as many relics of former inhabitants as strata of much less vertical dimensions (occupying the same geological horizon), the latter ought to be appealed to in preference to the former, as superior evidence for compiling the history of the earth.

Professor Edward Forbes has clearly shown, that what he has laid open in existing nature cannot but have been true in the remotest antiquity, and that in former as well as in the present seas, animal life can only have existed down through a given thickness. Now, assuming that the Lower Silurian is the oldest type of animal life, we might expect that at that period there would be a diminution in the numbers of the animals in proportion as the strata were accumulated at greater and greater depths, and that in those protozoic days there might have been depths of the sea

* Quart. Geol. Journ. Vol. ii. p. 129.

in which no fauna existed. It must, indeed, be evident that we gain no additional knowledge concerning the true chronology of the earth, by dwelling upon great local expansions of sediment, if no new groups of animals are discoverable in them. For example, a coal-field of thin vertical dimensions, whose relations are clear, is quite as instructive historically, if charged with fishes, shells and plants, as the enormously thick coal basin of Glamorganshire recently measured by Sir H. De la Beche.

Mineral masses of very great thickness and importance doubtless occur in North Wales and in the North Cumberland Mountains, but no new group of fossils has been found in those tracts. This, it appears to me, is the only question at issue between my friend Professor Sedgwick and myself; and although in the memoir already referred to he speaks of his Cambrian group, as the most remarkable physical group of England, he admits that he cannot say it is characterized by peculiar fossils* distinct from those published as Lower Silurian, nor that it is physically separated from what I defined as Lower Silurian by any line of general dislocation as formerly supposed (see Phil. Mag. June, 1845). Under these circumstances, and believing that there was no clearly-defined base-line in England for these palæozoic rocks, I have appealed to those countries in which, though the mineral masses be not of such great vertical dimensions, the earliest visible fossil types have been accumulated in tranquil seas, and have been so raised up for our inspection as to show a decrement of animal life in descending order, until all traces of organic existence are lost, and the whole series is seen to repose on slaty and crystalline azoic rocks. The geologist therefore ought I think to prefer this simple and unbroken legend of primæval life, to that which, however voluminous it may be, is interleaved with numerous blank, torn and ruffled pages, and whose earlier leaves are so nearly illegible, that they have not yet been deciphered.

In conclusion I beg to say, that if the alterations proposed in the Silurian classification by Professor Sedgwick, instead of being the result of researches in slaty, broken, contorted and igneous districts of the British Isles only, had been arrived at in consequence of a general appeal to nature's clear and normal types—or again, if even now, any sufficient data should be produced (of which I am as yet

* One of the few zoological reasons given by Professor Sedgwick for the belief on his part that his Cambrian rocks may be distinguished from the Lower Silurian, is that he has not found the *Asaphus Buchii* in the former. At the same time he admits that the *Asaphus tyrannus* is abundant in his Cambrian. Now the latter of these Trilobites is quite as characteristic, if not more characteristic, as a Lower Silurian species than the other; and surely no one who is acquainted with the habits of crustaceans and their frequent isolation in special localities can attach importance to this negative fact. The *Asaphus Buchii* occurs abundantly in the Lower Silurian rocks of Norway together with other common Lower Silurian Trilobites of Sweden, and at least 30 or 40 species which have never been found in the latter country, whilst in Sweden the *Asaphus Buchii* is so exceedingly rare, that tracts larger than those alluded to by Professor Sedgwick exhibit no appearance of it; and so by parity of reasoning I might speak of the "Odinian" or lowest group of Sweden as distinguished from the lowest group of Norway, though they are in fact absolutely synonymous.

ignorant), and that rocks with peculiar fossils should be pointed out in lower positions than any of those charged with Lower Silurian forms, and reposing on still lower strata—or lastly, if Sir Henry De la Beche and his coadjutors, who are now subjecting North Wales to a rigorous survey, shall assure me that there is a distinct fossiliferous system beneath that which they have honoured me by terming "Lower Silurian," then I hope I have sufficient candour to modify my views according to such evidence and render them subservient to the advancement of Geological science. But supported by the fossil proofs and the order of superposition derived from investigations in Europe and America, and by the opinions of all those palæontologists with whom I have acted (including Mr. James Sowerby and M. de Verneuil), I adhere at present firmly to my classification, founded on original researches in Siluria.

The additional matter supplied in this memoir will, I trust, at all events be taken as affording the clearest evidence, that in Scandinavia the Lower and Upper groups are well-defined by the same divisional lines as those originally proposed by me for the classification of these deposits; for he who would attempt to rob the Wenlock formation of Gothland of one of its members, in order to include it in the Lower Silurian group of those countries, would most certainly be opposed by every geologist who had ever seen either the country or the fossils.

