ON THE GEOLOGY OF THE FYLDE DISTRICT.

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Without any premising, I shall enter at once upon my subject by saying, that however the scientific disagree about the subdivisions of geology, they recognize six large divisions, each of them distinctly separated by a "disturbance," viz., the elder and later primitive, the elder and later secondary, and the tertiary with the recent surface of the earth. In the subdivisions of the tertiary system I shall attempt to class the district of the Fylde. My first step, therefore, will be to describe briefly its predominating features, and then to test the characteristics of our neighbourhood by them.

These deposits lie in the hollows or basins of the secondary rocks; whilst their strata are precipitated in nearly a similar manner to those at the mouths of our present estuaries. They link together the past and the present, gliding through the subdivisions of the Eocene, the Miocene, and the Elder and Newer Pliocene. Marl and clay deposits are predominant, and these being eroded by currents at the bottom of the sea, are filled up with shingles and sand, which are now recognised as the remains of elevated sea beaches, at times very extensive, and frequently forming conglomerate or plum-pudding stone with ferruginous breccia. Intermixed also with these strata are layers of fresh water deposition. The fauna disclosed are all more or less intermixed throughout, the extinct with the recent, or are identical with those that now people our shores.

The first feature of the tertiary group is their formation in basins of the secondary rocks, whence they receive the materials that compose their deposits. In such a hollow the upper strata of our district have been precipitated. The following facts suggest that new red sandstone, if not eroded, lies at the bottom of the basin. This formation is of great extent. It fills the basin of the Eden from the neighbourhood of Brough to the Solway Frith; it is seen at St. Bees Head, on the banks of the Duddon,

and the western heights of Low Furness. At Cockersand, however, it crops out, and again exhibits its dipping. At the Wyre the basin is deep or is totally abraded, which is doubtful, as it reappears in the bed of the Ribble and thence runs forward through Cheshire, and from the mouth of the Tees to that of the Severn. It is, however, a mistake to suppose the red sandstone to run to the foot of the Pennine chain. At Garstang and Ellel, &c., the rock is of a grey and coarser material, as well as harder, and is neither red sandstone nor the grit of the fells. My supposition, therefore, is that the deposits of our district lie on a floor of red sandstone. Of the presence of coal beneath I will say little. I shall only record that when Professor Phillips surveyed the land at the mouths of our estuaries he pointed to the Fylde as most promising; but at the depth of no less than four hundred yards were we to expect it. And his supposition is not unreasonable, since coal pits were worked by Thos. Tyldesley, Esq., in 1712, at Ellel, and a seam of it at the Bay Horse, near Garstang.

The lowest stratum which manifests itself as a section at Blackpool cliffs is a deep deposit of brown till. Its vast aggregate is not entirely manifested, and much of its mass sinks below the level of the shore. There is enough, however, to describe its characteristics, though not its depth. It is literally laden with stones, like plums in a pudding, so much so that at the base of its disclosure "they constitute fully one-third of the whole." These lie every side up, topsy turvy, in all directions, some standing on their edges, others on their sides, and some again on their flat surfaces. They are sometimes intermixed with huge blocks of granular and fibrous gypsum, and their average size is greater than those in the upper beds; whence we may suppose that the masses of granite, greenstone, limestone, &c., which stud the shore are for the most part the product of this deposit, though there are others as large, lying on the tops of the hills in every quarter. One difference between the boulders in this stratum and those in the superior ones the observer cannot fail to see. They are not so much rounded, though originally torn from the same rocks; whilst more than one-half here are so, wholly or in part. Besides, says Binney, there is scarcely "a slate of a few inches diameter, or a carboniferous rock, without some marks of striæ upon it, nearly always running parallel to the major axis of the stone." Of course the porphyries and greenstones, on account of their hardness, have fewer marks of scratchings upon them.

Such is the lowest deposit of which we have a section, and this to the depth of sixty feet. It carries all the appearance of a raised sea bottom, which after the reception of debris and reproduction of its families of shells, from time to time was overspread with loads of boulders and gravel, that sunk into its soft mud.

The next bed above this till is of a red, stratified, pliable and silty loam, which originally had been precipitated in an horizontal line, from the fact of this deposit being always about the depth of three or four feet, except where it had filled up to the level the eroded hollows of the till on which it lay. It is much twisted and contorted by the heaved up mass beneath. At a glance you perceive how, where it appears, its two anticlinal axes receive the synclinal deposits of the upper beds. Its medium depth is about, as I said, three feet; but it expands or diminishes gradually, whether it rises from the south, or falls to the north, as it draws near, or receives the superior strata of sand and gravel. In fact this layer of loamy sand may be called the base of all the gravel and loose sand deposits throughout the country,—at Preston, Kirkham, Poulton, Marton, and elsewhere. We say that it was formed under water from the presence of boulders and sea shells. I have also detected within it much riddle stone and iron dust, very soft and discolouring the fingers. One thing is remarkable; whilst its top is converted into a thin layer of sandstone, the whole is cased above, as it were, with a single row of boulder pavement or a dark ferruginous breccia, and beneath by a baked, glaze-surfaced and slate-coloured lamina of fresh water silt, hard and leafy, and which evidently had been washed down from higher ground upon a sea beach and sands which the tide was leaving.

