On the Occurrence of the Megalichthys in a Bed of Cannel Coal in the West of Fifeshire, with Observations on the supposed Lacustrine Limestone at Burdiehouse. By LEONARD HORNER, Esq. F. R. SS. L. & E. Fellow of the Geological Society. Communicated by the Author *.

THE specimen which has led to this communication was given to me, a few weeks ago, at Dunfermline, by Mr Mackie, manager of the factory of Messrs Arthur, Aitken and Company. It is an object of considerable geological interest, being a very fine specimen of a tooth, of the same nature with those found in the limestone of Burdiehouse, near Edinburgh, which were first brought under the notice of the scientific world by Dr Hibbert. He conceived them to be the teeth of a saurian reptile; but their true nature was afterwards determined by the more experienced eye of M. Agassiz, who pronounced them to have belonged to a sauroid fish. M. Agassiz considered the fish to be a new genus, calling it Megalichthys, in reference to its great size, which the largeness of the teeth indicate; and he designated the particular species found at Burdiehouse by the name of Megalichthys Hibberti. This specimen was found accidentally in a mass of cannel coal, which they were breaking into small fragments, to be cast into a gas retort; and it is to be feared, that many precious relics of a similar nature have been destroyed by the same fate which awaited this very ancient record of the past ages of our globe.

The tooth is two inches long, and seven-eighths of an inch in diameter at its base. It is covered with a thin shining enamel, which is longitudinally striated, and, within a quarter of an inch of the base, deeply furrowed. It is not entirely circular, but is somewhat flattened. The enamel of the teeth, found in the limestone of Burdiehouse is of a pale brown colour, but this is black; the internal substance is, however, the same in both. It is in size and general appearance very similar to that figured at page 183. of Dr Hibbert's Memoir (*Transactions of the Royal Society of Edinburgh*, vol. xiii.), and is, I believe, the

* Read at a meeting of the Royal Society, 1st February 1836.

largest and most perfect tooth that has yet been met with in the coal itself; those hitherto found at Stoneyhill, near Musselburgh, being in general small.

This cannel coal was brought from Halbeath in the county of Fife, about two miles eastward of Dunfermline. I had not an opportunity of examining the locality at the time I got the specimen, the weather not being then favourable for such a purpose; but through the kindness of Mr Bowes, surgeon in Dunfermline, I was referred to Mr Geddes, mining engineer, who is intimately acquainted with the coal-fields in that part of Fifeshire, and especially with the colliery from which this specimen was obtained. He has been so obliging as to give me a description of the spot, from which I have extracted the following particulars, as more particularly bearing upon the subject of this communication.

The country around Dunfermline is composed of the stratified rocks of which the coal-measures usually consist, viz. alternations of sandstones, slate-clay, bituminous shale, which is frequently indurated, clay ironstone, and coal. There are, besides, beds of limestone, which, as seen at Charleston, appears to form the outer or high edge of the basin in which the coal-measures are situated, and at a vast depth below the bed of coal in which the fossil tooth was found. This is usually considered to be the mountain or carboniferous limestone. The alternating sandstone is of variable thickness, being in one bed as much as 102 feet, and the slate-clay varies from a few inches to several feet. The seams of coal are also of different dimensions, from five inches to seven feet. They are chiefly distinguished with reference to their economical applications; and they include both cannel coal and glance or blind coal. A section at the Halbeath colliery of 431 feet, gives 26 feet of workable coal. The general bearing of the strata is between south-east and north-west, and the lower beds have been ascertained to extend between two points which are five miles asunder. The superior beds appear to have been carried off by denudation in many places, after having been thrown up and shattered by disturbing forces, which have occasioned numerous faults. Although no trap-dikes appear, there is an overlying mass of trap in the vicinity, which, I conceive, is in all probability connected with a deep-seated dike. It is

most likely that the eruption of the trap has been the chief cause of these disturbances.

