2. *On the* PERMIAN ROCKS *of* SOUTH YORKSHIRE; *and on their* PALÆONTOLOGICAL RELATIONS. By JAMES W. KIRKBY, Esq.

(Communicated by Thomas Davidson, Esq., F.R.S., F.G.S.)

[PLATE VII.]

CONTENTS.

§ I. Introduction.
§ II. Permian District in South Yorkshire.
Sections near Doncaster.
1. Bunter Schiefer.
2. Upper Limestone or Brotherton Beds and Lower Red Marl.
3. Small-grained Dolomite.
4. Lower Limestone.
5. Rothliegendes or Lower Red Sandstone.
§ III. Comparison of the Permian Strata of South Yorkshire with those of Durham.
§ IV. Remarks on the Permian Fossils of Yorkshire.
1. Cephalopoda.
2. Gasteropoda.
3. Conchifera.
4. Brachiopoda.
5. Polyzoa.
6. Entomostraca.
7. Foraminifera.
8. Algæ.
§ V. Distribution of the Fossils.
A. Fossils of the Lower Limestone.
1. Fossils at Moorhouse.
2. Fossils at Hampole.
3. Fossils near Broadsworth.
4. Fossils near Pickburn.
B. Fossils of the Brotherton Beds.
§ VI. Permian Fossils of South Yorkshire compared with those of Durham.
§ VII. Permian Fossils of South Yorkshire compared with those of Lancashire.
§ VIII. Permian Fossils of Ireland.
§ IX. The Zechstein.
§ X. Distribution of the Permian Fauna in Time.

§ I. *Introduction.*—In the present communication I propose to speak of the geology and palæontology of the Permian strata that lie between the towns of Pontefract and Knottingley, on the one hand, and Tickhill and the village of Maltby, on the other. In doing so my chief objects are, first, to endeavour to determine the equivalency of the subdivisional groups of these strata with those of the adjoining county of Durham; and second, to throw some additional light, if possible, upon the distribution of Permian species south of the Durham area. Towards the accomplishment of these objects I have made two visits to the district in question—one in 1854, and the other during the summer of 1859.

Prof. Sedgwick has already described the geology of this region in his admirable memoir "On the Geological Relations and Internal Structure of the Magnesian Limestone*." Prof. Phillips has also noticed some of its features in a short paper "On the Geology of Ferry Bridge and its Vicinity," published about the same period as the preceding†. And since the publication of these papers, Mr. H. Clifton Sorby and Mr. Edward W. Binney appear to have pursued investigations in the same district, though the results have not been published‡. Sir Roderick Murchison has also alluded to certain points of its geology in the last edition of 'Siluria§.'

* Trans. Geol. Soc., 2nd ser. vol. iii. pp. 37–124.

† Philosophical Magazine, vol. iv. 1828.

‡ See Prof. King's remarks on *Mytilus squamosus*, *Bakevellia antiqua*, and *Dentalium Sorbyi*, Mon. Perm. Foss. pp. 160, 170, 218.

§ Siluria (1859), pp. 348, 349.

The continued researches that have been pursued of late years in the Permian strata of Durham have carried our knowledge of their palæontology and geology much in advance of that of the Permian formation of Britain generally; and nowhere is the contrast greater than with the Yorkshire portion of that formation, more particularly in regard to its palæontology: and it is with a desire to add something to what we already know of the Permian strata of the district specified that I make the following observations. The exhaustive investigations of Prof. Sedgwick, however, have left little to add to the full account of the lithology of this district given in his memoir; so that I am obliged to confine my attention chiefly to its palæontology. It is a delicate, and certainly a difficult, matter to notice its geology at all after Prof. Sedgwick; and I only do so somewhat briefly in order to show how it would seem best to co-ordinate the subdivisions of strata with those of the Durham series, and for the sake of more fully explaining some of the facts relating to the fossils.

§ II. *Permian District in South Yorkshire.*—Before proceeding further, it may be remarked that, in examining a geological map, the Permian strata of Yorkshire are seen to traverse the centre of the county in a long narrow stripe, running about N.N.W. and S.S.E., apparently almost wearing out in the former direction, and gradually increasing in width towards the south until a maximum of about five miles is attained, at which width they continue into Nottinghamshire. Their western boundary—most ably described by Sedgwick—usually forms a well-marked escarpment, often of comparatively great elevation above the low-lying plain of the coal-measures to the west*. Their eastern boundary, where they dip beneath the Triassic strata, is more difficult of determination, being often masked by alluvium or marsh-land. As the general dip of the strata is easterly, their order of succession can easily be examined by passing transversely across their outcrop. This I did repeatedly during my peregrinations in this region, and always found the same sequence of beds.

Sections near Doncaster.—In going west from the town of Doncaster, which stands on the alluvium-covered western edge of the New Red Sandstone, the first rocks we meet with are some thin flaggy beds of limestone, with occasional bands of red and green marls, which, as a group, we readily recognize as the "Brotherton Beds" of early geologists. After passing extensive quarries of this limestone (which, by the sinking of wells and other artificial excavations, is known to have a deposit of marl and gypsum at its base) we come to an extensive series of thick and irregular beds of limestone of a whitish or yellowish colour and a subcrystalline texture. These beds form a group of much greater thickness than the preceding member, and are described by Prof. Sedgwick under the name of the "Small-grained Dolomite." Still further west we meet with a series of pisolitic, cellular, arenaceous, and compact limestones, some of which are fossiliferous. The lower beds of this latter group rest immediately

* As at Barnborough Cliff, Hooten Pagnell, and several other places, where the prospect westward is most magnificent.

upon a deposit of false-bedded, incoherent sandstone, which it is not difficult to identify as the Lower Red Sandstone or Rothliegendes. Beyond this are the Coal-measures.

There are several routes across the outcrop of the beds, with Doncaster for the starting-point, that show this succession of strata. It is well shown on the south side of the Don on the road leading by Hexthorpe, Warmsworth, and Conisborough to Hooten Roberts, and on the north bank of the same river along the road by Newton and Sprotborough to Cadeby,—the numerous quarries on each route affording a good general section. A magnificent section is to be obtained by traversing the valley of the Don from Doncaster to a little beyond Conisborough; and yet another, and one of the best, which Sir Roderick Murchison has already noticed*, on the South Yorkshire Railway between the points last-named. In all these lines of section the same superposition occurs,—and not only here in the valley and on the banks of the Don, but north as far as Pontefract, and south to Roche Abbey, which are the limits of the district I have examined. North of the Don an excellent section is to be obtained in the Vale of Went, from east of Little Smeaton to Wentbridge; and to the south there is one almost equally instructive from Tickhill to Maltby.

From the investigations of Sir Roderick Murchison and the officers of the Geological Survey, it would appear that there are some beds of red sandstone and marl overlying the Brotherton Limestone of this district, which also belong to the Permian formation†. And, though I have not been able to identify these beds myself, I include them in the following list of subdivisions as the uppermost member of the Permian series of South Yorkshire on the authority of these observers.

To recapitulate, then, the Permian series of South Yorkshire seems capable of being naturally divided, in the descending order, as follows (see fig. 1):—

1. Bunter Schiefer.
2. Upper Limestone—including the Brotherton Beds and Lower Red Marl and Gypsum.
3. Small-grained Dolomite.
4. Lower Limestone.
5. Lower Red Sandstone.

As Prof. Sedgwick has already described the physical geology of these subdivisions, it will scarcely be required of me to notice them at any great length. It is requisite, however, that I should give a description of these strata as far as necessary for their features to be understood, and for the proper appreciation of their relations to each other and to the subdivisions of the Permian group of Durham. For fuller descriptions I refer the reader to the memoir of Prof. Sedgwick in the 'Transactions' of this Society for 1835.

1. *Bunter Schiefer.*—Soft red sandstone and marl (Murchison and Geol. Surveyors).

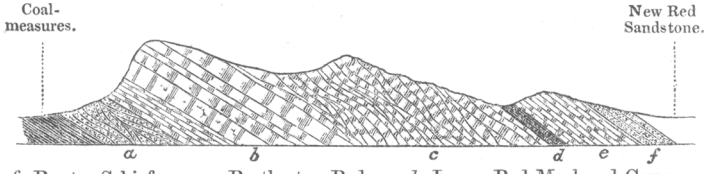
2. *Upper Limestone or Brotherton Beds, and Lower Red Marl.*—The Brotherton Beds are a series of thin, flaggy limestones, usually hard and compact, and of a yellow or grey colour. The surface-

* Siluria, p. 348.

† Siluria, p. 326, and Table of Strata, p. 432.

planes are generally a little apart, and often coated with red, green, or purple clays or marls; bands of marls similarly coloured are occasionally met with among the limestones (Hexthorpe).

Fig. 1.—*Sketch-section of the Succession of the Permian Strata in South Yorkshire.*



f. Bunter Schiefer. *e*. Brotherton Beds. *d*. Lower Red Marl and Gypsum.
c. Small-grained Dolomite. *b*. Lower Limestone.
a. Rothliegendes or Lower Red Sandstone.

In certain localities some of the beds contain casts of *Axinus dubius* and *Myalina Hausmanni*, together with some obscure remains that seem referable to *Algæ*.

The Lower Red Marl and Gypsum immediately underlie the preceding beds. They consist of beds of red and variously coloured marls with bands of gypsum, are apparently unfossiliferous, and are rarely seen in section.

The slight importance which the Lower Red Marl seems to hold in the physical geology of this district, the absence of any palæontological feature belonging to it, and the occasional presence of red and other coloured marls in the Brotherton Beds have induced me to describe it along with the last-named deposit, and to suggest the propriety of considering it as part of the same subdivision. I do this with much diffidence and some doubt, being aware that such a view is opposed to the opinions of Prof. Sedgwick and the officers of the Geological Survey.

The Brotherton Beds are well exposed at Knottingley, Womersley, Hexthorpe, Wadworth, and many other localities, being much worked for lime-burning and road-repairs.

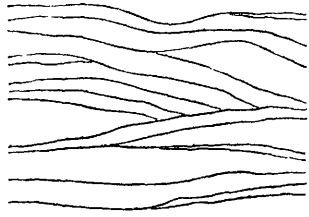
3. *Small-grained Dolomite.*—A crystalline, subcrystalline, or compact limestone of a slightly yellow, cream-coloured, whitish or lustrous grey tint. Thickness of beds ranging from 3 feet to 1 foot and under. Stratification very irregular, beds thickening to maximum, and thinning out suddenly; it being almost the exception for one stratum to appear in section for a moderate distance: planes of stratification curiously pitted. Among the uppermost beds occur intercalations of greenish clay or marl a few inches thick (Cliff Quarry, Brodsworth).

This limestone seems to be entirely void of fossils, except inferiorly towards its junction with the Lower Limestone, where faint traces of them occur (Town Quarry, Conisborough); and in these lowest beds there is also a tendency towards an oolitic character, that is never to be observed in the middle and upper parts, though much less evident than in some of the beds of the Lower Limestone.

The very peculiar stratification of the Small-grained Dolomite is

mentioned by Prof. Sedgwick as having been noticed by him at Steetly, near Mansfield, and other places*. It is a common characteristic of it generally. In the old quarries at Warmsworth sections most illustrative of this character are to be seen, one of which is represented in the accompanying woodcut.

Fig. 2.—*Sketch of the False-bedding in the Small-grained Dolomite at Warmsworth Quarry, near Doncaster.*



The different beds are interwoven as it were, and form about as curious a piece of undisturbed stratification as it is possible to conceive. Beds which have a maximum thickness of 2 feet actually thin out in each direction within a space of 20 feet, their places in the section being taken by others almost equally brief in continuance. It is thus difficult to trace a line of bedding for any great extent; and within the traceable extent even of the most continuous beds the line is often a curved one of great irregularity. Indeed some of the sections in the Warmsworth Quarry†, as well as in others, are neither more nor less than highly illustrative instances of false-bedding—a character common enough in arenaceous deposits, but very unusual in limestones.

Another peculiar feature of this limestone is the manner in which its planes of stratification are pitted—almost as though worked by an artist, Prof. Sedgwick likening it to "artificial rustic work‡." These surfaces are covered as thickly as possible with little pits or hollows, that extend for $\frac{1}{8}$th or $\frac{1}{4}$th of an inch into the limestone, with diameters of about the same measurements (that is, when largest), their depth and width often being much less. I have little doubt myself of this feature being due to some peculiar concretionary action, analogous to that which gave the Upper Limestone of Durham its remarkable structures.

For architectural purposes the limestone of this member is perhaps unequalled in England. It can be obtained in blocks of any moderate size, has a texture and hardness highly suitable for delicate masonwork, is of a beautiful tint, and will withstand almost any amount of weathering. It is therefore scarcely to be wondered at, that many of the finest edifices in England are constructed of it. Its quarries

* Trans. Geol. Soc., 2nd ser. vol. iii. p. 84.

† The quarry here referred to lies at the west end of the village, and just to the south of the main road leading to Conisborough.

‡ Trans. Geol. Soc., 2nd. ser. vol. iii. p. 84.

of Huddlestone, Bolsover, Steetly, and Roche Abbey are amongst the most famous in the country*.

Its maximum thickness must be about 200 feet or more. This thickness it would appear to attain on the right bank of the Don, a little to the south of the river. In other places it cannot be near so thick, as between Hampole and the Great North Road; indeed, the variability in the amount of space between the outcrops of the Brotherton Beds and the Lower Limestone, allowing for difference of position in surface, indicates a great variability in its thickness in its north and south range. For this reason, and on account of its irregularity of bedding, I am disposed to look upon it as having originated in a comparatively shallow sea. Its general structure implies the influence of currents of great inconstancy, and altogether reminds us of that which may be supposed to characterize those submarine banks, such as the "Dogger Bank" of the German Ocean, that accumulate in water of no great depth, under the influence of variable currents, at some distance from land.