The next deposit especially demands our attention, as it alone contains the reservoirs whence we draw water, and consists of those calcareous and aluminous sands which render certain lands so productive. Here opens a wide field for a better geologist than myself. The chief body, however, of this deposit appears to have been a brownish coloured till, at least primary, and may have been most extensively abraded by currents when a sea bottom, as it is entirely abraded or widely intersected with hollows, so deep and long, that the beds of red and grey sand and gravel which fill them up rest on the red loamy silt we have been describing, and miles of country are occupied by them. These materials, whilst distinctly separate, are strangely inter-

mixed. In the space of Poulton market-place we meet with beds of marl, loam, grey and red sand and gravel in close position and near the surface, yet not mixed in an incoherent medley. This must be the result of agencies. We must forego the old cherished idea that the deluge effected this, as well as deposited the whole mass of diversified strata. Had it done so, what a jumblement of matter would there have been! Whatever may have been the modifications produced on the surface of the globe by that catastrophe, they must be discarded here. What then were the agents employed? Internal heat, the wave and probably wind. Compare the deposition and different characteristics of the grey and red sand and gravel. These whilst they lie above one another, beneath one another, under clay and marl, and very frequently cap the summit of our hills, have yet all been precipitated in layers thinner or deeper according to the periods of the year when the swollen stream was heavily surcharged with matter, or was clear and placid. We may see nature still at the same work on the estuaries of the Ribble and Wyre. The currents of the flowing tide being laden with silt, sand, &c., meet at right angles the stream of the Ribble, likewise surcharged. This encounter causes both to drop their burdens, which the wave spreads out in strata, as an inspection of the sides of the Horse-bank channel demonstrates. Besides, whoever is desirous of witnessing how smoothly for miles the wave and its currents can deposit shingle, may be gratified by such a sight near the Fleetwood piles. A gardener could not rake his walks more carefully. But I must look more narrowly at these sands and gravel. Inspect first the grey coarse sand. This is nearly altogether composed of well-rounded quartz, some soft matter and perfect and comminuted shells. It is intersected with beds of shingle, which form a thin scattering beneath or above, and gradually become deposits of greater or less depth. How thinly the laminæ of this sand may be laid, you can perceive by the formation of a conglomerate stone within its beds. These are the product of innumerable cakes by which the rise and dip of the deposit may be ascertained. If we count their ages by these plates, like oaks by their circles, their vastness would confound our ideas. So similar also is the deposition of this sand to the ripple marks on the shore, which a transverse section shows, that few would deny that one and the same agent elaborated both. Take a walk on the shore. It inclines to the bed of the ocean, and almost at regular intervals you step upon patches of sand and gravel, distinctly and separately

strewn by the sea, with here and there a row of boulders and a bed of gravel; whilst on the top of the ridge, heaped up by the wave, is a continuous line of shingle, scattered shells, perfect and broken, together with lumps of rolled marl stuck full of gravel. Besides, long heaps of soft blown sand are everywhere manifest; some out of tide reach, others covered with gravel and fresh coarse sand brought by the return of the wave, and a third completely coated with a thick mud deposit of marl spewed down from the cliff by water. Now mount the sea banks and inspect the stratified gravel and grey sand beds. What strikes you? The sand is the same, and is deposited like that which you just now trod on, and after the same order: the pebbles are the same granites, traps, slates, and limestone, and you collect identical shells and exhume flat and rounded nodules of marl in no respect differing from those which the wave daily at present produces from the masses of clay it washes out of the cliffs.

There is, however, another sand to be noticed before we draw our conclusion. I mean a loose red sand which is more abundant than the grey, and appears to have been deposited by a different agent. This sand also, like the grey, lies in various positions. It is of a very soft nature, owing to its quartz being small and not in proportion to the other matter. Its colour also varies. At the top it is red, but becomes gradually lighter as its bed sinks downwards: nor is it so friable; nay, some of it, as on the south declivity of Marton, is not acted upon by acids, and emits an aluminous smell. It is free also from stones and shells—*so free* that not a particle of one of the latter can be discovered; but on piercing the ferruginous breccia or loamy sit on which it lies, both are met with in abundance. Such my own experience declares; yet further investigation is needed, since I am aware that Professor Forbes notices the discovery of a solen sèliqua, a mactra lustraria, and a dentalium at Preston, since also shells are not found in the fine sands and gravels of Kersal moor; yet the same deposit at Bowden is said to produce them in abundance; and, because workmen have brought me a Trochus from Layton out of this deposit; nevertheless it ought to be ascertained whether the shells were really taken out of the soft, loose sand, or the loamy redsilt, which always occurs where the other is found. My enquiries discovered such to be the case with the Layton shell, and so it may be elsewhere.