Again referring my readers to the first three chapters in the work on Russia and to my former Memoir on Scandinavia, as well as to the comparative tables then and now published, I leave this subject to the consideration and decision of geologists, merely expressing my hope, that the classification of Lower and Upper Silurian may not be put aside or obscured, so long as the order of succession and zoological evidence sustain it. My aim during the last few years has been, not to dwell upon the peculiar development and details of the sections in North Wales; for that ground is in the course of survey by several Government geologists, who will accurately determine the dimensions of such strata and all their physical and zoological features. My chief objects, on the contrary, have been, to ascertain on a great scale, whether the lowest stage containing vestiges of life in other parts of Europe was or was not zoologically the same as the Lower Silurian of my own country, and whether it was there, as in England, succeeded in ascending order by another member of the same natural system of deposits which I had termed Upper Silurian. The Silurian system, so defined, has been shown to be successively surmounted, over wide tracts, by the Devonian, Carboniferous and Permian systems, thus completing the history of palæozoic succession in Northern Europe.

Postscript to the Memoir on the Silurian Rocks of parts of Sweden, published in the Quarterly Journal of the Geological Society of London, Feb. 1, 1847.

At the time when the above memoir was written, my colleague M. de Verneuil was travelling in North America, and since his return to Paris the list of fossils prepared by Mr. James Sowerby was unluckily not sent to him for revision. The introduction of the following errors and discrepancies which he has just pointed out to me, has been the result; and I therefore hasten to announce them, and also to relieve my friend from the responsibility which, through an unintentional paragraph in the text, has been thrown upon him, in respect to certain species which have been inserted in the table of shells (p. 28 *et seq.*) without the prefix of an asterisk. Thus, *Cyrtæna Baltica* is simply a misprint for *Cytherina Baltica*; *Spirifer caudatus* is an unknown name which has unaccountably found its way into the table, and the *Avicula aptera* is a new species, named by Mr. Sowerby. The *Terebratula semi-sulcata* (a shell so termed in a collection from a Gothland fossil formerly given to me by M. Lovén) was identified by Mr. Salter with an unpublished Upper Silurian or Ludlow rock fossil of England. *Spirifer? ptychodes* ought also to have had an asterisk prefixed, since the species of Gothland is considered by Mr. Sowerby to be synonymous with the form published in my 'Silurian System[1].' The specific name *catenulatus*, Dalm., should have been given in the table (as well as in the text) as a synonym for *Euomphalus rugosus*, Sow., although the latter is the older name. Again, Mr. Sowerby is responsible for the *Euomphalus carinatus*, which is distinct from *Inachus sulcatus* (His.); whilst the *Euomphalus discors*, *Orthoceras trochleare* and *O. Ibex* were inserted on my authority. The *Calymene? Rowii* (Green) was identified by Mr. Salter and myself by comparing a fragment from Gothland with the cast prepared and named by the American author[2].

M. de Verneuil considers the fossil named *Pentamerus didyma* to be a *Terebratula* very near to the *Atrypa nitida* (Hall), from the Niagara group of North America, and he reminds me, that the *Terebratula canaliculata* of my list is really the *Spirifer lynx*, a Lower Silurian fossil which does not occur in Gothland, where it is represented by a small analogous form which may prove to be a new species. It is to this small fossil (p. 28), and not to the *Orthis elegantula*, that the side observation (p. 29) of "very rare in Gothland" ought to have been applied. I must further remark, that there are two or three errata in the text, viz. at p. 5, the term *Orth.* (Orthoceratites) *regu-*

[1] According to M. de Verneuil, the *Delthyris ptychodes* Dalm. is a small variety of the *Pentamerus galeatus*, and differs greatly from the *Spirifer ptychodes*, figured in the Silurian System.

[2] This trilobite, which occurs in the Upper Silurian rocks of England, will soon be described by Mr. Salter, who will show that it is not a Calymene, but the Proetus of Steininger.

laris has been misprinted *Orthis regularis*; the so-called *Pleurotomaria articulata* (p. 23) was afterwards recognised by Mr. Sowerby to be the *Murchisonia* (*Pleurotomaria*) *corallii* of the 'Silurian System;' and at p. 24, the shells mentioned as *Cypricardiæ*, are the *Avicula retroflexa* and *A. reticulata* of the Ludlow rocks, under which names they are, indeed, alluded to both in other parts of the text (pp. 23. 25) as well as in the table.