The Small-grained Dolomite can be easily examined in numerous localties west of Doncaster, where it is well exposed in the picturesque crags of the Don, and in the quarries that have been opened on the banks of that river. Amongst other localities may be named the quarries at Warmsworth, Levit Hagg, Cusworth, Outmoor, Cockhill, Sprotborough, Roche Abbey, and Brodsworth; the cliffs in the Vale of the Went, and on the banks of the Don east of Conisborough.

Professor Sedgwick notices it as occurring also at Mansfield, Bolsover, and Steetly further south, and at Huddlestone, to the north of these localities.

4. *Lower Limestone.*—Between the beds just described and the

* It should be remembered, however, that even this limestone, like all other rocks of sedimentary formation, requires selection; for intercalated among the beds of good stone are others which do not possess the most important property of capability to withstand atmospheric action. And not only so, but it is exceedingly difficult to distinguish such beds from the best. It thus happens that a certain percentage of stone of an inferior quality is often supplied to the builder along with a large quantity of good, and is used by him without suspicion of the evil. I saw an illustration of this in the new church of St. George at Doncaster, which is chiefly built of this limestone, where the surface of stray blocks in the exterior was already in a state of decay when I visited it only one year after it had been opened. Much of the stone used in the erection of the New Houses of Parliament is from quarries (Huddlestone and Bolsover) of the Small-grained Dolomite; and it would seem as if stones from its worst beds had been supplied rather extensively. For I cannot think that stone from its best beds would ever have shown such signs of decay as it is asserted the stone of the river-front of the palace already shows, even if we allow the atmosphere of the metropolis to be very deleterious indeed. And, notwithstanding all the obloquy that has been thrown upon the parliamentary commission appointed to select the building-stone for fixing upon a magnesian limestone, and this in particular, there can be no doubt they were right in their choice—the fault not being in the stone chosen, but apparently in the neglect of the architect in not seeing that it was taken from the right beds. To obtain a good supply of stone of uniform good quality, it is necessary to appoint some one at the quarry to select the beds to be worked, and to see to the honesty of the contractor or quarryman in working only those selected,—the only difficulty being the requisite knowledge to determine which are the superior; and this, I conceive, is rather to be attained by long practical experience than from experiments in the laboratory.

Rothliegendes is a series of limestones of various characters which may be conveniently grouped as the Lower Limestone. Some of these are oolitic, pisolitic, and nodulous (Brodsworth, Moorhouse, &c.); other beds may be termed polyzoan, being almost solely composed of fragments of *Polyzoa* (Brodsworth, Cadeby, &c.); others are cellular and unstratified (Pontefract); and others, again, are compact (Hickleton, Conisborough, &c.), or arenaceous (Bag Hill, Pontefract, Barnborough Cliff). Perhaps there is no single section of the Lower Limestone that shows the whole of these beds, though by examining a mile or two of the escarpment, or a few transverse sections of the limestone west of the Small-grained Dolomite, limestones of all the characters mentioned may be met with, besides others that are more or less modifications of these. In the vicinity of the Don the upper portion of this subdivision is a soft, thick-bedded, yellowish, oolitic limestone,—the roe-like grains being in some beds intermixed with irregularly rounded concretions as large as peas, and in others with concretionary nodules an inch or more in length, it being not uncommon to find the same stratum oolitic, pisolitic, and nodulous. Several species of fossils occur in these beds, generally as casts. A little lower down are some thick beds equally as soft as the former, which are chiefly composed of comminuted *Polyzoa*, principally of the species *Acanthocladia anceps*. Beneath these and immediately above the sandstone are other beds, which are thinner, darker-coloured, and more compact, or rarely earthy. Numerous remains of a few species of fossils occur in these beds, but often most imperfectly preserved *.

In other places more to the north, especially about Pontefract and at Wentbridge, the upper part of this subdivision is soft, yellowish, amorphous, and full of irregularly shaped sparry cavities. Under it are some thick beds of a harder limestone in which are immense quantities of *Gervilliæ* (casts). Below these are some thin strata of hard, compact, pisolitic, and arenaceous limestones, charged with the remains of *Axinus dubius* and *Gervillia antiqua*. These latter beds are seen to rest upon the Rothliegendes at Bag Hill, opposite to Pomfret Castle, where they become arenaceous and almost graduate into sandstone.

The junction of the lower beds of limestone with the Rothliegendes can be seen to great advantage in several sections in and about Pontefract, as Prof. Sedgwick has pointed out. It can be well studied in section to the south-west of the town in some road-cuttings and quarries, particularly in one on the Carlton and Ackworth road. Another interesting section is to be seen in an obscure old quarry on the escarpment, just above the pretty little hamlet of Carlton, where the lowest limestone, which is cellular, void of stratification, and charged with a few badly preserved fossils, rests upon an irregular surface of the sandstone, the latter being yellowish, moderately hard, and false-bedded. The lowest limestone in this instance appears to

* Prof. Sedgwick describes the most characteristic of these beds in section ix. of his "Great Middle Deposit of Yellow Magnesian Limestone." Trans. Geol. Soc., 2nd ser. vol. iii. p. 93.

be the equivalent of the amorphous limestone previously mentioned; and from this we infer that the beds found beneath that deposit in some of the sections about Pontefract are here wanting.

One of the most interesting sections illustrative of the junction of the lower limestone with the Rothliegendes is at Wentbridge, in the cutting on the Great North Road. The latter deposit is here seen towards the south end of the cutting, forming a large portion of the cliff on each side of the highway, and capped by a few feet of limestone, which, by the ascent of the road and the dip of the beds, gradually increases in quantity to the north-east—the sandstone disappearing, and fresh beds of limestone coming in that direction. The beds of limestone immediately above the sandstone are thinnish, of a brown colour, compact in texture, and contain the remains of *Axinus dubius* and *Gervillia antiqua*. These strata occupy a few feet of the section and are superimposed by a stratum of hard limestone about 6 feet thick, full of the casts of *G. antiqua*. Other massive beds follow, some of which are fossiliferous; and above them are some thinner beds of soft and friable limestone, also with casts of *Gervilliæ*.

On other parts of the escarpment, as at Hampole Stubbs*, the Rothliegendes is covered by some thick beds of reddish limestone of a compact, subcrystalline, or oolitic character, and which contain several species of fossils, among others *Axinus dubius* very large. But in this section the oolitic beds of the member occur much nearer the sandstone than in other places to the north and south.

Another section showing the two deposits in juxtaposition is found on the escarpment between Hooten Pagnell and Hickleton, where a series of thin-bedded, hard, crystalline, unfossiliferous limestones of a brown colour are seen to rest immediately upon the Rothliegendes, which is here soft and very incoherent. The structure of these limestones rather resembles that of the Brotherton beds, the strata being of similar thickness and hardness as those of that member. As a section of the Lower Limestone it certainly differs most widely from any other that I met with on the escarpment or elsewhere in South Yorkshire †.

Viewing the Lower Limestone as a whole, we perceive it to be more inconstant in structure, composition, and general character, than any of the other subdivisions of the series. The sections just noticed suffice to prove its mutability; and more comprehensive details would only tend to make the fact more evident. Nevertheless, though the most variable member of the Permian formation in South Yorkshire, it can always be easily distinguished from either of the limestone members that overlie it, its features being peculiar and well marked.

Most of the limestones of this group are included along with the

* The locality of Hampole Stubbs, which is on the road leading from Doncaster to Wakefield, and just beyond Little John's Well, would seem to be identical with the "Stubbs Hill" of Sedgwick.

† This section occurs in a plantation scarcely a mile south of Hooten Pagnell, and near to a footpath that winds along the escarpment from that village to Hickleton.

Small-grained Dolomite in the third subdivision or "Great middle deposit of Yellow Magnesian Limestone*" of Prof. Sedgwick. Some of the most inferior appear to be placed in his second subdivision, the "Marl-slate and thin-bedded and nearly compact limestone†".

The organic remains of this subdivision possess considerable interest, as our knowledge of the distribution of the Permian fauna in this area is almost solely based upon them, there being but three species of the Yorkshire list that range beyond its limits. The state of preservation of the fossils is generally as casts, it being exceedingly rare to meet with examples in a more perfect condition. Their extreme abundance—at least of certain species—on some horizons has been alluded to in the cases of Wentbridge and Brodsworth. And so far as we may judge, this abundance extends over comparatively wide regions; for in the case of the Gervillia-bed, which occurs so thick at Wentbridge, I have traced it over a distance of twelve miles, having seen it also at Pontefract (Bullhill Quarry), Emsall, Hooten Pagnell, Brodsworth, Hickleton, and Barnborough Cliff. The polyzoan beds I have not traced so far; but they are to be found at Brodsworth (Freestone Quarry), Hampole, and Cadeby. Further particulars of the fossils of this member will be given in another part of the paper.

As an approximation, 120 feet may be given as the probable thickness of the Lower Limestone; it being questionable whether it ever exceeds that estimate, though scarcely so as to whether it sometimes reaches it.

Amongst other localities affording good opportunities for studying its various beds, may be mentioned the numerous sections alluded to in the neighbourhood of Pontefract, which illustrate the cellular and arenaceous forms of it; and the quarries at or near Brodsworth, Hampole, Hampole Stubbs, Emsall, Conisborough, Cadeby, Moorhouse, Hooten Pagnell, and Hickleton the oolitic, polyzoan, and compact beds.

5. *Rothliegendes or Lower Red Sandstone.*—A deposit of yellow, red, grey, or variegated sandstone; fine-grained, or rather coarse in texture; of irregular structure, false-bedding being common; and though sufficiently firm to form a soft building-stone in some localities (Pontefract, Barnborough Cliff, and Wentbridge), yet often very soft and incoherent (Wentbridge, Moorhouse, and Hickleton).

The Lower Red Sandstone of South Yorkshire differs little from that of Durham, except, perhaps, in being a little more coherent and finer-grained. And in no case have I observed any decided instance of its unconformability to the overlying limestone, though it is not always easy to say whether it is conformable or not, its stratification being subject to such irregularities. There is no section on that portion of the escarpment I examined that affords much support to the opinion of those who would separate it from the Permian strata on account of its unconformability to them—rather to the contrary.

This deposit is so well described by Prof. Sedgwick that I would rather direct attention to his remarks on it than attempt further description. It is easy of examination along the escarpment in

* Trans. Geol. Soc., 2nd ser. vol. iii. p. 81. † *Loc. cit.* p. 79.

South Yorkshire; and it is nowhere better exposed, nor more characteristically developed than about Pontefract *. In quarries on the north and west of that town it is worked as a building-stone, being of about similar coherency as the equivalent beds in the vicinity of South Shields, which are likewise used by the builder. Among other localities on the escarpment south of Pontefract, may be named those at Carlton, Wentbridge, Hampole Stubbs, Moorhouse, Hickleton, Barnborough Cliff, Cadeby, &c.

§ III. *Comparison of the Permian Strata of South Yorkshire with those of Durham.*—Having now given some details illustrative of the characters of the subdivisions of the Permian series of South Yorkshire, it will be of interest to attempt their co-ordination with the subdivisions of the equivalent series of Durham.

Commencing at the base, we have the lower red sandstone, the equivalency of which with the lower red sandstone of Durham, as well as with the typical Rothliegendes of Germany, has been so long known to geologists as not to require special pointing out. Indeed the researches of Prof. Sedgwick clearly show the Yorkshire and Durham beds to be portions of one deposit, in all probability yet continuous. We have thus contemporaneous subdivisions at the base of each series. If we pass on to the Brotherton beds, the highest calcareous member, we find that it agrees in position with the upper limestone of Durham, and, besides, that it is characterized by the same fossils, and by a similar paucity of them. For these reasons I look upon the Brotherton beds as the equivalent of the upper limestone, being fully persuaded that such agreements could not have occurred in deposits of different periods. Thus we have the lower limestone and small-grained dolomite confined between two determined horizons, with the marl-slate, compact limestone, and shell- and cellular limestone of Durham as equivalents. Of these I look upon the lower limestone as being parallelized by the marl-slate and compact limestone, and the small-grained dolomite by the shell and cellular limestone. The marl-slate has no special representative in Yorkshire. And, though it is possible that its deposition may have preceded the commencement of that of the lower limestone, I see nothing that leads me to suppose that it did. In classing it as the equivalent in part to that Yorkshire member, I rely upon the fact of its being the commencement of calcareous beds in the Durham series, just as the lower limestone is in the series of Yorkshire, and on the probability of the accumulation of arenaceous sediment having been consummated and that of calcareous sediment begun about the same period in both regions. It is the compact limestone, however, that is to be considered as principally equivalent to the lower limestone. In regarding the shell- and cellular limestone of Durham as the equivalent of the small-grained dolomite, it may be objected that the great difference that exists in their palæontological features is opposed to such an identification. To this I would reply that the dif-

* The fine deep soil in which the people of Pomfret grow the liquorice-root to manufacture the "Pomfret Cakes," for which, among other things, their town is so famous, seems to be largely composed of the débris of this member.

ference is one of distribution, similar to the differences seen in the distribution of marine life in recent seas—the bottoms of which, we know, offer many examples of great irregularities in the distribution of the various forms of life that people them. To conclude, we have the Bunter Schiefer of Yorkshire apparently parallelized by some obscure and little-understood beds of red sandstone which occur in the south-east portion of the county of Durham, superior to the upper limestone, and which have been classed by Mr. Howse * as Permian under the name of Lower Bunter.