The faults vary in width from 2 feet to 240 feet. In Halbeath colliery the strata are subject to five different dislocations, in a distance of about half a mile, as is represented in the annexed section in Plate III., besides other troubles, which produce similar effects on a smaller scale. The bed marked *b* is the seam of cannel coal in which the fossil tooth was found; it is twenty-three inches in thickness, the immediate roof being a slaty sandstone, and the floor an ordinary white sandstone.

It will thus be seen, that this bed of cannel coal, containing remains of a sauroid fish, is one of a regular series of alternating coal-measures of the usual characters, some of which abound in vegetable remains, which, as well as those from which the coal itself has been derived, must have been nourished during their growth by fresh water; that it is in conformable stratification with the shales containing these plants, and partakes in all the dislocations of these and the other strata.

The interest which has been excited among geologists by Dr Hibbert's researches at Burdiehouse, leads us naturally to inquire, whether the occurrence of remains of the same species of sauroid fish, in this new locality, tends to shew an analogy between the deposit at Halbeath and that at Burdiehouse? I think it does; not, however, by establishing a difference between the beds at Halbeath and those of coal-fields in general, but because I have not been able to discover any thing in the phenomena exhibited at Burdiehouse, which should lead us to consider any member of the series of strata there as having been formed in a manner different from that, which is now generally considered to be the most probable explanation of the circumstances under which deposits of coal, and the accompanying sandstones and shales must have taken place. Dr Hibbert, on the other hand, considers the deposit at Burdiehouse as an exception to the general rule, by the existence in it of a bed of limestone of peculiar characters, and which he denominates a FRESH-WATER FORMATION.

A large proportion of the stratified rocks which contain marine remains, may be said to be, in great part, of fresh-water origin; for the materials of which they are chiefly composed

must have constituted the substance of pre-existing rocks, which were abraded by atmospheric agencies and running water, the detritus being afterwards transported by rivers to the sea; and in some of the beds thus formed, such as the coal-measures, the products of fresh-water are in great abundance. But this is not the sense in which Dr Hibbert employs the term: he considers the bed of limestone in question to have peculiar distinctive characters; that he has made a discovery of a new feature in our coal-fields, and one, moreover, which he had been long expecting to find. "I had long," he says, "been prepared to expect that a limestone of a fluviatile or a fresh-water origin would, some time or other, be proved to exist."—P. 169. He states (p. 267) "that it must have been the result of a deposit in fresh-water, hostile to the growth and increase of marine shells and corallines;" that this limestone bed "indicates some fresh-water river or lake, within which calcareous matter was elaborated.—P. 253. Farther, that "the beds of argillaceous shale, both above and below, enclose the same organic remains as are found in the limestone, along with coprolites, shewing that they are themselves a portion of the *lacustrine* deposit of this locality."—P. 244. And, at p. 272, he says, "Hitherto, however, I have not found the slighest traces of marine mollusca or corallines in the limestone of Burdiehouse; and hence, I am not induced to consider it as any thing but *a pure lacustrine formation*."

It is now generally admitted, as the most probable theory of the formation of coal-deposits, where there are interstratified marine beds, that they have taken place in estuaries, in those deep indentations of the land which often occur at the mouths of great rivers; and where the beds that are gradually formed, by the subsidence of the solid materials brought into it by the waters, must contain the productions both of the sea and land; those of the land, however, naturally predominating. The beds of coal are usually considered to have been formed by the accumulation of large quantities of vegetable matter, drifted into the estuary from the land, and deposited upon a previously formed surface of sand, clay, and mud, indurated afterwards into stone by pressure, and by a chemical action among the particles, induced by that enormous pressure; the vegetable matter being converted into coal by the combined chemical action of water

and that same compressing force. The numerous alternations observed in the coal-measures, and the frequent intercalation of beds of limestone abounding in marine remains, indicate not only frequent changes in the nature of the materials brought from the land, but the predominance of sea over fresh water for long periods, over the areas occupied by the accumulations of transported detritus, and repeated submergence and re-elevation of the bed of the estuary.