Regretting that my able coadjutor, who had, in fact, recognised a large portion of the Gothland species "in situ," had no opportunity of making the above corrections and suggestions before the memoir was printed, I console myself with the reflection, that his valuable criticism does not in the slightest degree weaken the force of my reasoning, either upon the separation of the Lower and Upper Silurian rocks in Sweden, or on the close comparison between the Upper Silurian succession of Gothland and Britain, which were my chief objects.

In relation, however, to the Silurian rocks in Dalecarlia, I must say, in justice to my colleague, that whilst like myself he considers them to be of Lower Silurian age, he differs from me (as he did indeed when we were on the spot) as to the probable detailed order of succession in that disturbed tract. I have endeavoured to explain in the text, the difficulties which the natural features present in that region, so perforated by porphyry and granite of posterior date, and which prevent the field geologist from satisfactorily determining the precise order of the beds. For reasons which I need not here dwell upon, but which ought, I admit, to have due weight, M. de Verneuil is of opinion, that the lower sandstone and black alum schists have no representatives in Dalecarlia, and that the whole ascending succession is probably there composed of,—1. Orthoceratite limestone. 2. Graptolite schist. 3. Whetstone (*Slepsten*). Now, although guided by the analogies of many other parts of Sweden (which my fellow-traveller has not seen), I have, on the contrary, considered the whetstone or slepsten as the equivalent of the lower sandstone (1), followed in ascending order by (2) a black schist representing the alum slate, (3) orthoceratite limestone and (4) graptolite schist. I must repeat that I attach no great importance to my own view of these details. The truth is, that the accurate succession of such subordinate beds in Dalecarlia, as stated in the text, has, through the agency of numerous eruptive rocks, been rendered a geological puzzle, which can only be correctly worked out by more extended researches in the environs of Ostersund and other places which we did not visit. In the mean time, however, the points of chief importance have been satisfactorily determined; viz. that all these Dalecarlian strata are of "Lower Silurian" age; that rocks of the same period occupy the mainland of other parts of Sweden and the Isle of Oland; whilst Gothland has been proved to exhibit a very complete Upper Silurian series, from the lowest to the highest beds.

RODERICK IMPEY MURCHISON.

February 19, 1847.

DESCRIPTION OF PLATE I.

1. Dalecarlian Sections.

Fig. 1. Section near the eastern end of the Lake Siljan in Dalecarlia, between Leksand and Rättvik, showing how the Lower Silurian limestone (*c*) is thrown off by the "granitello" (*q*) at Alsarby. The slope below the limestone is covered by detritus.

2. Relations in the Isle of Soller of the Lower Silurian rocks.—(*a*) inferior sandstone, (*b*) schist obscured by morass, and (*c* & *c**) beds of limestone with Orthoceratites and Cystidea in irregular contact with the granitello (*q*). The limestones are broken by transverse faults, and in one part (not represented in this drawing), mantle in an altered condition around bosses of granite.

3. Section at Watnaes near Möra.—The same Lower Silurian limestone (*c*) as that of the preceding diagrams, appears at intervals in highly-inclined strata, but is here separated from the eruptive rocks (*p**), which form the western part of a great porphyritic dome, by quartzose rocks, siliceous sandstone and fine conglomerate (*x*), which seem to have been altered by igneous agency.

4. Section at Skatunge on the north side of the great dome of porphyry and granitello, exhibiting regularly stratified and jointed, earthy, red porphyry (*p*).—A slope obscured and the Lower Silurian limestone and shale (*c**) with Cystidea in highly-inclined positions.

5. Section across the insulated hill called Osmundsberg, which is composed of Lower Silurian limestone (*c*), the inferior schist (lerskiffer) (*b*) and sandstone (*a*), being for the most part covered by detritus.

6. Relations at the waterfall of Styg-fors near Böda on the eastern flank of the eruptive dome. The subjacent or eruptive rock is here a granitello (*q*), and the sandstone (*a**) in contact with it is a highly-indurated quartz rock, which is surmounted by peculiar nodular shale (*b**).

2. Sections and Drawings in Oland and Gothland.

7. A general transverse section showing how the Lower Silurian sandstone (*a*) reposes (though chiefly in dismembered lumps) on the azoic or antecedent crystalline rocks of the province of Smoland (*az*); and also, how the same sandstone (fucoid grit of my former memoir) is seen on the western shore of Oland to be surmounted first by the alum schist (*b*), and finally by the Lower Silurian limestone (*c*), which occupies the great surface of the island of Oland in very slightly-inclined strata. The surface of the mainland is obscured by erratic blocks (*bl*).

8. Geological view, looking from Hög Klint, the highest point of the cliffs of Gothland, and representing Upper Silurian rocks, consisting of the nodular Wenlock shale (*e*) surmounted by the Wenlock limestone (*f*), both to the S. and N. of the city of Wisby.