In arriving at these conclusions I have chiefly been guided by the relative positions of the subdivisions of each series. Indeed, in this instance, with such differences in the palæontological and structural features of the subdivisions, vertical position is almost the only test that can be used in attempting to parallelize them; and in series of strata, or rather in portions of the same series so little apart as the two compared, vertical position would seem to be as good a test as any that could be used. I would also observe that, in regarding subdivisions to be equivalents, I also consider them to be of contemporaneous deposition. Thus the Brotherton Beds and Upper Limestone not only represent the last deposition of calcareous sediment in each area during the Permian era, but are looked upon as contemporary. It is not, of course, supposed that the accumulation of each commenced and ceased at exactly the same periods in both areas, but that the bulk of each subdivision was synchronously deposited. [*See the Tabular View of the Permian Strata of Durham and South Yorkshire*, p. 298].

§ V. *Remarks on the Fossils.*—I now proceed to notice the species I have met with in this district.

Cephalopoda.

1. Nautilus Freieslebeni, Geinitz, Neues Jahrbuch, p. 637, pl. 11. fig. 1.

   Syns. *N. Bowerbankianus*, King; and *N. Theobaldi*, Geinitz.

A cast of a body-chamber of a young individual of this species occurred at Brodsworth. It is rather less than half-an-inch long, is a little more compressed medianly than Durham specimens of similar age, and shows traces of a shallow median sulcation.

This is the only Cephalopod I have met with in Yorkshire; but Prof. King quotes it from Aldfield, Yorks. (in the cabinet of Prof. Phillips)†.

Gasteropoda.

2. Turbo helicinus, Schlotheim, Petrefactenkunde, p. 161.

   Syns. *Turbo Mancuniensis*, *T. minutus*, and *Rissoa obtusa*, Brown; *Littorina Tunstallensis*, Howse; and *Turbo Thomsonianus*, King.

Full-grown specimens of this species in Yorkshire have five whorls, and are about one-sixth or one-fifth of an inch in length. At Ham-

* Ann. and Mag. Nat. Hist., 2nd ser. vol. xix. p. 34.

† Mon. Perm. Foss. of England, p. 220.

Tabular View of the Permian Strata of Durham and South Yorkshire.

Subdivisions.	Durham.	South Yorkshire.
1. Bunter Schiefer	*Red Sandstone* overlying the Magnesian Limestone in the S.E. portion of the county? (Howse). Thickness 50 ft.?	*Red Sandstone* and *Marl* near Doncaster and Tickhill (Geol. Survey). Thickness 50 ft.?
2. Upper Limestone	*Yellow*, *Concretionary*, and *Crystalline Limestone* of Marsden, Fulwell, Roker, Hartlepool, &c.* Thickness 250 ft.	*Brotherton Limestone* and *Lower Red Marl* and *Gypsum* of Brotherton, Knottingley, Womersley, Wadworth, Tickhill, &c. Thickness 120 ft.
3. Middle Limestone	*Shell-* and *Cellular Limestone* (*Fossiliferous* and *Pseudo-brecciated Limestone* of King) of Tunstall and Humbleton Hills, Ryhope, Galley's Gill, Down Hill, Claxheugh, &c. Thickness 150 ft.	*Small-grained Dolomite* of Vale of Went, Lound Hill, Cusworth, Levit Hagg, Roche Abbey, Warmsworth, &c. Thickness 200 ft.
4. Lower Limestone	*Compact Limestone* of Pallion, Whitley, Pensher, Houghton-le-Spring, Ferry Hill, Thickley, &c. Thickness 200 ft.	Lower Limestone of Pontefract, Wentbridge, Hampole, Emsall, Brodsworth, Conisborough, Micklebring, &c. Thickness 120 ft.
5. Kupfer-Schiefer	*Marl-slate* of Claxheugh, Down Hill, Mid-deridge, Ferry Hill, &c. Thickness 10 ft.	
6. Rothliegendes	Lower Red and Yellow Sandstone of Tynemouth, Claxheugh, Hylton Castle, &c. Thickness 100 ft.	Lower Red, Yellow, and Variegated Sandstone of Pontefract, Hickleton, Cadeby, &c. Thickness 100 ft.
Total thickness	760 ft.	590 ft.

* In a table of Permian and Triassic strata which appeared in a former volume of this Journal (vol. xiv. p. 225), the *concretionary* and *crystalline limestone* is erroneously stated to occur in Yorkshire; and the *fossiliferous limestone* is quoted as being found in Nottinghamshire, in which county the *marl-slate* is also said to occur. It may not be unimportant to point out, more especially as the statements are made by an officer of the Geological Survey, that these stratigraphical groups are not known to occur out of Durham, the two first-mentioned being confined to the north of that shire. In the remarks accompanying the same table another slight misstatement is made, where the *Rothliegendes* is said to be confined to the Western and Midland Counties, the author evidently having forgotten that the Lower *Red Sandstone* of Durham and Yorkshire has been identified with the *Rothliegendes* by Sedgwick, Murchison, King, Howse, and all who have written on it.

pole immense quantities of young and probably rather dwarfed specimens are to be had, some portions of the limestone being literally full of them; and as all these specimens are testiferous, and many of them in a perfect condition, they have afforded me a good opportunity for studying some of the variations of form and character to which this species is subject. The following remarks are therefore solely based upon these materials.

The common form is usually as wide as long, with a large body-whorl, a short, depressed spire (which occupies less than half the entire length), and a large umbilicus. The whorls are ventricose and rather flattened behind; the body-whorl increases rapidly and has two prominent central ribs, bounded on each side by others of less strength, which characterize the species; the apex is obtuse; the aperture orbicular with a slightly reflexed pillar-lip.

Many of the specimens are proportionally longer (the spire being drawn out a little and the body-whorl of less width), and have the whorls rounder and the spiral ribs of uniform strength.

Another variety is without spiral ribs, or with very faint indications of them, and has the whorls somewhat shelving behind, most prominent a little below the median line, and well rounded in front, with a narrow, flattish region bounding the suture.

There are numerous intermediate forms that are more or less modifications of the three noticed, whose differences they serve to connect by numberless slight gradations. This is strikingly the case with the differences observed in the strength of the spiral ribs, it being possible to form series of specimens showing their gradual obliteration; and so it is with the differences seen in the size of the spire, and with those of the rotundity of the whorls. Indeed, it is almost easier to pick out specimens showing some slight differences than specimens which show none.

The Hampole specimens invariably have a more obtuse apex than those of Durham, the first and second whorls being flatter compared with the succeeding ones.

The generic position of this species, like that of several other Permian univalves, is still somewhat uncertain. It has been placed in *Turbo*; and its general resemblance to the shells of that genus induces me to allow it to remain there. Its resemblance to *Littorina*, to which it has also been referred, is perhaps almost as great. And it is only right to mention that the operculum of this shell has never been found, which is better explainable on the supposition of its being horny, like that of *Littorina*, than calcareous like that of *Turbo*. There is, however, no instance on record of the operculum of any of the Permian Gasteropods having occurred in England or Germany.

Loc. Pontefract, Hampole Stubbs, Moorhouse, Pickburn, Brodsworth, Conisborough, and Barnborough Cliff. Taken by Prof. Sedgwick between Marr and Hickleton*; and by Prof. Phillips at Aldfield †.

* Trans. Geol. Soc., 2nd ser. vol. iii. p. 118.

† Mon. Perm. Foss. of England, p. 205.

3. Rissoa Leighi, Brown. Pl. VII. figs. 1–6.

R. Leighi, Brown, Trans. Manchest. Geol. Soc., vol. i. p. 64, pl. 6. figs. 9-11.

Syns. *Rissoa Gibsoni* and *R. pusilla*, Brown.

Typical specimens of this minute species are ovately conical in general form; with four, or rarely five, flatly convex smooth whorls, that increase quickly in length and width, and which are divided by a deepish and slightly oblique suture. One half of the length is occupied by the body-whorl, which has a well-rounded basal slope; the spire is conical, with rather a blunt apex. The aperture is nearly oval and of moderate size, the outer-lip being strongly arcuate, the pillar-lip somewhat curved, and reflected, with a slight umbilical chink behind it.

Length $\frac{1}{8}$ inch; breadth $\frac{1}{12}$.

There are other specimens almost obovate in form, with convex whorls, more depressed spire and obtuse apex. Others, again, have a large body-whorl, rounded whorls, and also an obtuse apex.

An examination of a type specimen of *Rissoa Gibsoni* from the Lancashire Permian beds (kindly lent me by Mr. Binney) has led me to place that species along with the one I am noticing, of which it seems to be but an enlarged form.

The *Trochus pusillus*, Geinitz, of the Unter Zechstein, is a related form, but undoubtedly distinct from the present. So it would appear is the *Turbo Permianus*, King, of the Shell-limestone of Durham.

Rissoa Leighi has only occurred to me at Hampole, where it is not rare in the beds containing *Turbo helicinus*. It is found in greater plenty in the Permian marls and limestones of Colyhurst near Manchester*. It has also been met with under its *Gibsoni* form by Prof. King, at Tullyconnell†.

4. Turritella Altenburgensis, Geinitz. Pl. VII. figs. 9, 10.

Turbonilla Altenburgensis, Geinitz, Verstein. deut. Zech. p. 7, tab. iii. figs. 9, 10.

Syns. *Loxonema fasciata*, King; *L. Geinitziana*, King; *Turritella Phillipsii*, Howse; *T. Tunstallensis*, Howse; and *Rissoa gracilis*, Schauroth.

Specimens of a minute turreted shell are not rare in the Lower Limestone at Hampole. Like the individuals of other Gasteropods from this locality, they are evidently young individuals, and somewhat stunted in growth.

These specimens are minute, turreted, and smooth. They have only five whorls, rarely six, which increase gradually in length, and somewhat quickly in breadth. The whorls are ventricose and equally rounded; the suture is deep, rather wide, and oblique. The body-whorl is about as long as one-third of the entire length. The aperture, which occupies rather more than one-fourth of the length of the shell, is obovate, being rounded behind and rather produced in

* Messrs. Binney and Brown in Trans. Manch. Geol. Soc., vol. i. p. 63; and Prof. King in Mon. Perm. Foss. of England, pp. 205, 206.

† Journ. Geol. Soc. of Dublin, vol. vii.

front; the outer lip is strongly convex; the pillar-lip is slightly convex, and a little reflected; behind it is a very minute umbilicus which in some specimens is scarcely observable.

Length $\frac{1}{12}$ inch; breadth $\frac{1}{26}$ inch.

In the adjoining quarries of Moorhouse and Hampole Stubbs other specimens of what is evidently the same species occur, twice or thrice as large as those just described, and with a greater number of whorls. These specimens are always in an imperfect condition.

These Yorkshire *Turritellæ* agree very well with Geinitz's figures and description of *Turbonilla Altenburgensis*, their general width, perhaps, being a little less compared with their length. They also very much resemble the specimens found by Prof. King in the Tullyconnell limestone, and referred by him to this species. There is a much greater difference, however, between them and the *Turritellæ* of the Shell-limestone of Durham, as there also is between the latter and those of Germany. The Durham examples are much more finely developed, ranging from half-an-inch to an inch in length, and with from 8 to 12 whorls; their aperture is also different, being more angulate by the greater straightness of the pillar-lip. Still I think that the Durham specimens may likewise belong to this species, their differences being such as we may easily suppose to be due to their higher state of development. I do not wish to assert this opinion with much dogmatism, though it seems the most probable to me: and I would add that it is in a similar spirit that I class with this species the various forms indicated by the synonyms at the head of these remarks. It is my opinion that the whole of them are referable to the present species—it apparently having the right of priority; and this is also the opinion of other Permian palæontologists, whose views are of more worth than my own*. Still it should be acknowledged that the question is one of some difficulty and not easy of solution; and that there is, even yet, much to be said in favour of the specific distinction of some of the forms here included as synonyms.

5. Chemnitzia Roessleri, Geinitz, Jahres. Wetter. Gesell. 1850–51.
Syn. *Loxonema Swedenborgiana*, King, Mon. Perm. Foss. p. 210.

A single impression of a fragment of this species occurred at Hampole Stubbs. The specimen shows five whorls strongly ribbed transversely. It is about $\frac{1}{5}$th of an inch in length. The apex is not shown, neither does the largest whorl of the impression appear to be that of the body-whorl. Nevertheless the specimen possesses sufficient character to allow the species to be determined,—the form of the whorls and their transverse ribs being unmistakeably those of *C. Roessleri*.

This species is found also in the Unter Zechstein and in the Shell-limestone of Durham.

* See Mr. Howse on *T. Altenburgensis* in Ann. and Mag. Nat. Hist., 2nd ser. vol. xix. pp. 446–448; and Baron von Schauroth in Zeitschr. d. deut. Gesell. 1856, pp. 236–244.

6. Straparollus Permianus, King, Mon. Perm. Foss., p. 211, pl. 17. figs. 10, 11, 12.

I procured five or six specimens of this species at Hampole. They are as large as the Durham examples, and have three much compressed and rapidly increasing whorls, a large body-whorl, and a slightly elevated spire. In the latter respect they differ somewhat from the majority of the Durham specimens, in which the spire, though still low, is higher, as it also is in examples from the Unter Zechstein of Germany. All the specimens are deeply and largely umbilicated, and have apparently an almost orbicular aperture.

7. Natica minima? Brown. Pl. VII. figs. 7, 8.
Natica minima, Brown, Trans. Manch. Geol. Soc., vol. i. p. 64, pl. 6. figs. 22, 23, 24.