Now, after an examination of the spot and the specimens, and after a careful perusal of Dr Hibbert's memoir, I cannot find any thing in the limestone of Burdiehouse adverse to the theory of its having been so deposited in an estuary; but, on the contrary, the evidence appears to me strongly to favour that hypothesis, and to be hostile to the idea of its being a lacustrine deposit.

Dr Hibbert himself, in speaking of the great coal-formations of the Scottish Lowlands generally (p. 258), while he makes an exception in regard to this particular bed of limestone, admits, "that even large tracts of dry land might have subsisted, and have been invaded by arms of the sea or estuaries;" and, in another place, in the summary of the evidence he adduces in favour of his theory of a lacustrine deposit, he says (p. 265), "the calcareous deposite must have taken place in a depression or basin, perfectly surrounded with a dense vegetation, which has been washed into inland waters. But this circumstance, he goes on to say, "would of itself prove little, as we may easily suppose that an estuary or arm of the sea might have stretched through a tract where a dense vegetation has prevailed." In his account of what he considers an analogous formation in Linlithgowshire, Dr Hibbert says (p. 255), "Near Bathgate, a limestone of marine origin may, at its junction with a fluviatile bed, be found to actually graduate into a fresh-water deposit." Now, this is exactly such a kind of formation as one might expect would take place in an estuary, where any of the beds might partake, in some degree, of a fresh-water character.

The evidence which Dr Hibbert considers as conclusive in favour of this limestone being of lacustrine origin is, (p. 264),

1. The absence of all mollusca and conchifera, of acknowledged marine origin.

2. In connection with the absence of marine shells, the profusion of terrestrial plants.

3. The presence of the remains of fishes that inhabited fresh water, but which Dr Hibbert admits to be an ambiguous criterion, (p. 271).

4. The abundance of the shells of entomostraca, scattered through the limestone.

Let us now examine the weight of that evidence; and first, as to the absence of marine shells.

In the immediate vicinity of Burdiehouse, there is a limestone abounding in marine remains, which Dr Hibbert describes, and which occurs in nearly conformable stratification with the other coal-measures, and with the so-called lacustrine limestone. The mere inspection of the diagram given by Dr Hibbert to shew the relative position of the two beds of limestone would lead us to conclude that they were deposited in the same waters, and belong to one series; and we know that nothing is more common than to find, in a series of strata, some beds of limestone containing organic remains, and others in which not a trace of an organized body can be discovered. Near Lulworth, in Dorsetshire, where the Purbeck beds are largely developed, and which abound in organic remains, there are compact varieties of Purbeck stone, which are devoid of shells, and which attain a thickness of from 60 to 100 feet.* Many of the beds of the lias and oolite series of limestones, and which alternate with shales and sandstones, are almost wholly made up of organic remains, while others of the same series are wholly destitute of them. The same thing has been observed in the carboniferous limestone of Wales, of the north of France, and of Belgium. Marine *shells* may not, as yet, have been discovered in the limestone under consideration, but marine *organic remains* are abundant in it, as I shall presently shew. But even beds containing exclusively fresh-water shells, in the opinion of geologists of great authority, do not afford conclusive evidence of a lacustrine deposit. In the memoir of Professor Buckland and M. De La Beche, on the Geology of the Neighbourhood of Weymouth,† the authors observe, "One of the most important points in the

* Geol. Trans. 2d ser. vol. iv. p. 12. † Ibid.

geological history of the Purbeck series, is the occurrence of a bed of oyster-shells, called the cinder-bed," often many feet in thickness, and almost wholly composed of dark-coloured small oyster-shells in the midst of a series of strata, some of which contain exclusively shells of fresh-water formation, and others an admixture of fresh-water shells with those which are marine; and although we cannot infer from it the return of the sea for any long period in the middle of the Purbeck formation, yet it shews that the district it occupies could not have been a lake of pure fresh water, but was probably an estuary at the time when these oysters occupied its bottom, and were accumulated to the thickness of many feet over a distance of many miles." The same authors add a note descriptive of the Lake Menzalé, at the mouth of the Nile, which, they remark, "is highly illustrative of the mode in which living animals, of a mixed character, are associated together near the confluence of great rivers with the sea."