9. View of "Hög Klint," or High Cliff, as seen from its northern base, and showing the detailed order of the Wenlock limestone (*f* & *f**), in relation to the subjacent nodular shale (*e*). Two or three erratic blocks (*bl*) are seen on the summit.

10. Grotesque forms of the Upper Silurian coralline limestone (Wenlock) at Länna, in the fine bay and anchoring-ground of Slite on the east coast of Gothland.

11. General Section from N. by W. to S. by E., showing an ascending order in the Upper Silurian strata of Gothland from the Wenlock shale and limestone of the environs of Wisby, through other strata near Klinte, which represent the Lower Ludlow rock and Aymestry limestone (*g*, *h*) into overlying oolite, calc grit, and sandstone at Grötlingbo, which are true equivalents of the Upper Ludlow rocks (*i*, *j*). The coralline limestone of Mount Hoburg (*k*) may represent a passage into strata of the Devonian age (see memoir).

12. Detailed order of the strata at Mount Hoburg, the southernmost promon-

tory of Gothland, where the preceding section terminates; showing how the same sandstone (*i*) which occupies the surface of the plateau at Grötlingbo on the N., is here brought down to the sea level; thus proving a general southerly inclination. The overlying calcareous strata (*j*, *k*, and *k**) are described in the memoir.

Fig. 13. General section from E. to W. across Scania. This is merely given to indicate, as far as possible, the successive outcrops of Lower and Upper Silurian rocks in a low obscure tract much covered with mud, rolled blocks and gravel (*bl*). The Lower Silurian sandstone (*a*) is partially seen, the alum schist (*b*) with its fine trilobites is copiously exposed, but the prevailing Swedish and Russian Orthoceratite limestone with Cystidea is no where seen, its place being taken by an occasional thin course of black limestone subordinate to graptolite schists (*d*). The Upper Silurian rocks are recognizable in grey limestones and shales (*f*, &c.) which are surmounted by purple sandstones containing casts of Cypricardiæ and other fossils apparently belonging to the uppermost zone of the Ludlow rocks. The porphyry of Ofved Kloster is marked (*p*).

June 17, 1846.

George Aug. M. Dermott, Esq., and Thomas Macdougall Smith, Esq., were elected Fellows of this Society.

The following communications were read:—

1. *Description of a Fossil* Chiton *from the Silurian Rocks, with remarks on the fossil species of the genus.* By J. W. Salter, Esq., F.G.S., of the Geological Survey of Great Britain.

The discovery of a species of Chiton in beds of undoubted Silurian age appears to be a fact sufficiently important to be brought under the notice of the Geological Society, not only from the rarity of the genus in a fossil state, but because it carries back to an earlier date another of the many families we are in the habit of considering as characteristic of later epochs. The shell I have now to describe presents peculiarities distinguishing it both from recent species, and also from those found in the carboniferous rocks. In introducing the subject I propose to glance at the ordinary characters of the family, for so this group must be considered, in order to show the relation of the fossil with the living species.

The Chiton is one of the lowest forms of Gasteropodous Mollusca, and is considered by naturalists as closely allied to the genera *Patella* and *Lottia*, and as forming with them a distinct order of Mollusca under the name of *Cyclobranchia* (Cuvier), distinguished by the arrangement of the branchiæ. The Chitons have a double generative system, terminating (according to Blainville and Rang) on either side of the body. This is a very marked character, and one indicating strongly the low position the group holds in the order to which it belongs. The shell is of course the only part with which we have to do (in treating of fossil species), and its variations are fortunately

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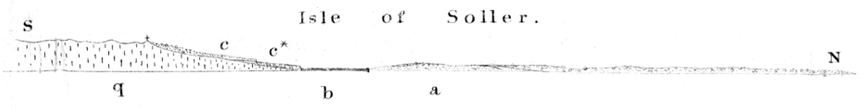

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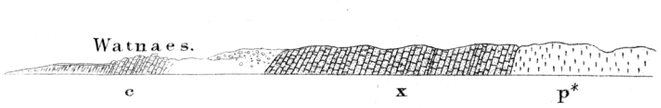

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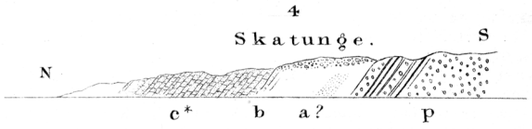