Three specimens of a smooth shell with three whorls have occurred to me at Hampole. They most nearly resemble the *Natica minima* of Brown. The whorls are ventricose, rather oblique, flattened behind and rounded in front; the body-whorl is very large, and the spire short; aperture apparently suboval, outer-lip convex, pillar-lip nearly straight.

The condition of these specimens is not such as will allow me to speak positively in thus referring them to this species. Nor are the figures and description given by Capt. Brown such as afford much aid in their identification. A specimen of the shell, with which I have been kindly favoured by Mr. Binney, does not look much unlike a squat form of *Turbo helicinus*. Nevertheless there is a possibility of its representing a distinct species; and as there is also a possibility of these Yorkshire individuals proving to be the same, I refer them for the present to it—doing so, however, with considerable doubt.

8. Chiton Loftusianus, King, Mon. Perm. Foss. of England, p. 202, pl. 16. figs. 9–14.

I have a posterior plate (cast) of a *Chiton* from Brodsworth, and an intermediate one (cast) from Moorhouse, which appear to belong to this species. The former is rather narrow, and has an elevated and reflexed apex. The latter is obtusely angulated medianly, and has its posterior and anterior margins almost at right angles to the dorsal line. The shell of these plates appears to have been somewhat thick; and the posterior plate, which is the largest, must have belonged to an individual about five-eighths of an inch in length.

Two plates of a *Chiton* are mentioned by Prof. King as having occurred in a Permian limestone at Kirkby Woodhouse in Nottinghamshire*.

9. Dentalium Sorbyi, King, Mon. Perm. Foss. of England, 1850, p. 218.
Syn. *Dentalium Speyeri*, Geinitz, Ueber den Zechstein der Wetterau, 1852, in the Jahres. der Wetterau. Gesell. for 1850–51.

Not rare in the Lower Limestone at Hampole Stubbs. Specimens

* Mon. Perm. Foss. of England, p. 203.

are not well preserved, being either casts of the interior, or impressions left in the matrix after the decay of the shell. They are half an inch or less in length, and are slightly curved, more so posteriorly than towards the aperture; they taper gradually, and have apparently been smooth.

Prof. King first described this species from a specimen discovered by Mr. H. Clifton Sorby at Conisborough.

More than a year ago I found a *Dentalium* in the Shell-limestone of Durham, which evidently belongs to this species. It is testiferous, of the same length, of similar curvature, and smooth like the examples just noticed. It perhaps increases a little more rapidly in width, and is more acuminate posteriorly than they; but these differences seem of little import.

There does not appear to be much doubt as to this species being identical with the *Dent. Speyeri* of Geinitz, which occurs in the Unter Zechstein and Zechstein-Dolomit of Germany. Specimens from these deposits, sent to me by Baron von Schauroth as those of *D. Speyeri*, show little variation from English examples. And I have also compared the latter with drawings of type specimens with which I have been kindly favoured by Dr. Geinitz, but can detect nothing that will constitute a specific difference.

Loc. Hampole Stubbs, Conisborough (*Sorby*).

Conchifera.

1. Gervillia antiqua, Münster; Goldfuss, Petrefacten, part 2. p. 126.
   Syns. *Bakevellia tumida*, King; *Avicula inflata*, *A. Binneyi*, and *A. discors*, Brown.

Two forms of this species occur in Yorkshire. One is longer than wide, rather inflated, with a shallow curvature in posterior margin, and a deep byssal sinus. The other is wider than long, rather flat, and with a byssal sinus not so deep as the first. Neither is found above half-an-inch wide, generally less. The surface of both is marked with the regular, finely raised lines of growth so characteristic of the species in Durham.

The relative thickness of the shell appears to have been greater in the Yorkshire individuals than in those of Durham. The muscular impressions and pallial lines are thus often very clearly indicated on the casts. The hinge-teeth are also very instructively shown in many specimens.

In one quarry near to Pickburn I obtained specimens of the more elongate form which assume the character of the *Bakevellia tumida* of King,—the valves being very tumid, the hinge-line of great width, and the shell altogether more irregularly grown than in type specimens of the species.

G. antiqua occurs in immense quantities in the Lower Limestone, associated with remains of other *Gervilliæ* apparently belonging to the species *keratophaga*. At Bull Hill Quarry near Pontefract, and at Wentbridge, their remains almost solely form thick beds of limestone. It is almost invariably in the state of casts, and generally in detached valves.

It occurs at Bull Hill, Bag Hill, and other localities about Pontefract, at Wentbridge, Hampole Stubbs (Stubbs Hill, *Sedgwick*), Hampole, Moorhouse, Pickburn, Brodsworth, Conisborough, Hooton Pagnell, Emsall, Barnborough Cliff, Cadeby, Braithwell, and near Micklebring, all localities of the Lower Limestone, and in all of which it is common.

2. GERVILLIA KERATOPHAGA, Schlotheim, Denksch. Akad. Münch., vol. vi. p. 30, pl. 5. fig. 2.
Syn. *Bakevellia bicarinata*, King.

Specimens of this species occur more rarely than those of the preceding. They never attain the size of the largest Durham specimens, though in common with those they possess the same obliquity of valves, forked posterior margin, and prominent and somewhat distant lines of growth that characterize the species.

It occurs at Brodsworth, Pickburn, and, I think, in other localities; but the preservation of the specimens is such as will not allow me to speak positively on the matter. Prof. King gives the neighbourhood of Pontefract as a locality for it.

3. MYALINA HAUSMANNI, Goldfuss, Petrefacten, part 2, p. 168.
Syns. *Mytilus squamosus* and *M. acuminatus*, J. de C. Sowerby; and *Mytilus septifer*, King.

Generally about half-an-inch long, rarely an inch. Not very common. Occurs both in the Lower Limestone and the Brotherton Beds, being much dwarfed in the latter.

Loc. Lower Limestone; Bull Hill Quarry near Pontefract, Hampole Stubbs, Barnborough Cliff, near Sprotborough, Conisborough, Brodsworth, and Moorhouse. Brotherton Beds; Hampole Quarries*, Knottingley, and Loversall.

4. MYOCONCHA COSTATA, Brown, Trans. Manch. Geol. Soc., vol. i. p. 32, pl. 6, figs. 34, 35.

Specimens of this species are not rare. They never exceed $\frac{3}{4}$ths of an inch in length, have generally rather convex valves, slightly curved dorsal and ventral margins, with well-marked posterior ribs, and the surface covered with strong lines of growth.

Loc. Brodsworth, Hampole Stubbs, near Barnborough Cliff, Moorhouse, Hampole, and Bull Hill near Pontefract, all in Lower Limestone.

5. CARDIOMORPHA PALLASI, De Verneuil, Geol. Russ., vol. ii. p. 316.
Syn. *C. modioliformis*, King.

A single right valve of this species occurred in the Lower Limestone at Brodsworth. It is $\frac{2}{5}$ths of an inch long, is strongly angulated, has its umbone depressed, and appears to have had a very thin shell.

* "Hampole Quarries" is the name on the map of the Ordnance Survey for the quarries on each side of the Great North Road, a little to the north of the Holmeroyd Bridge and a mile to the east of Hampole village, and rather more than a mile to the east of the old quarry of Lower Limestone so often mentioned in this paper as the locality of "Hampole."

6. AXINUS DUBIUS, Schlotheim, Denksch. Akad. Münch., vol. vi. p. 31, pl. 6. figs. 4, 5. Pl. VII. figs. 11 and 12.

Syns. *Ax. obscurus*, Sowerby; *Ax. parvus*, *pusillus*, *productus*, *undatus*, *elongatus*, *rotundatus*, and *Lucina minima*, Brown; *Schizodus Schlotheimi*, Geinitz; and *Sch. truncatus*, King.

The most common form of this species in Yorkshire is that which has been described by Sowerby under the specific name of "*obscurus*." Its distinguishing features being already so well known, it will be unnecessary to notice them in detail. It differs from other varietal forms of this species in its greater depth anteriorly and in its greater posterior production, in the convexity of its umbonal region and larger umbone, in the obliquity of its hinge-line, and (generally) in the thickness of its shell.

Specimens from some localities—especially those from Moorhouse—show several deep furrows and ridges in the concavity of the umbonal region, running somewhat radiately from the umbone, which are probably visceral markings. Such examples also generally show traces of the muscular impressions. These internal markings are, of course, best seen in specimens with thick shells, and are very faint or not at all perceptible when the shell has not been of moderate thickness, as at Emsall and Brodsworth. The thickness of the shell has been quoted as a specific character by those who consider "*obscurus*" a distinct species; but it may be pointed out that, though the shell of the Yorkshire *Axini* is usually much thicker than the shell of those occurring in Durham, yet its thickness is subject to variation, just as the size of the shell is variable. Some individuals, and those not young ones, have the shell little or no thicker than that of the "*truncatus*" variety of the Shell-limestone of Durham, whereas in other cases the shell is fully three times as thick. Thus, instead of the difference in shell-thickness being of specific value, it would seem to be merely a difference of individual growth, due probably to age and locality, which are known to effect analogous results with the shells of recent Mollusca.

It would appear that *Ax. dubius* attained its maximum development in the British area in the sea of the Lower Limestone. It was there of greater size, more robust, and more prolific than at any other period of its history. In no other district, and on no other horizon, in Yorkshire, Durham, or any other part of Britain where Permian strata occur, does it ever again attain the same size and abundance. During the same period—while the Compact Limestone was accumulating—it was a rare species in the Durham area. And this is a fact worthy of attention: for the two regions are only some eighty miles distant; yet in one it is the commonest species, and in the other amongst the rarest.

The *Axini* of the Brotherton Beds also belong to the "*obscurus*" type; but they are there much dwarfed in size, seldom exceeding half-an-inch in width.

In some localities another variety of this species occurs (figs. 11, 12), which is much smaller than the preceding, its width being only $\frac{6}{10}$ths of an inch. It is almost ovate in marginal outline, is regu-

larly rounded anteriorly, and is a little more produced in that direction than "*obscurus*" or any of the other varieties. Its umbone is comparatively small, and does not extend much above the hinge-line; the hinge-line slopes gently inwards, and its ventral margin is regularly rounded and likewise slopes inwards to the posterior extremity. The valves are regularly convex, and the shell is comparatively thin.

This pretty form of *Ax. dubius* is somewhat rare, and has only occurred to me in Lower Limestone at Conisborough, Hampole Stubbs, and Brodsworth.

Loc. In the Lower Limestone at Bull Hill Quarry and other localities about Pontefract, at Wentbridge, Hampole, Hampole Stubbs, Moorhouse, Pickburn, Brodsworth, Conisborough, Hooton Pagnell, Emsall, and Barnborough Cliff; on Prof. King's authority it likewise occurs at Garforth Cliff, Woodhall, and Nosterfield.—In Upper Limestone at Knottingley, Loversall, Wadworth, and south of Robin Hood's Well.

7. MACRODON STRIATUS, Schlotheim, Denksch. Akad. Münch., vol. vi. p. 31, pl. 6. fig. 3.

Syns. *Cucullæa sulcata*, Phillips*; *Arca tumida*, J. Sowerby; *A. antiqua*, Münster; *A. Loftusiana*, Howse; *A. Kingiana*, De Verneuil.

Three separate valves of this species have occurred to me in the Lower Limestone. Their size is very small compared with Durham examples, being apparently of stunted growth. The largest is half-an-inch in width.

Loc. Moorhouse, and Holywell Hill (Conisborough).

8. LEDA SPELUNCARIA, Geinitz, Versteinerungen Zech., p. 9, pl. 4. fig. 6.

Syn. *Leda Vinti*, King.

I possess two specimens of this interesting species from the Lower Limestone of Moorhouse. One is a good cast of a right valve with a portion of the shell adhering to one extremity; the other is a bad cast of a left valve. The former is about $\frac{5}{8}$ths of an inch in width, and differs little from Durham specimens, except in being rather more acuminate posteriorly, and in having the umbonal ridge much broader and stronger than they.

BRACHIOPODA.

1. TEREBRATULA ELONGATA, Schlotheim, Denksch. Akad. Münch., vol. vi. p. 27, pl. 7. fig. 7.

Syns. *T. sufflata*, *complanata*, *lata*, *communis*, and *intermedia*, Schlotheim.

Both the typical form of this species and the variety *sufflata* occur in the Lower Limestone, the individuals of both varying in relative length and width in different localities, but never attaining so large a size as in Durham. My largest specimen is half an inch long,

* This is probably the shell noticed by Prof. Phillips, under the name of *Cucullæa*, as occurring in the neighbourhood of Ferry Bridge. See Phil. Mag., new series, 1828, p. 401.

which is an uncommon length. It is not a rare species at Conisborough, where the individuals belong to the typical form; nor at Hampole, where individuals of both forms occur, though exceedingly stunted even for Yorkshire.

T. elongata is the only Brachiopod that has been found in the Permian series of South Yorkshire.

Loc. In Lower Limestone at Conisborough, Brodsworth, Hampole, Hampole Stubbs, and near Wentbridge. It has also been noticed by Prof. Phillips in the vicinity of Ferry Bridge.

POLYZOA.

1. ACANTHOCLADIA ANCEPS, Schlotheim, Denksch. Akad. Münch., vol. vi. p. 20, pl. 2. fig. 7.

A. anceps is the common *Polyzoon* of the Permian strata of this district. It here takes the place—and more than takes it—of the *Fenestella retiformis* of the Durham beds. It is usually, however, much broken up, good characteristic specimens being rare. In only one quarry (Freestone Quarry) near Brodsworth, have I met with illustrative examples showing the symmetrical branching of the stems, and more rarely the celluliferous surface.