2dly, As to the plants. All the species of plants which have been found in this limestone have been met with in the shales and sandstones of other coal-fields, either of this country or of the Continent. The *Sphenopteris affinis* which, as Dr Hibbert states, occurs in greatest abundance in the limestone, is common in the roof of the Bensham coal-main in Jarrow colliery, near Newcastle;* and the Lepidostrobus variabilis, of which a specimen from the limestone is figured by Dr Hibbert, associated with a fish of the genus Palæoniscus, which I shall afterwards shew must have lived in the sea, is also met with in Jarrow colliery.† But these plants are not confined to the coal-measures; but are met with throughout the whole carboniferous series, from the old red to the new red sandstone. M. Elie de Beaumount describes the graywacke rocks, at the extremity of the Vosges Mountains in Alsace, and of the Bocage in the department of Calvados, a part of ancient Normandy, as containing vegetable impressions scarcely differing from those found in the coal-formations.‡ They are by no means uncommon in the carboniferous limestone; and I have seen in the collection of Professor Jameson, specimens collected by him near Pettycur in Fifeshire, of a coarse limestone belonging to the coal-measures

* Fossil Flora of Great Britain, plate 45.

† *Ibid.* plates 10 and 11.

‡ Phil. Mag. and An. vol. x. p. 247.

containing the same class of plants.* It is clear, therefore, that the mere existence of terrestrial plants does not prove a lacustrine deposit.

3dly, As to the remains of fish. These are the Megalichthys, Pygopterus, Amblypterus, and Eurynotus, and are supposed to have approached the cestracion of modern times.

Dr Hibbert considers the Megalichthys as a fresh-water fish, in one part of his memoir, for, in describing the circumstances under which he conceives the coal deposits of Scotland to have taken place, he says, "During such a condition of the globe, the calcareous deposit of Burdiehouse was formed, new races of fish inhabiting *fresh waters* were created, *and among them the Megalichthys.*"—P. 258. And, in another place, he says, "As the remains of the Megalichthys are found in bituminous shale, and even in coal itself, it is evident that the animal must have frequented shallows and wet marshes."—P. 262. He points out the analogy, observed by M. Agassiz, between the Megalichthys and the recent Lepidosteus; speaks (p. 207) of the Lepidosteus Spatula as being "a living type of the Megalichthys; and states (p. 213) that the Lepidosteus dwells among the lakes and rivers of the most thermal regions of America. In speaking of the coprolites, however, he makes use of some expressions which would seem to indicate a different view, viz. that this great fish must only have been an occasional visiter of fresh water. He says, "In proportion as coprolites increase in size, we find that they contain the scales of fish, shewing that the larger fish, to which these fœcal remains are referred, must have frequented the ancient river or lake, indicated by the limestone of Burdiehouse, in quest of their prey." Now, this is obviously quite inconsistent with the idea of a "pure lacustrine formation," for when he speaks of large fish frequenting the ancient river or lake in quest of their prey, he obviously means that they were not regular inhabitants of the river or lake; and as we must presume that they came from the sea, and must have swam into the lake, it must therefore have communicated with the sea. But there is a passage in Dr Hibbert's memoir which

* For an account of Professor Jameson's discoveries in this locality, see Proceedings of Wernerian Natural History Society, in Edinburgh Philosophical Journal, January 1836.

I am quite at a loss to reconcile, either with his statement that the Megalichthys was a fresh-water fish, or with his theory of a "pure lacustrine deposit." He says, p. 271, "As for the remains of Cestracientes (*and perhaps of the Megalichthys*), which appear in more than one description of carboniferous limestone, they point to estuaries, no less than to fresh-water lakes, as having been, in primeval times, frequented by large animals in quest of prey."