Another feature regarding this loose red sand must not be omitted.

Inspect it narrowly and you cannot fail to be struck with the thought, that the same agent fashioned it which raises the sand hills on the north and south of Blackpool as well as the ridges on the beach and even on the top of the cliffs. The wind at every blast carries forward the sand wave, leaves its burden and returns for another, which takes a different shape and thickness from being acted upon by irregular currents; and the consequence is the singular conjunction of queer layers of various sizes, thickness, and shape, all intermingled together. Only tincture these with oxyde of iron, and these ridges and hills are counterparts of our red sanded eminences, as sections demonstrate.

What can we conclude then? but that these beds of grey sand and gravel, as well as the drifted loose sand, comprise the remains of ancient sea beaches.

One moment more and I close this portion of my subject. Solidification in calcareous rocks often takes place at the time of deposition, but occasionally afterwards where the water of ferruginous or calcareous springs has flowed through a bed of sand or gravel and deposited iron or carbonate of lime in the interstices between the grains or pebbles: so that in certain places the whole has been bound together into a stone, and the same set of strata in other parts remains loose and incoherent. Dr. Leigh gives a most foolish account of the conglomerates which fall out of our cliffs at Hagberg near Blackpool. This is the true one. Water charged with oxyde of iron and carbonate of lime, trickling down the various substances of the brow, converts in its course certain portions to which it has affinity—the gravel and loose, coarse sand commixed with shells, into solid concrete masses,—leaving the rest unchanged. This arrangement and disposition are in no particular or determined order of stratification; but on the contrary, the different strata and veins, consisting of various depths and diameters, are mixed and interspersed in wild and irregular confusion, sometimes running in horizontal, sometimes in perpendicular, and frequently in zigzag directions. The vis saxifica, in the course of its filtrations, appears to avoid the marl and clay, and selects only the gravel and coarse sand as its favorite food; and, as these are disposed in wild and fantastic irregularity, the connection takes place in correspondence with them. The process of their formation is downwards, and they are found hanging in the cliff like icicles and stalactites with their points toward a centre,

crowned generally with a large flat flag of the same substance about three yards from the top of the cliff, with one or more cobble stones round which the infiltration commences. Penny stone, at the edge of the wave, is a huge conglomerate, and hundreds protrude yet from the breast of the cliff of immense bulk and length.

In the beds of marl, however, there takes place a process quite the reverse. As by the infiltration of crystallized carbonate of lime these sands are converted into stone, so the effect of carbonic acid gas is to dissolve granite, or to reduce it to a friable state by its solvent influence on the felspar, thus setting at liberty its other component parts of quartz and mica. What the labourer terms "rotten stone" has been thus acted on. I have also seen limestone boulders taken from the ancient sea beach beneath Pilling moss partially decomposed, the outside being changed into a soapy, whitish matter. I have tested these with muriatic acid, and there was left some residuum; so we may conjecture that the superincumbent bog gives out an acid which takes off the calcareous matter of the pebbles and leaves behind the soft substance. Or the decomposition may occur thus:—part of the bog, by the decomposition of Pyrites, may evolve sulphuric acid. If so, the acid would carry off all the carbonic acid on the surface of the stones and convert the calcareous portion of the coating matter into sulphate of lime, or the material of the Plaster of Paris. I may be speaking unadvisedly, since last week I detected a similar process on a limestone which I took from an ancient foundation within the Roman station at Walton. Some such chemical power, however, has been and is destroying the shells in some deposits. Thus in the abovenamed Pilling beach every vestige of them is gone, whilst in another, not so old, they are fast decaying. In the lower bed of our till the fauna also are very brittle, having lost their calcareous coating; but in the grey sand and gravels they are remarkable for their freshness, some of them, as the periwinkle, cockspur, &c., retaining their natural colours. "Thus," says Lyell, "we have the conservative and disintegrating effects of carbonic acid cementing the loose beach in solid blocks by incrustation; and when in a gaseous state or combined with water dissolving the granite by its action on the felspar."