Both in the quarry named and in others at Cadeby and Hampole, the remains of this species form almost the chief bulk of thick beds of limestone that have long been wrought as a building-stone in the district a little west of Doncaster. The remains of *Acanthocladiæ* are to be seen studding the surfaces of the weatherworn walls of the ancient stone buildings of this district. When at Conisborough I saw it in company with *Gervillia antiqua* in the stones of the walls of the castle-keep—probably old acquaintances of Athelstan the Unready and his compatriots in 'Ivanhoe'!

Loc. In Lower Limestone at Brodsworth, Pickburn, Hampole, Hampole Stubbs, Bull Hill Quarry (Pontefract), and Conisborough.

2. THAMNISCUS DUBIUS, Schlotheim, Petrefacten, p. 341.

Syn. *Fenestella ramosa*, King.

I have taken a specimen of a *Polyzoon* which very much resembles this species. It is rather above an inch long, shows the uncelluliferous face, and has a principal stem about $\frac{1}{25}$th of an inch in width, with many irregular branches almost as wide.

Loc. Freestone Quarry, Brodsworth.

3. RETEPORA EHRENBERGI, Geinitz, Grundriss der Versteinerung., p. 585, pl. 23. fig. 12.

Syn. *R. Lonsdalii*, Howse; *Fenestella Permiana*, King.

Interesting fragments of this scarce species occur, along with the two preceding, in the Freestone Quarry at Brodsworth.

4. STENOPORA MACKROTHI, Geinitz, Grundriss der Versteinerung., p. 582.

Small specimens of simple and branched stems of this species occur among the débris of *Acanthocladia anceps*. In the Brodsworth Freestone Quarry the examples are always sections, some of which show the internal arrangement of the cells very clearly. At Hampole

I have taken it in minute globose and egg-shaped masses, one of which has a spine-like body for an axis.

Loc. Lower Limestone; Freestone Quarry, Brodsworth, and Hampole.

ENTOMOSTRACA.

1. CYTHERE (BAIRDIA) PLEBEIA, Reuss, Jahresbericht der Wetterau. Gesell. 1854, p. 67.

Syn. *C.* (*Bairdia*) *curta*, Jones (not McCoy).

Several specimens of this species have occurred in the Lower Limestone at Hampole, and amongst them the varieties *elongata*, *Neptuni*, and *compressa*. Also a single specimen of the variety *ventricosa* at the neighbouring locality of Moorhouse.

2. CYTHERE (BAIRDIA) SCHAUROTHIANA, Kirkby, Ann. & Mag. Nat. Hist., ser. 3. vol. ii. p. 329, pl. 10. f. 14; and Trans. Tynes. Nat. Field-club, vol. iv. p. 147, pl. 9. f. 14.

A single specimen of this species occurred at Hampole.

3. CYTHERE (BAIRDIA) AMPLA, Reuss, Jahresb. Wetter. Ges. 1854, p. 68, f. 7 *a*, 7 *b*.

A fine example of this species occurred to me in the Lower Limestone at Hampole, and has been noticed and figured by Mr. Jones in the Transactions of the Tyneside Naturalists' Field-club (vol. iv. p. 166, pl. 11. figs. 19 *a*, 19 *f*).

Its only other locality in England is in the Upper Limestone of Durham at Byers' Quarry, where it is a rare fossil.

4. CYTHERE (CYTHERIDEIS) JONESIANA, Kirkby, Ann. & Mag. Nat. Hist., ser. 3. vol. ii. p. 432, pl. 11. figs. 1, 2; and Trans. Tyne. Nat. Field-club, vol. iv. p. 151, pl. 11. figs. 24, 25.

Syn. *Bairdia gracilis*, Reuss (not McCoy).

Occurs rarely at Hampole.

5. KIRKBYA PERMIANA, Jones, Monog. Perm. Foss. of England, p. 66. pl. 18. fig. 1; and Trans. Tyne. Nat. Field-club, vol. iv. p. 129, pl. 8 *a*. figs. 1–9.

I have only met with this species once at Hampole. The specimen found agrees in size and general character with those of the Shell-limestone of Durham; the sculpture of the valves is well marked.

The specimens of *Entomostraca* which I have obtained at Hampole are pretty well preserved, and are generally perfect carapaces*. One of the beds at this locality is very friable, and decays rapidly by the action of the weather; and it is in the débris thus formed that I have found most of my Yorkshire examples of this class.

FORAMINIFERA.

1. MILIOLA PUSILLA, Geinitz, Sp. Verstein. Zechstein. und Roth., p. 6, pl. 3. figs. 3–6.

Rather common at Hampole along with the *Entomostraca*. In

* The locality of Hampole is so often mentioned in this memoir, and is so well worthy of further search, that I may remark that it refers to a little old quarry by the side of the road leading from Doncaster to Wakefield, a short distance to the west of the village, and not far from the Swan Inn.

most cases oval-shaped and flat; the coils approximating more or less to a regular arrangement on one plane, as in *Spirillina*. Rarely disk-shaped, simulating (?) the *Spirillina*. Occasionally more globose or cylindrical in form,—the coils overlapping irregularly, as generally occurs in Durham examples. The coils are also narrower, and the general habit of the specimens less robust than in Durham examples.

Usual size: $\frac{1}{20}$th in. long, $\frac{1}{30}$th in. greatest width, $\frac{1}{60}$ in. least width; largest specimens, $\frac{1}{15}$th in. long, $\frac{1}{18}$th in. greatest width, $\frac{1}{40}$th in. least width.

In Yorkshire it only occurs at Hampole. It is not rare in the Shell-limestone of Durham, nor in the Unter Zechstein of Germany.

Algæ.

The surfaces of slabs in the Brotherton Beds are often covered with the remains of an obscure fossil which probably belongs to the *Algæ*. The fragments are filiform, linear or slightly curved, cylindrical or rather compressed, rarely branched, about an inch in length when longest, but generally shorter, and about $\frac{1}{40}$th of an inch or less in breadth. They are often of a brown or reddish tinge—the surface of the slabs being grey or yellowish—and stand out in relief. They show no trace of structure; and they not only occur on the surface of the slabs, but in the substance of the beds.

These are often associated with *Axinus dubius*. At Knottingley the fragments are arranged linearly, with their longer axis in one direction, as if by the influence of a current. Indeed the imperfect condition of the specimens, and the manner in which they are scattered over the surface of the slabs, would seem to indicate that they were all more or less subjected to drift-action.

In the Upper Limestone of Durham—the equivalent of the Brotherton Beds—obscure remains of *Algæ* similar to those under notice likewise occur, and they are also associated with the same shell. These remains are in a carbonized state, and are scarcely so much broken up as those of Yorkshire, but they possess much the same character as the latter, and it is not improbable that they may belong to the same species.

The obscure fossils resembling *Serpula* or *Dentalium*, noticed by Prof. Sedgwick in the Brotherton Beds at Cold Hill, near Aberford*, are probably identical with this fossil.

Loc. In Brotherton Beds at Knottingley, Pickburn Leys, and Wadworth.

The occurrence of another fossil, of somewhat obscure affinities, though possibly an Annelid, may here be noticed.

It is a cast of a laterally compressed tube, 3 inches long (neither end being perfect), $\frac{3}{8}$ths of an inch in longest width, and $\frac{7}{30}$ths in shorter width. It is slightly arcuate longitudinally, and has an oval, or rather ovate section transversely—the convex edge being more flatly rounded than the other. Between the cast and the investing matrix there is a slight space, which appears to have been originally occupied by the walls of the tube.

* Trans. Geol. Soc., 2nd ser. vol. iii. p. 118.

A similar fossil has occurred in the Shell- and Compact Limestones of Durham, agreeing in most respects with the one described.

Loc. In Lower Limestone at Hampole Stubbs, and from a roadside stone-heap between Hampole and Hooton Pagnell.

The following table gives a synoptical view of the Permian species of South Yorkshire, and shows their general distribution in the Permian deposits of Britain:—

	Names of Genus, Species, &c.	South Yorkshire.					Durham.					N.W. of England (Lancashire Beds).	Ireland.
		Rothliegendes.	Lower Limestone.	Small-grained Dolomite.	Brotherton Beds.	Bunter Schiefer.	Rothliegendes.	Marl-slate.	Compact Limestone.	Shell Limestone.	Upper Limestone.	Bunter Schiefer.	
1	* Nautilus Freieslebeni, *Geinitz*	...	*	...	...	...	...	...	*	*			
2	* Turbo helicinus, *Schloth.*	...	*	...	...	...	...	...	...	*	*	...	*	*
3	Rissoa Leighi, *Brown*	...	*	...	...	...	...	...	...	...	...	...	*	*
4	Turritella Altenburgensis, *Geinitz*	...	*	...	...	...	...	...	...	*	...	...	...	*
5	Chemnitzia Roesleri, *Geinitz.*	...	*	...	...	...	...	...	...	*				
6	Straparollus Permianus, *King*	...	*	...	...	...	...	...	...	*				
7	Natica minima? *Brown*	...	*	...	...	...	...	...	...	...	...	...	*	
8	* Chiton Loftusianus, *King*	...	*	...	...	...	...	...	...	*				
9	* Dentalium Sorbyi, *King*	...	*	...	...	...	...	...	...	*				
10	* Monotis speluncaria, *Schloth.*	...	*	...	...	...	...	...	*	*				
11	* Gervillia antiqua, *Münst.*	...	*	...	...	...	...	...	*	*	...	...	*	*
12	* —— keratophaga, *Schloth.*	...	*	...	...	...	...	...	...	*				
13	* Myalina Hausmanni, *Goldf.*	...	*	...	*	...	...	*	...	*	*	...	...	*
14	Myoconcha costata, *Brown.*	...	*	...	...	...	...	...	*	*	*	...	*	*
15	* Macrodon striatus, *Schloth.*	...	*	...	...	...	...	...	...	*				
16	Leda speluncaria, *Geinitz*	...	*	...	...	...	...	...	*	*	*			
17	* Axinus dubius, *Schloth.* var. obscurus, *Sow.*	...	*	...	*	...	...	...	*	*	*	...	*	*
	—— ——, ——, new variety	...	*											
18	Cardiomorpha Pallasi, *De Vern.*	...	*	...	...	...	...	...	...	*				
19	* Terebratula elongata, *Schloth*	..	*	...	...	...	...	...	*	*				
20	Acanthocladia anceps, *Schloth*	...	*	...	...	...	...	...	*	*				
21	Thamniscus dubius, *Schloth.*	...	*	...	...	...	...	...	...	*	...	...	...	*
22	Retepora Ehrenbergi, *Geinitz*	...	*	...	...	...	...	...	*	*				
23	Stenopora Mackrothi, *Geinitz*	...	*	...	...	...	...	...	*	*	...	...	...	*
24	Cythere (Bairdia) plebeia, *Reuss*	...	*	...	...	...	...	...	...	*	*			
25	—— —— Schaurothiana, *Kirkby*	...	*	...	...	...	...	...	...	*				
26	—— —— ampla, *Reuss.*	...	*	...	...	...	...	...	...	...	*			
27	—— (Cytherideis) Jonesiana, *Kirkby*	...	*	...	...	...	...	...	...	*	*			
28	Kirkbya Permiana, *Jones*	...	*	...	...	...	...	...	...	*	*			
29	Miliola pusilla, *Geinitz*	...	*	...	...	...	...	...	*	*	...	...	...	*
30	*?Sp. undetermined (Alga)	...	...	...	*	...	...	...	...	...	*			
31	Sp. undetermined (Tubular fossil)	...	*	...	...	...	...	...	*	*				

Those species with asterisks on their left have been previously noticed by Professors Phillips, Sedgwick, and King, as occurring in Yorkshire.

It is stated by Prof. Sedgwick that *Productus horridus* (or *P. calvus*) was found by him in the "upper thin-bedded limestone" between Nosterfield and Well*. It is very difficult to doubt the observation of Prof. Sedgwick; but I can scarcely help doing so in the present instance when I consider the utter absence of Brachiopods in *all* the Upper Permian Beds, not only of England, but of Western Europe generally.

§ V. *Distribution of the Fossils.*—This list of fossils contains all that are yet known to occur in the Permian rocks of South Yorkshire. Without including the localities searched by Profs. Sedgwick and Phillips, it represents the result of an examination of not less than twenty fossiliferous localities visited by myself. If we add to these the localities examined by the geologists named, and not visited by me, and consider that they only met with one species which I have not found, I think we may almost conclude that the list given takes in most, if not all, of the common fossils of the district. Nevertheless it is not to be doubted that a more continued search would add to the number of species, and improve our knowledge of them generally.

It will be apparent enough from this list that fossils are only found in two subdivisions—in the Lower Limestone and the Brotherton Beds. And it will be just as apparent that nearly all the species are confined to the Lower Limestone, only three occurring in the Brotherton Beds. What we know, therefore, of the fossils of the Permian rocks of this district is in the main derived from a single subdivision belonging to the inferior half of the series.

A. *Fossils of the Lower Limestone.*—In the Lower Limestone the best localities for fossils are in the oolitic, and what I have termed the polyzoan beds. Fossils are found throughout the whole of the various beds of this member, but are most plentiful, both in species and individuals, in the beds mentioned. They are not, however, well preserved, being in most cases casts merely, those of Hampole being the chief exception. The best localities—those most rich in species and individuals, and where the latter are most finely developed and best preserved—that I had the opportunity of examining are the old quarries at Hampole, Hampole Stubbs, and Moorhouse, the Freestone Quarry near Brodsworth, and the Holywell Hill Quarries at Conisborough; all of which would certainly repay further examination, and particularly the continued researches of a local geologist. In all localities the *Conchifera* are generally found in single valves. This holds good with every species of this class†. The *Polyzoa* too are

* Trans. Geol. Soc., 2nd ser. vol. iii. p. 108.