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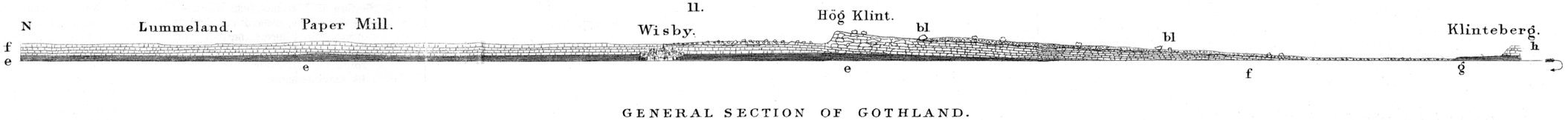
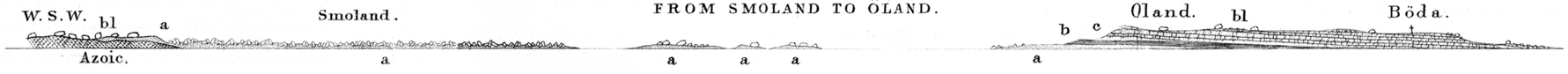


GENERAL SECTION OF GOTHLAND.

7

FROM SMOLAND TO ÖLAND.



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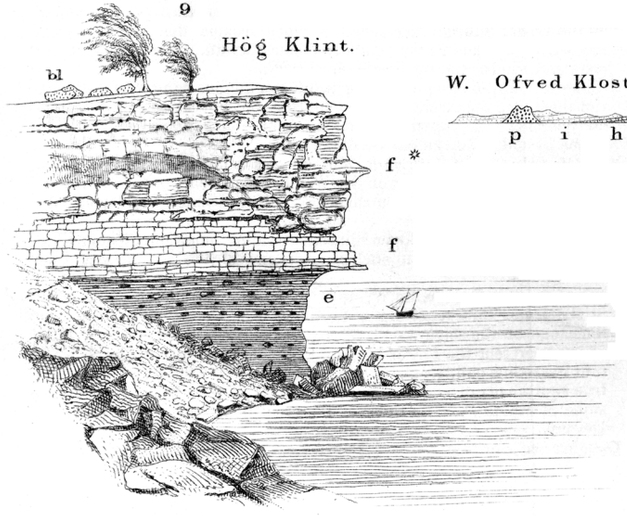

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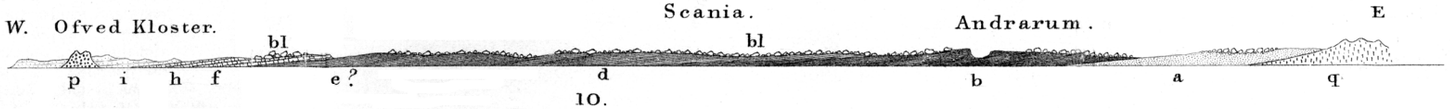

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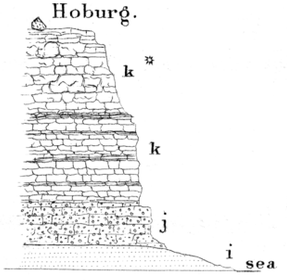

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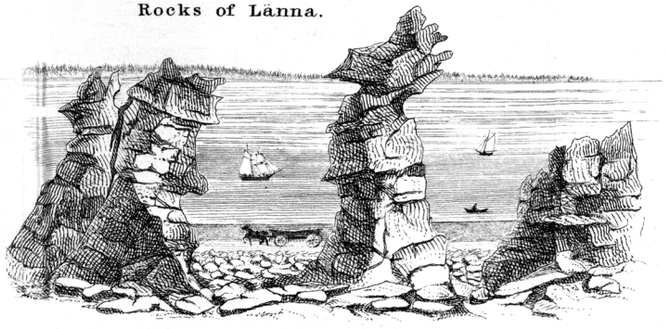
Rocks of Länna.



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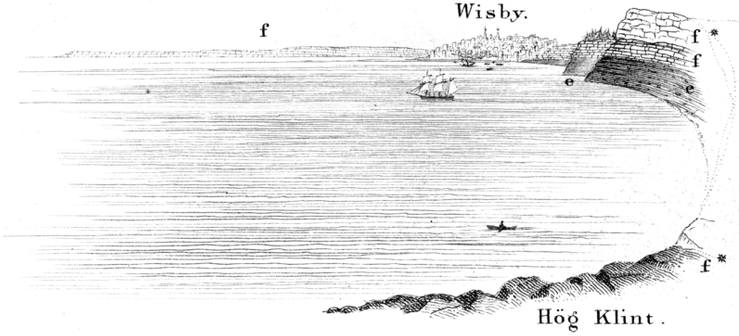

R. I. Murchison, del.t

C. F. Wallis, Sculp.t