M. Agassiz, in his memoir on the Geological Distribution of Fossil Fishes, read before the Geological Society on November 1834, states that "he cannot, on ichthyological data, decide on the fresh-water or marine origin of the fish of the ancient groups." There is, therefore, no evidence afforded by the remains themselves, either of the marine or the fresh-water habits of the Megalichthys; but we may infer that M. Agassiz inclines to the opinion of its having been a sea fish, from what he says in his "*Rapport sur les Poissons Fossiles découverts en Angleterre.*" In speaking (p. 28) of the Megalichthys Hibberti of Burdiehouse, he says, "Ces fossiles proviennent d'un poisson d'une famille qui ne comprend que deux genres dans la creation actuelle; dont les représentants peuplaient surtout *les mers* qui recouvraient la terre, avant la déposition des terrains crétacés; famille que j'ai appélée celle des sauroïdes." Dr Hibbert quotes Cloquet's article in the *Dict. des Sc. Nat.*, when he describes the Lepidosteus as an inhabitant of the lakes of South America. But Cloquet is then speaking only of the two species, L. Gavial and L. Spatula. In describing the other species, the L. Robolo, he says, "on peche ce poisson dans la mer qui arrose le Chili—les insulaires de l'Archipel de Chiloe font secher à la fumée une grande quantité de ces robolos, et en font un commerce étendu." Dr Hibbert ought, therefore, to have shewn that the megalichthys has a closer affinity to the fresh-water than to the marine species of lepidosteus, before any conclusive argument can be drawn from the resemblance.

Thus it is evident, that the remains of the megalichthys afford no evidence whatever of a lacustrine deposit, while their occurrence in the regular coal-beds at Halbeath, and in those of Stoneyhill near Musselburgh, the neighbourhood of Glasgow, and other places, tend to prove a similarity of formation be-

tween the supposed fresh-water limestone and the other coal-measures.

The other sauroid fish, remains of which have been found at Burdiehouse, is the Pygopterus. Now, most of the specimens of this genus of fish which have hitherto been met with, have been derived from strata abounding in marine fossils, viz. the Zechstein of Mansfield and other places in Germany, and the magnesian limestone of the county of Durham; they have also been found in the coal formation at Saarbrock;* and M. Agassiz has recognised, in the above mentioned limestone of the coal-measures at Pettycur, a new species which he has named P. Jamesoni.

"The fish," says Dr Hibbert, "which the limestone entombs in far the greatest number, is an individual which I had little difficulty in referring to the genus Palæoniscus."—P. 190. Now the genus Palæoniscus is found abundantly in the Zechstein of Mansfeld, and in the equivalent of that rock in England, the magnesian limestone at East Thickly in the county of Durham.† In this last locality the remains of this fish are associated with vegetable impressions which Professor Sedgwick refers to the fern tribe,‡ and with an impure coal. They have been met with, besides, in different coal-formations in England, France, Germany, and the United States; and three species have been recognised in the limestone of Pettycur, one of which, P. Robisoni, is identical with that which is found in such abundance at Burdiehouse.

Of the five species of Amblypterus described by Agassiz, four are from the regular coal deposits of Saarbrück and that neighbourhood, the other being from Brazil, but in what formation it is not mentioned.

The Eurynotus is said by Dr Hibbert, p. 192, to resemble the Platysomus. M. Agassiz describes five different species of the Platysomus, and of these, two were obtained from the Zechstein, and three from the magnesian limestone. He has found a species of Eurynotus in the limestone of Pettycur.

It appears, therefore, that the fish found in the limestone under consideration, in place of being an "ambiguous criterion,"

* Agassiz, Poissons Fossiles. † Ibid.