† The dislocation of the valves of fossil *Conchifera* does not necessarily imply that they were subjected to the action of currents, and probably transported from distant regions prior to their being imbedded in sediment and fossilized. In most cases when a Conchifer dies and its adductor muscles relax, the valves of its shell spring open more or less by the elasticity of the ligament. And should the valves thus remain for a moderate length of time uncovered by sediment, the ligament and fleshy portion of the Mollusk decay, or are otherwise removed, and

always more or less fragmentary. The *Gasteropoda* seem to have suffered no injury prior to inhumation. In several places the specimens, even as casts, are so badly preserved as scarcely to be determinable. This appears to result from two causes,—sometimes being apparently the fault of the investing matrix, whose preservative qualities have been poor; and at others it is owing to the distortion of the specimens by compression during the process of fossilization. The most remarkable instance of the latter kind that I have met with is near to Hampole Stubbs, where there is a bed of compact brown limestone full of *Axini* pressed flat, and, in consequence, broken into many pieces. I observed another example of this kind at Conisborough, where *Terebratula elongata*, which is not a rare shell there, and of rather large size for Yorkshire, is almost invariably more or less distorted by pressure, while the shells of other species—Gasteropods and Conchifers—are scarcely ever similarly affected. In this case the *Terebratulæ* must have been less able to resist the amount of pressure to which the organic remains of this locality were subjected than their associates. And perhaps this may be explained, in the first place, by their much thinner shell, and in the second, because of their having been imbedded with closed valves, their dental system not allowing the easy opening or dislocation of the valves after the death of the Mollusk, which would thus prevent the entrance of sediment into the cavity of the shell, to the great disadvantage of the valves resisting the pressure of the gradually increasing superincumbent mass.

Moorhouse.—One of the most interesting localities is an old quarry near to the hamlet of Moorhouse, where *Axinus dubius* occurs in great profusion, and most finely developed, both in respect to size, thickness of shell, and general character. Its peculiar umbonal ridges are very finely displayed in the casts of this locality. Several other species likewise occur, and amongst them some of the rarest of the Yorkshire forms. The limestone is oolitic; and there is one bed in particular which contains the fossils most abundantly; its position is only seven or eight feet above the Lower Red Sandstone, which is exposed in the same quarry.

Hampole.—About half a mile to the east of the preceding locality is another old quarry, of very ignoble appearance, at Hampole, where there are some beds of fossiliferous limestone apparently situated a little above the oolitic beds of Moorhouse. From this spot I have obtained seventeen species, and many of them are immature and somewhat dwarfed. *Axinus dubius*, which is so large at Moorhouse, is here never more than half-an-inch in width. And *Turbo helicinus*, which

all connexion between the valves ceases, in which state they would subsequently be imbedded, were a deposition of sediment to take place before the decay of the valves themselves. It is extremely probable that this is one of the causes of the valves of fossil *Conchifera* so often occurring detached. When shells of this class are found fossilized with their valves closed and in perfect juxtaposition, it is natural to suppose that their ligament was slight and of little strength, or that they were burrowers, or, at least, if not burrowers, that they had been enveloped in sediment while living; so that, on the relaxation of the adductor muscles from death, the valves would be kept closed by the external pressure of the surrounding sediment.

is the common fossil of the locality, is only one-fourth its usual size. The molluscan remains are mixed with comminuted *Polyzoa*, chiefly of the species *Acan. anceps*, the fragments being very small, though numerous. As it happens, however, the reduction in size of the fossils is accompanied by an improvement in their state of preservation, and particularly in respect to the Univalves, which are generally testiferous. So numerous are these minute fossils in some parts of the quarry, that the quantity of them that occur in a small portion of matrix is most surprising, a fact rendered easy of proof by the friable nature of the matrix. As illustrative of this, I may mention that in but a quarter of an ounce of limestone I have picked out 298 separate organisms, the majority being specimens of *Turbo helicinus*. Another experiment of a like kind, the quantity of limestone being the same, yielded even more astonishing results. From it I extracted 461 specimens of *T. helicinus*, 18 of *Turrit. Altenburgensis*, 7 of *Ris. Leighi*, 2 of *Terebrat. elongata*, 1 of *Bairdia plebeia*, 24 of *Miliola pusilla*, and 8 fragments of *Stenopora Mackrothi*; in all 513 organisms. A cubic foot of this limestone of equal richness as the latter throughout, and supposing it to weigh 120 lbs. (a low estimate), would contain very nearly 4,000,000 of distinct individuals—and these not truly microscopic, but distinguishable with the naked eye, most of them being Gasteropodous *Mollusca*. All the limestone of this locality, however, is not so highly fossiliferous as in these examples, there apparently being certain zones of limestone that are pre-eminently fossiliferous. Besides illustrating the extreme abundance of these minute fossils, the above facts give a good idea of the relative abundance of individuals belonging to the different species. They show that *Turbo helicinus* is by far the most common form, and that its individuals outnumber many times over the aggregate of those of all the other species. And this is the only instance I have met with where the Gasteropod in question, though very generally distributed in the Lower Limestone, has taken the leading place among the fossils of a locality. And, besides, this is the only locality in Yorkshire—perhaps in England—where *Gasteropoda* hold so important a position in the list of species, about half of the *Mollusca* being species of this class.

Near Brodsworth.—Another interesting locality is near to Brodsworth in some old quarries just to the west of the village, where the beds belong to the higher part of the Lower Limestone. The predominating fossil here is *Gervillia antiqua*, its casts composing almost the whole of the substance of some of the beds. This species is just as common here as *Axinus dubius* is at Moorhouse, or *Turbo helicinus* at Hampole. And the beds in which it is so plentiful are probably identical with those at Wentbridge, Pontefract, etc., where we have noticed it as occurring in similar profusion. Along with the *Gervilliæ* are to be found the remains of a few other species, amongst which (rarely) are those of *Nautilus Freieslebeni* and *Chiton Loftusianus*.

Near Pickburn.—Between Pickburn and Marr there is a quarry called by the villagers the "Freestone Quarry*"—of thick-bedded

* In the south of Yorkshire any stone that can be easily worked by the mason is termed a "freestone." In Durham this term is only applied to sandstones.

oolitic and polyzoan limestone, from which I obtained an interesting suite of fossils. The common fossil is a *Polyzoon—Acanthocladia anceps*. The associated species, among which are those mentioned as the common fossils of other localities, are all of subordinate importance in respect to individual distribution. Besides the species of *Polyzoa* named, three others have occurred to me in the polyzoan beds, two of which (*Retepora Ehrenbergi* and *Thamniscus dubius*) are peculiar to it. The beds in which the *Polyzoa* are so profusely distributed scarcely ever contain species belonging to other classes.

I chiefly notice these fossiliferous localities in detail to draw some attention to the manner in which different species characterize certain localities. In some cases this seems to be due to the localities representing different horizons of the Lower Limestone, consequently different periods of Permian time, which in this area were characterized by the prevalence of different common species. This is certainly the case with the Moorhouse and Brodsworth localities, whose vertical position in the series it is not difficult to test, the former evidently underlying the latter. In other instances the differences observed appear to be merely those of geographical distribution; as, for example, that of Hampole and the Freestone Quarry near Pickburn, the beds of both appearing to be of the same relative position. To the palæontologist these groups of species and their differences are of particular importance—just as much, perhaps, as the larger groups (and their differences) belonging to different formations of strata: for, as the one tells of great and widespread changes in the relations of ancient life during the elapse of immense ages, so does the other of the small and limited changes which happened during shorter periods, and from which the first eventuate.

The species that are found furthest down in the Lower Limestone are *Axinus dubius* and *Gervillia antiqua*. Casts of these shells (those of the former being most prevalent) occur in the lowest beds of compact and earthy limestones immediately above the Rothliegendes at Carlton, Wentbridge, and Pontefract (Bagg Hill). Other species soon appear in the beds that follow; but for some feet upwards *Axinus dubius* holds its own, and increases in size and numbers, until it attains its maximum in certain strata, not so very far above the sandstone as at Moorhouse and Conisborough. In the succeeding beds *Gervillia antiqua* becomes very numerous and takes the place of the other as common species. Near about the same horizon as the latter, or possibly a little below it, are the beds in which *Acanthocladia anceps* is so common in the region between the Don and the Went. Above these beds and in the highest portion of the member, fossils become rarer, and the species that occur are more equally represented.

The assemblage of fossils at Hampole is, perhaps, the most curious of any that occurred to me in South Yorkshire. As already remarked, it is chiefly composed of Univalves, all of which are minute, their small size being due in the case of *Turbo helicinus*, *Turritella Altenburgensis*, and one or two others, to the immature condition of the specimens, which are invariably young and somewhat dwarfed

individuals. The associated specimens of *Rissoa Leighi*, *Natica minima*, and *Straparollus Permianus* are mature individuals, so far as the development of these species is known to us from their occurrence in the Permian strata of other districts. The latter, however, are smaller species than the former, and their individuals are of about similar gravities as the immature examples of the first-named species. Hence when we consider their great numbers, smallness, and general uniformity of size, and the comminuted state of the *Polyzoa* that occur along with them, it seems likely that we have here an instance of the accumulating action of currents. It is easy to understand how a submarine current of a certain power, passing over a sea-bottom strewed with various forms of marine life, could sweep away those organisms whose specific gravities it could overcome to some region more or less distant, where its force became spent or lessened, and there deposit them in quantities as countless as those of Hampole. If its power never exceeded a certain limit, the larger and more weighty organisms would not be removed, while the smaller, if unattached and not otherwise held down, would be carried off; and supposing the currents were periodical and occurring only at stated seasons, hosts of young shells at a particular stage of development might be swept away at intervals. It must certainly be allowed that the fossils individually show no perceptible traces of such a removal, though to what extent traces of this kind in the shape of abrasion, etc., would be perceptible in the case of transportation over a soft sea-bottom, such as the Lower Limestone in the course of deposition would surely form, does not appear, though we can readily conceive that they would possibly not be very evident. There may be other ways of accounting for the aggregation of so many minute Univalves in one locality; but I certainly know of none that so well explains the facts of the case as the one suggested. Nor do I know of any other instance in the Permian deposits of Yorkshire and Durham, where we seem to have such indications of the influence of ancient submarine currents in the distribution or rather accumulation of their organic remains.

The polyzoan beds also seem to be at first sight an accumulation of drifted materials. This is only a natural surmise on finding so fragmentary an assemblage of remains as those which enter so largely into the composition of these strata. Nevertheless I am disposed to consider them the remains of *Polyzoa* that lived where we find them, and that the range of the beds marks the site of an ancient ground or zone altogether (or nearly so) peopled by *Polyzoa*,—where they lived and died generation after generation for a long period, the latter generations growing on a sea-bottom composed of fragments of the polypidoms that preceded them, until at last, owing to reasons unknown, their growth ceased after the accumulation of several thick beds of their remains. This I think is proved by the fossils belonging nearly altogether to *Polyzoa*. Had they been accumulated by the action of a current sweeping over the bottom of the sea, there would surely be observed amongst them a greater mixture of other species, more especially as we know that there were several others which helped

to people the sea-bottom of the South Yorkshire region during the aggregation of the beds.

B. *Fossils of the Brotherton Beds.*—Little can be said relative to any peculiarities in the distribution of fossils in the Brotherton Beds. The chief feature is most certainly their great paucity both specifically and individually. The three species which occur in them are generally associated; when any one of them is found alone, it is *Axinus dubius*. Their occurrence is not general throughout the vertical thickness of the beds, there being many of the strata quite unfossiliferous. They characterize certain strata, and on the upper surfaces of these they are often rather thickly strewed. The size of the two Conchifers which occur is greatly reduced in the Brotherton Beds, more particularly in the case of *Ax. dubius*. Here it never exceeds half-an-inch in width, while in the Lower Limestone it is at times fully two inches. It also shows slight modifications of form, approaching in outline the variety *Schlotheimi* of Geinitz, though somewhat intermediate between it and *obscurus*. The only species peculiar to these beds is the *Alga* already noticed.

§ VI. *Permian Fossils of South Yorkshire compared with those of Durham.*—An examination of the preceding table shows that all the species, with the exception of two, occur in the Permian beds of Durham; and both of these are found in the Lancashire beds. It is thus seen that none are peculiar to South Yorkshire. It is also evident that most of the species are not confined to the British area, several being among the most sporadic of Permian species. Out of the 31 species 25 are common to Germany and Britain, most of which existed in the former region at the period of the Lower Limestone. Ten species are common to Russia and Germany, and a less number (4) to Russia, Germany, and the Permian strata of North America. The *Conchifera*, along with the Cephalopod and the Brachiopod, are all extra-British; two-thirds of the former and each of the representatives of the latter classes range through Germany into Russia. All the *Polyzoa* are German; but none are Russian. The *Entomostraca*, with one exception (*Bairdia Schaurothiana*), are German, one (*Kirkbya Permiana*) having also Russian varieties. The Rhizopod is a Zechstein species. The species most confined in their range are Gasteropods. Of the members of this class only one is Russian, 5 are German, and 3 are peculiar to Britain. In all, 5 species appear to be confined to the British area.

Compared with the Permian fauna of Durham—taking it at its maximum development during the deposition of the Shell-limestone—the group of species found in the Lower Limestone forms but a meagre life-group so far as number of species is concerned. The number of species composing the former is 118, while of the latter there are only 31. This does not, however, prove a rarity of life in the Yorkshire area; for the fewness of species seems to have been counterbalanced in some degree by a greater individual abundance,—the remains of *Gervillicæ* at Wentbridge, &c., and of *Turbo helicinus* at Hampole, exceeding anything of the kind to be observed in the most fossiliferous localities of Durham. The chief differences are

absences, that of Brachiopoda being the most notable. In the most fossiliferous localities in Durham, Brachiopods are the commonest fossils. In Yorkshire the only species of this class that occurs is almost among the rarest. The two common Polyzoans of Durham—*Fenestella retiformis* and *Synocladia virgulacea*—are also wanting, their places being apparently taken by *Acanthocladia anceps*. The commonEchinoderm of Durham is absent, as are also other species too numerous to name, several of which are common forms in the Durham beds. On the other hand, *Nautilus Freieslebeni*, *Chemnitzia Roessleri*, *Straparollus Permianus*, *Chiton Loftusianus*, *Monotis speluncaria*, *Macrodon striatus*, *Terebratula elongata*, *Acanthocladia anceps*, *Retepora Ehrenbergi*, *Miliola pusilla*, as well as others that are common to both faunæ, and which in Durham and Germany are confined to the lower and middle subdivisions, form a most intimate relationship between the two, and afford strong palæontological evidence—were any wanting—of the inferior position in the series of the deposits containing the Yorkshire group of species.

But to form a just comparison with the Durham fauna, we must take it as developed during the deposition of the Compact Limestone, the equivalent—in great measure—of the Lower Limestone. But before doing this, it may again be pointed out that the fossils of the Compact Limestone do not represent the earliest traces of Permian life in Durham, as do those of the Lower Limestone in Yorkshire. In the latter county the deposition of the Lower Red Sandstone or Rothliegendes was immediately followed by that of the Lower Limestone; at least there was no intermediate deposition. In Durham a deposit of semicalcareous, semiargillaceous sediment followed that of the Rothliegendes, and preceded that of the Compact Limestone —thus separating the two deposits by a few feet of calcareous shale, which has been named the Marl-slate. It was during the deposition of this shale that animal life may be said to have first appeared in the Durham area during Permian time,—*Lingula Credneri*, *Discina Konincki*, and *Myalina Hausmanni*, with several Fishes, forming this *avant-garde* of the larger fauna that afterwards peopled the same area. I have little doubt that these species were contemporaries with those of the fauna of the Lower Limestone, though only for a season; for on the commencement of deposition of the Compact Limestone, another set of species gradually took their place, and became in turn contemporaries of the same Yorkshire species, which continued to people the Yorkshire area while the changes noticed were occurring in Durham. And it was not until the era of the Compact Limestone that the physical conditions of the Durham area became analogous to those prevailing in the area of Yorkshire, and that the distribution of species therein became, like those of Yorkshire, of an unquestionably marine character. It is, therefore, chiefly with them that we have to do in comparing the contemporary faunæ of the two districts.

As far as we are acquainted with the fossils of the Compact Limestone, they amount to 31 species, thus forming a group of equal number with those of the Lower Limestone. A list of these species is

given in the following table, the *Mollusca* and *Polyzoa* of the Lower Limestone being placed in juxtaposition for the sake of easy comparison :—

Compact Limestone (Durham).	*Lower Limestone (South Yorkshire)*.*
Dentalina Permiana.	
Miliola pusilla.	
Kirkbya Permiana.	* K. Permiana.
Retepora Ehrenbergi.	* Retepora Ehrenbergi.
Acanthocladia anceps.	* Acanthocladia anceps.
Fenestella retiformis.	
Stenopora Mackrothi,	* Stenopora Mackrothi.
Synocladia virgulacea.	
	Thamniscus dubius.
Lingula Credneri.	
Discina Koninckı.	
Productus horridus.	
Strophalosia lamellosa.	
———— Goldfussi.	
Streptorhynchus pelargonatus.	
Spirifera alata.	
Camarophoria crumena.	
———— globulina.	
Spirifera Urii.	
Terebratula elongata.	* Terebratula elongata.
Monotis speluncaria.	* Monotis speluncaria.
Gervillia antiqua.	* Gervillia antiqua.
	* ——— keratophaga.
Axinus dubius.	* Axinus dubius.
Myoconcha costata.	* Myoconcha costata.
Leda speluncaria.	* Leda speluncaria.
Astarte Vallisnieriana.	
——— Tunstallensis.	
Solemya biarmica.	
——— normalis.	
Pecten pusillus.	
Myacites lunulata.	
	Myalina Hausmanni.
	* Cardiomorpha Pallasi.
Pleurotomaria Verneuili.	* Macrodon striatus.
	Turbo helicinus.
	Rissoa Leighi.
	Turrit. Altenburgensis.
	* Chemnitzia Roessleri.
	Natica minima.
	Chiton Loftusianus.
	* Dentalium Sorbyi.
	* Straparollus Permianus.
Nautilus Freieslebeni.	* Nautilus Freieslebeni.
† Platysomus striatus.	

It is thus seen that 11 species are common to both groups, amongst which are the Cephalopod, 5 Conchifers, the Brachiopod, 3 Polyzoans, and 1 Entomostracan. When we consider the nearness of the two areas—their distance apart being only about 80 miles—

* The species marked with asterisks occur in the Zechstein.

† The list of species from the Compact Limestone is based upon the researches of Prof. King, Mr. Howse, Mr. Manson, and Mr. Parker.

so slight an admixture of species is a matter of surprise, particularly when an examination of the fauna of the Unter Zechstein, which appears to have been of contemporaneous deposition with the Compact Limestone of Durham and the Lower Limestone of Yorkshire, shows that 21 of the Yorkshire species (viz. 1 Cephalopod, 3 Gasteropods, 8 Conchifers, 1 Brachiopod, 3 Polyzoans, 4 Entomostracans, and 1 Rhizopod) were distributed in the German area during the same period.

In the Yorkshire fauna 9 of the species are Gasteropods; in that of the Compact Limestone there is only a single member of the same class. In the Compact Limestone fauna 11 of the species are Brachiopods; in the other there is only one. It is in these respects that the two faunæ differ most. Five out of the 9 Yorkshire *Conchifera* occur in the Compact Limestone: among them are the two common species *Ax. dubius* and *Gerv. antiqua*; but neither of these shells is common there. The most common shell of the Compact Limestone is *Productus horridus*. No species is so common as it; *Strophalosia lamellosa*, *Spirifera alata*, and *Camarophoria crumena* being next in the list of common species. *Acanthocladia anceps*, the common Polyzoan of the Lower Limestone, is not rare in the Compact Limestone, but the place of the common Polyzoan is there taken by *Fenestella retiformis*. One of the Yorkshire Entomostraca is found in the Durham subdivision. The Rhizopod *Miliola pusilla* is common to both faunæ, it being accompanied by a *Dentalina* in the Compact Limestone.

In these differences, in two contemporaneous assemblages of Permian species, we have a good illustration of some of the peculiarities that pertained to the distribution of marine life in palæozoic times. It is thus shown that, according to present researches, there is only about one-third of the species of each fauna common to both groups, thus leaving about two-thirds that are peculiar to each. And it may be remarked that, though all the species peculiar to the South Yorkshire assemblage, except two, were afterwards distributed in the Durham area during the Shell-limestone period, it would yet appear that none of those peculiar to the Durham group were ever common to the other. We can scarcely refer these differences to the result of geographical distribution of species, for we cannot but consider that the Permian deposits of Durham and Yorkshire were accumulated in the same sea; so that it would be perfectly unwarrantable to ascribe differences so great in specific distribution to an agency of this kind, when the two regions were so nearly situated and the nature of the sea-bottom the same. To changes belonging to the distribution of species in depth, however, the differences would easily seem referable; it being now well known that great differences obtain in the distribution of marine life as the zone of depth varies, even with short distances. I would therefore refer the differences observed in these local faunæ to a change in the conditions of depth of sea existing in each area, while their respective deposits were accumulating; the difference being in the greater depth of sea over the Durham area than to the south-

ward over the other. It is probable when we acquire a better knowledge of the fossils occurring in the intervening range of Permian strata in the northern half of Yorkshire, that the differences noticed may be found to be the result of gradual changes in the distribution of species. And it is possible that still further south other arrangements of species may obtain that are peculiar to their own localities; just as in the case of the two following local faunæ which, in all probability, had a contemporaneous existence further to the west.

It is worthy of attention that several of the Yorkshire species, which were of contemporaneous existence in Germany, appeared in the British area first in Yorkshire. This is the case with *Chemnitzia Roessleri*, *Dentalium Sorbyi*, *Turbo helicinus*, *Straparollus Permianus*, *Turritella Altenburgensis*, and *Macrodon striatus*, which did not appear in the Durham area until the era of the Shell-limestone. It is not very evident whether in the latter case the migration was from the Yorkshire region or that of Germany; but as other species accompanied these which do not occur in the Lower Limestone of Yorkshire, though common to the Unter Zechstein, it may be presumed that it proceeded from the latter. Indeed, when we remember that the Permian fauna attained its maximum in Germany during the period of the Unter Zechstein*, and in England not until that of the Shell-limestone, it seems highly probable that a general migration of species—or rather of their individuals, the species still continuing in the old area—took place to the westward while the middle portion of the Permian series was being deposited, especially as more than half of the additions to the British fauna during the Shell-limestone period were Unter Zechstein species.

§ VII. *Permian Fossils of South Yorkshire compared with those of Lancashire.*—There is another group of species with which it may be well to institute a comparison. I refer to that belonging to the Permian strata of Lancashire, whose geographical position is nearer to the Yorkshire beds than that of the Compact Limestone, though their vertical position in the series is not so well determined. This little local fauna consists of only seven species; three of these are Gasteropods—viz. *Turbo helicinus* (with var. *Mancuniensis*), *Rissoa Leighi* (with var. *Gibsoni*), and *Natica minima*. The rest, with the exception of a Sponge (*Tragos Binneyi*), are Conchifers—viz. *Gervillia antiqua*, *Axinus dubius*, and *Myoconcha costata*. Now all these species, except the Sponge, occur in Yorkshire; and all of them are common species there, but the one just-named and *Natica minima*. Two of the species we readily recognize as the most common of the Yorkshire fauna. And two of the Univalves (*Natica minima* and *Rissoa Leighi*) are in England only found in the Lancashire and Yorkshire beds.

Therefore making every allowance for the smallness of the Lancashire group of species, there seems to be a much more intimate relationship between it and the Yorkshire fauna (Lower Limestone), than

* See an excellent table of species occurring in the Zechstein of Germany, by Baron von Schauroth, in the Zeitsch. d. Deut. geol. Gesell. 1854, pp. 569, 574.

between the latter and the Durham fauna during the Compact Limestone era. It is certainly difficult to attempt comparisons with so small a group of species, which may or may not give a fair idea of the original distribution of life in that area, though I incline to the former opinion. We see, however, the same ascendency of Gasteropods and Conchifers, and the same rarity of Brachiopods that obtain in the fauna of the Lower Limestone of Yorkshire. And in these respects we might almost argue a similarity of physical conditions prevailing in the two areas. But the absence of *Polyzoa* and the great reduction in the number of species point to a difference as great perhaps as that which existed between the conditions of the Yorkshire and Durham areas. Between the Lancashire and the Durham faunæ, that of Yorkshire holds an intermediate place. Its zone of depth, as already remarked, was apparently not so great as that of the Compact Limestone, though decidedly greater than that of the sea of the Lancashire area. The fauna of the latter appears to have existed on the argillaceous and semicalcareous submarine mud-flats that lay off the coast of a Permian land-area; the Yorkshire fauna certainly existed further away in deeper water and within the limits of regular deposition of calcareous sediment, though still towards the shallower zones of that region; the fauna of the Compact Limestone of Durham seems to have dwelt still further seaward, where the depth was greatest. These conclusions are in perfect harmony with the teachings of a more comprehensive view of the Permian deposits of Britain; for an examination of them leads to the opinion that the sea which covered so much of the British area in Permian times, deepened to the north and east and shallowed to the south and west. This we may easily prove by tracing the Permian strata from the north-east corner of Durham south and westward, noting the gradual change from magnesian-calcareous deposits to others which are argillaceous, arenaceous, and conglomeratic,—these lithological changes being likewise accompanied by analogous changes in the distribution of the remains of organic life, there being at the one extreme (Durham) a deep-sea fauna in calcareous strata, and at the other (Bristol) a conglomerate charged with the remains of Reptiles.

As before stated, the exact horizon of the fossiliferous beds of the Lancashire series has not been determined; nor is it easy to do so. But it may be suggested that, as the beds in question (which are thin limestones and marls) most probably represent the period of greatest depth of sea attained in the Lancashire area in Permian time, being the only calcareous beds of the series, they may easily be of synchronous deposition with the Lower and Compact Limestones, which are considered to be representatives of the same period in their respective areas. This would certainly be the case if the depression of sea-bottom, which originated the increased depth of sea, arrived at its maximum in all parts of the British area at the same time: and, so far as we know, there is nothing that seems to disprove that it did; at least it is much more likely, when we consider the nearness of the Lancashire and Yorkshire areas, that they were affected alike and attained their maximum depth of sea about the same time, than that

they were affected differently and attained their maximum depths at widely different periods *. Granting the former, the comparison we have instituted with the Lancashire fauna is attended with some degree of interest; for it then relates to a group of species of contemporaneous existence with that of the Lower Limestone, as in the case of the Compact-limestone group.