‡ Geol. Trans. 2d ser. vol. iii.

clearly indicate that the bed in which they are found must have been deposited in salt or at least brackish water, and not in a fresh-water lake.

Apparently the strongest argument, which Dr Hibbert has brought forward, in favour of his theory, is the great abundance of the shells of microscopic animals, *entomostraca*, which are scattered through the substance of the limestone; and which he considers to belong to the fresh-water genus Cypris. Now supposing him to be correct in this, it is by no means a conclusive proof of a lacustrine deposit; for the animals may have lived in marshes or stagnant waters, such as are common near the mouths of great rivers, and have been washed into the estuary during floods. But it is not at all clear that these shells are really fresh-water. The similarity between the shells of the Cypris and those of the Cytherina of Lamarck was long ago pointed out by Müller. This is a marine genus of entomostraca; and Müller, in describing it, says, "Species *variæ* in Fucis et Confervis marines degunt, in flustris, præsertim in lineata, delitere amant;"* and Lamarck says that they inhabit the seas of the northern latitudes.† I am informed by Mr Lyell that Mr Lonsdale has recently discovered abundance of those microscopic shells in chalk, mingled with marine zoophytes and testacea; and he adds, that if they had been met with in the fresh-water deposits of the Wealden, they would undoubtedly have been called Cypris.

Dr Hibbert observes (p. 225.), that, "in the diffusion of the vegetable and animal remains through the limestone, little or no order is preserved. Vegetable and animal remains are not confined to particular seams of the rock, but may occur in any part of it. Nor are they confined to the limestone itself, since they have been found in argillaceous and bituminous shale both above and below the bed." Now this is surely very unlike that tranquil deposition which we find so generally characteristic of lacustrine formations; but it is very like that more disturbed state which we might expect to find in the waters of an estuary, agitated by the continued flow of a river, and by the motions of the tides.

* Otho. Frid. Müller, Entomostraca, Lipsiæ, 1785, 4to, p. 64.

† Lamarck, Animaux sans Vertebres, v. 125.

Upon a review, therefore, of the whole evidence, it appears to me, that there is nothing to warrant us in considering the limestone at Burdiehouse as a pure lacustrine formation; that the series of coal-measures there are different in geological characters from other series of carboniferous deposits; or that the limestone bed in question was formed under conditions different from those of the shales, sandstones, ironstone, and seams of coal with which it is associated.

In thus freely expressing my doubts of the soundness of the conclusions to which Dr Hibbert has arrived, I trust that I have not exceeded the limits of fair scientific criticism; and I farther hope, that nothing which I have said can be construed as inconsistent with a just admiration of the industry and zeal displayed by him in these researches, or with the respect that is due to him, for his many valuable contributions to science and literature.*

Remarks on the Dublin and Kingstown Railway, intended as a Supplement to a former Paper on the Liverpool and Manchester Railway, in the 18th Volume of this Journal, 1835. By David Stevenson, Esq. Civil-Engineer, Edinburgh.† With a Plate.

Since my paper on the Liverpool and Manchester Railway was laid before this Society, in the month of February last, I have, in the course of my professional pursuits, visited most of the public railways of the United Kingdom, and, in connection with this subject, I also paid a visit to some of the great iron-works in Wales.

The application of tram-roads and wooden railways to the

* Since this paper was read, I have seen the fifth Livraison of the work of M. Agassiz, "Sur les Poissons Fossiles," in which particular mention is made of the researches of Dr Hibbert at Burdiehouse. I have not found any observation of M. Agassiz at variance with the opinions I have ventured to express, and I observe, that, in speaking of the Sauroides, he specially calls the attention of his readers to his opinion, that they do not form a family intermediate between ordinary fishes and reptiles, adding, "En effet, mes Sauroides sont de vrais poissons; ce sont les premiers poissons voraces qui aient vécu *dans les mers* d'autrefois."

8th *March* 1836.

† Read before the Society of Arts for Scotland, 9th March 1836.