I am aware that Prof. King has incidentally suggested that these beds may possibly belong to the highest portion of the Permian series. But, except the weight of his opinion (for which I make every allowance), I see no fact that supports such a view. And besides the argument already offered in favour of a different classification, there is the fact that four of the species (*G. antiqua*, *R. Leighi*, *N. minima*, and *T. Binneyi*) never occur in the higher beds of the Permian series in other parts of England. This might not be of much consequence were the distribution of species at all variable in the upper beds, so that we might expect to meet with species specially characteristic of certain localities; but there is so great a uniformity of distribution in the highest beds of the series—the very reverse of that in the lowest—that the occurrence of species hitherto found only in the inferior strata in beds of uncertain horizons would certainly favour their classification with the lower rather than the upper members of the series.

§ VIII. *Permian Fossils of Ireland.*—But the group of Permian species to which the fauna of the Lower Limestone approaches most closely is that occurring in the magnesian limestone of Cultra and Tullyconnell in Ireland, described by Prof. King†. This group consists of 11 species; and all of them with one exception (*Cythere Tyronica*) are common to the Yorkshire fauna. Among the *Mollusca* are the common forms of the Yorkshire deposit, as *Gerv. antiqua*, *Ax. dubius*, *Myo. costata*, *Myal. Hausmanni*, *T. helicinus*, *Ris. Leighi*, and *Tur. Altenburgensis*; and among the other species there are also *Sten. Mackrothi*, *Th. dubius*, and *Mil. pusilla*. The two assemblages have very much in common, the principal differences being deficiencies. In both instances Conchifers and Gasteropods are the characteristic Mollusks; and in both, these classes are pretty equally balanced. The all but absence of *Brachiopoda* in the one, and their absence in the other, is another point of agreement; and the representation of *Polyzoa*, *Foraminifera*, and *Entomostraca* by species either identical or closely related completes the similitude.

And it is quite possible, in my opinion, that this Irish group of species may likewise have been of contemporaneous existence with the fauna with which I am comparing it. The horizon of the Cultra and Tullyconnell beds is certainly considered to be high in the series by Prof. King, though, with deference to the Professor's opinion, I would again suggest the possibility of a more appropriate classifica-

* I here argue on the usual assumption of calcareous beds being the deposition of deeper sea than those of an argillaceous and arenaceous nature. That there are exceptions to this it would be useless to dispute; but as a general rule it probably holds good.

† Journ. Geol. Soc. of Dublin, vol. vii. p. 73–78.

tion. In referring these beds to the highest member of the Permian series as developed in the North of England, Prof. King relies on their lithological, chemical, and palæontological characters, all of which are stated to offer a remarkably close agreement with the equivalent features of the highest Permian member of the North of England*. Now, in the first place, the lithological evidence of the Upper Limestone of the North of England is of very little value as an aid to classification. In proof of this I would refer to the Brotherton Beds of Yorkshire, which are as different lithologically from the Upper Limestone of Durham as they are from any other Permian limestone whatever, though their relative position and fossil remains indisputably prove them to be of the same general horizon. The lithological characters of the Upper Limestone of Durham are peculiar to that county; and so are those of the Brotherton Beds to the adjoining counties of Yorkshire and Nottingham. Indeed to take the Magnesian-limestone group as a whole, I question whether there is any series of rocks whose lithological characters are so variable and of so little value in the classification of its different parts. And so it is with the chemical composition of the Upper Limestone. Even in Durham alone, analyses of its different beds show as great a variation in the proportion of chief ingredients as do analyses of limestones of different members. Besides, analyses of the underlying members sometimes so nearly agree with those of the upper, as to destroy the worth of all arguments for the identity of age of different beds from their similarity of chemical composition†. And in respect to the fossils, there certainly does not seem to be much reason for considering them as a group characteristic of the upper beds. Out of the 11 species that occur, 6 (viz. *Sten. Mackrothi*, *Th. dubius*, *Gerv. antiqua*, *Tur. Altenburgensis*, *Ris. Leighi*, and *Mil. pusilla*) have never been found higher than the middle subdivision or Shell-limestone of Durham. And, as Prof. King has justly pointed out, the absence of *Polyzoa* among the species occurring in the upper member is one of the peculiar characteristics of its fauna‡. For this reason I must conclude that the occurrence of two species of this class in the Tullyconnell deposit is opposed to its being considered the equivalent of that member. Four of the species—viz. *Ax. dubius*, *Myal. Hausmanni*,

* *Loc. cit.* p. 79.

† I would refer to the following analyses in corroboration of this assertion. The first is one of the Upper Limestone with which Prof. King has identified the Irish deposit; the other is one of the Compact Limestone, the most inferior limestone member.

Upper Limestone, Hartlepool.		*Compact Limestone, Ferry Hill.*	
Carbonate of Lime	54·5	Carbonate of Lime	54·1
—— of Magnesia	44·9	—— of Magnesia	44·7
Oxide of Iron	0·3	Oxide of Iron	0·6
Earthy matter	0·3	Earthy matter	0·6
	100·0		100·0

Greenwell's Mine-engineering, p. 17.

‡ Mon. Perm. Foss. of England, Introduction, pp. xiv, xvi; and paper "On the Occurrence of Permian Magnesian Limestone at Tullyconnell, near Artrea, in the County of Tyrone," Journ. Geol. Soc. of Dublin, vol. vii. p. 60.

Myoch. costata, and *T. helicinus*—are undoubtedly common to the Upper Limestone and the Tullyconnell deposit, though likewise common to the inferior beds; and, had they occurred alone or with other species also characteristic of the higher portion of the series, their evidence would then have been more in favour of Prof. King's suggested classification. But, as they are associated with other species, such as *Sten. Mackrothi*, *Ris. Leighi*, and *Mil. pusilla*, which, in all districts where the succession of beds has been determined, are confined to the lower and middle parts of the series,—and as they are themselves among the most common species of the lower beds in some localities, it would appear pretty certain that the balance of palæontological evidence supports a classification of the Cultra and Tullyconnell beds with the inferior rather than with the superior members of the Permian series.

§ IX. *The Zechstein.*—Time will not allow my attempting comparisons with the groups of species found in the Zechstein of Germany; and to do so would require a wider scope than the limit of this paper permits. Comparisons, however, of this and of the other groups of species found in the Permian strata of Britain with those of the Zechstein would most assuredly bring to light many interesting facts connected with the distribution of marine life, in time and space, during the Permian era. The intimate relation which exists between the marine fossils of the Permian rocks of Britain and Germany proves them to be the remains of one fauna peopling the same geographical province or area of deposition. And to trace the various phases in the history of this fauna, its peculiarities of distribution in space and in time, its development, and manifold relations, will certainly be the work of some palæontologist when our knowledge of it and the strata containing it becomes more advanced.

§ X. *Conclusion. Distribution of the Permian Fauna in Time.*—After the deposition of the Lower Limestone and during that of the Small-grained Dolomite, it would appear as if there had been a total withdrawal of species from the South Yorkshire area. During the same period in Durham the Permian fauna was at its maximum. Thus we have another most remarkable instance of local difference in the geographical distribution of Permian species.

This exodus of species was in most cases permanent. Only two are known to return during the deposition of the Brotherton Beds. Others may certainly be undiscovered; but so far as we know *Axinus dubius* and *Myalina Hausmanni*, accompanied by one, or perhaps two, species of *Algæ* previously unknown, are the only ones that revisit the South Yorkshire area. During the early part of the same period a few other species were associated with these in the nearly adjoining region of Durham. But the Durham fauna, like that of Yorkshire, was greatly reduced in number, both specifically and individually, compared with its development in the preceding epoch. Out of its 118 Shell-limestone species only 22 reappear in the Upper Limestone, 6 new species appearing along with them. In the highest portion of this member (at Roker and Hartlepool), the only species that occur are the two Conchifers found in the Brotherton Beds, and

Turbo helicinus. In the equivalent strata of the Zechstein there is a similar falling off in the distribution of species; and the same forms are the characteristic fossils there, *Ax. dubius* under its "*Schlotheimi*" character being the most common. It would thus appear that in the whole of the West European area there was a most remarkable decrease in the Permian fauna during the period of deposition of the Upper Permian strata, the decrease being greater towards the close than at the beginning of that period, and affecting the same classes, and even the same species in most cases, in the different parts of that area, thus leaving a similar though exceedingly meagre group of species distributed throughout.

EXPLANATION OF PLATE VII.

Figs. 1, 2, 4, 5, 6. *Rissoa Leighi*, Brown. Five specimens illustrative of its variation of form; magnified about 14 times. Hampole.
Fig. 3. *Rissoa Leighi*, Brown. Young individual; magnified 16 times. Hampole.
Figs. 7, 8. *Natica minima*? Brown. Outer lip of specimen imperfect; magnified 12 times. Hampole.
Figs. 9, 10. *Turritella Altenburgensis*, Geinitz. Magnified 16 times. Hampole.
Fig. 11. *Axinus dubius*, Schlotheim. New variety. Cast; somewhat enlarged. Moorhouse.
Fig. 12. *Axinus dubius*, Schlotheim. New variety. Cast; somewhat enlarged. Conisborough.

March 20, 1861.

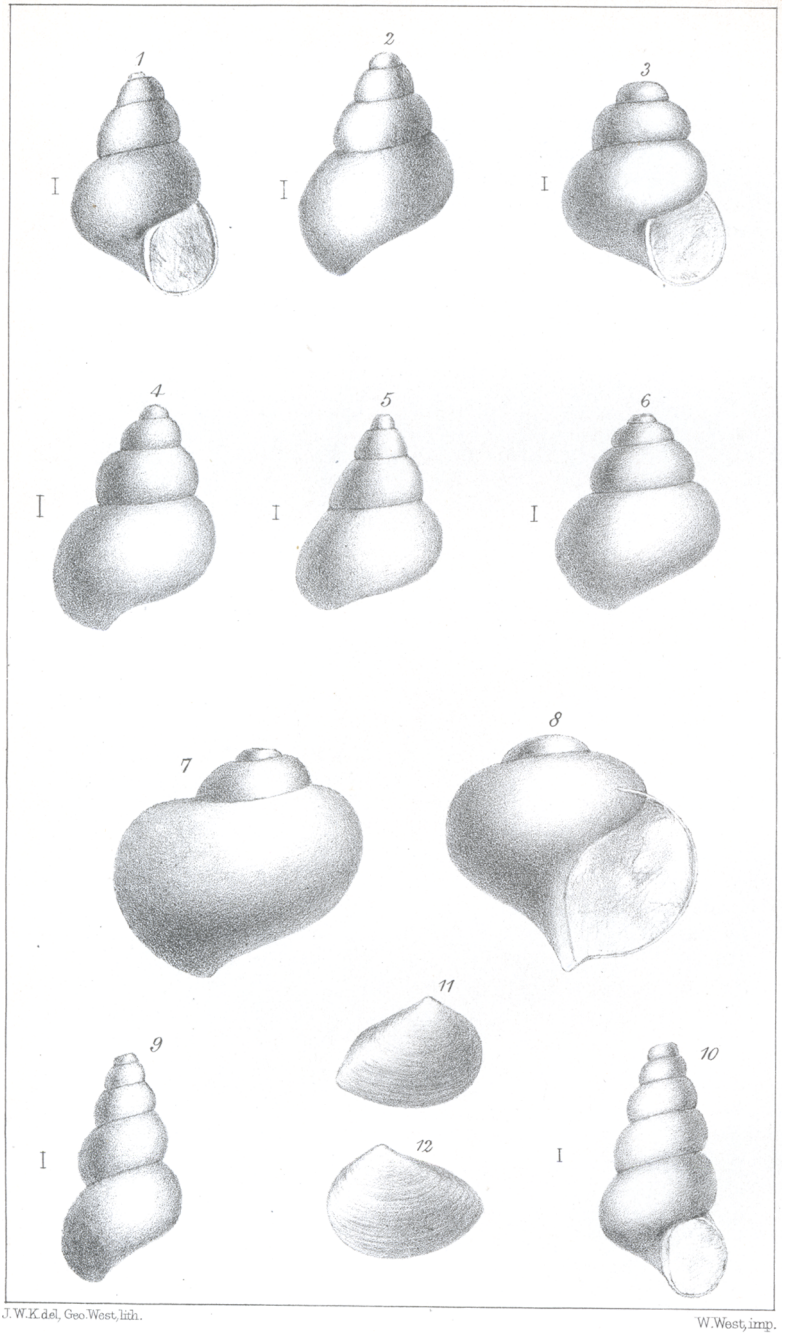
The following communications were read:—

1. *Notes on a* Collection *of* Fossil Plants *from* Nágpur, Central India. By Sir Charles J. F. Bunbury, Bart., F.R.S., F.G.S., &c.

[Plates VIII—XII.]

Introduction.—It is now some considerable time since the fine collection of fossil vegetable remains from the district of Nágpur in Central India, which had been presented to the Geological Society by the Rev. Messrs. Stephen Hislop and Robert Hunter*, was entrusted to me for examination and description. Owing to the obscure and equivocal character of many of these remains, the undertaking proved more tedious than I had expected, and there still remain many specimens to which I have not yet been able to give a thorough examination. But, as particular circumstances make it unlikely that I should, for some time to come, have sufficient leisure to devote to this pursuit, I think it best to lay before the Society at once the results of my inquiries as far as they have yet gone, rather than to keep them back for an indefinite time in the hope of completing them. The present paper, therefore, will contain the description of all the Ferns in the collection, and of all those remains of Stems and Leaves of other kinds which I have, to the best of my ability, sufficiently examined; these altogether constitute nearly

* See Quart. Journ. Geol. Soc., vol. xi. p. 348 and p. 369.



J. W. K. del, Geo. West, lith.

W. West, imp.

PERMIAN FOSSILS FROM YORKSHIRE.