The upper strata of our tertiary series is clay, which is fickle as to its colour and depth, and even its appearance at all on the surface, either

abraded or supplanted by beds of upheaved red sand. Its freedom from lime makes it suitable for the brickmaker. It is, however, like the marl, of marine origin, since it contains sea shells.*

Stones such as a geologist searches for are not unfrequently picked up. Each of them separately unfolds a history. I have collected magnesian limestone, permian conglomerates, flints that must have been carried from a distance, waterstone from the upper red marls of the trias, blocks of red, white, and shell marble (from the first of which a chimney piece was hewn for Rossal Hall), agates, &c., Kidney iron, gypsum, fossils, the *Gryphæa incurva*, *Cornu Ammonis*, madrepores, crinoidea, &c., impressions of plants, limestones pierced by the borer, and others enclosing recent shells, still retaining their natural appearance, though deprived of their calcareous matter, septarians, oval nodules of flint, and lastly, a black bituminous substance, probably petroleum, from the beds of marl and red sand. Such a specimen the Rev. J. D. Banister took out of the ancient sea beach at Pilling. It was soft when discovered, but soon hardened. Besides I am informed by a builder at Prestwich, that when it occurs in the red sand deposits there, that spot is avoided, as a speck of it chips off the plaster from the wall, if the mortar be mixed with it. We meet with it at times here. The workman calls it a cob of coal.

A question here meets us. From what parent rocks have the boulders and pebbles on the shore and in the strata, viz :—new red sandstones, carboniferous stones, grit, limestones, silurians, slates, granites, greenstones, porphyries, &c.,—been torn, and how were they conveyed? Cumberland and Furness, the rocks of Coniston, Wastdale, &c., may supply the upper slates and silurians, porphyries and lower limestones. Ireland also has contributed its quota, marbles perhaps; but Scotland has been, in my opinion, the greatest contributor. The mode of conveyance is, however,

* The following relative proportion of stones taken from this deposit at Blackpool, is extracted from the "Notes" of Mr. Binney, to whom I am greatly indebted.

	Angular.	Partly rounded.	Rounded.	Total.
Granites, Greenstones, Porphyries, &c.	17	20	12	49
Slates and Silurians	5	16	11	32
Mountain Limestone	3	2	1	6
Coalmeasures.....	4	9	2	9
New Red Sandstone and other superior rocks	1	2	1	4
	36	43	27	100

most perplexing. I can conceive how, on the upheaving of the Pennine chain, the floods of water occasioned thereby would wash the debris and torn fragments of its rocks into the muddy bottom of the sea at its base. I can conceive how afterwards the torrents of the Ribble and Wyre rolled down their boulders and shingle of mountain limestone, mill stone grit, &c.; but there is no marine wave of translation, now in action, that could convey a huge block of rock from the north west to the south east. The present condition of the stones in our deposits, especially in the lower till, scored, polished, angular, partly rounded, and lying all ends up, would seem to require them to have been borne on glaciers and icebergs, which probably floated in our ancient seas, and they were probably thus scratched and scored in their long passage by rubbing against the bottom. My late friend, Mr. Gilbertson, the fossilist of Preston, stoutly maintained, that not only did the Pennine chain manifest sure marks of being wave-worn, but that the sharp edges of its rock had been blunted and abraded by the grindings of icebergs. I too have seen, at the close of the great frost, huge girdles of ice heavily charged with boulders, gravel, and sand thrown on the shore at the Ribble mouth. This is the popular mode of conveyance; so whilst we are looking for a better we must be satisfied.

I might here content myself with having proved that our district must be classed under the tertiary system; but I would fix its position in one of the subdivisions of that group by an inspection of its organic remains, the best criteria of the age of any deposit. No remains of animals have been discovered either in the till, gravel, or sand beds. There have been floated down the streams of the Ribble and the Wyre, some belonging to more ancient rocks, and others to recent deposits, viz:—the upper jaw of the *Chirotherium* or hand-beast, in the possession of Mr. Simpson, watchmaker, Preston, the huge remains of an unknown animal found by the Rev. J. D. Banister in the clay of Pilling, the bones and horns of the *Bos latifrons, Bos longifrons, Bos primigenius, Cervus elaphus,* &c. Shells, however, which often escape obliteration under circumstances where the higher order of animals perish, are furnished in abundance. They are of marine origin; and the time and attention I have bestowed in collecting them from 1830 warrants me in saying that all of them, without exception, are identical with those that people the shores of Lytham, Blackpool, and Fleetwood. The land therefore under review was deposited during the era of the Newer Pliocene. The following list of fossil shells, arranged in

a descending scale according to the system of Lamarck, comprises those which have come under my notice.

Classis Mollusca.	Classis Conchifera.
Buccinum undatum.	*Ostrea edulis.*
Purpura lapillus.	*Pecten opercularis.*
Nassa reticulata.	*Mytilus edulis.*
—— *incrassata.*	*Cardium echinatum.*
Rostellaria pes-pelicani.	——— *edule.*
Murex erinaceus.	*Venus gallina.*
Fusus antiquus.	*Cyprina Islandica.*
—— *Bamffius.*	*Donax trunculus.*
—— *Turritella.*	*Tellina tenuis.*
—— *Terebra.*	——— *solidula.*
Littorina vulgaris.	*Psammobia Feroensis.*
——— *rudis.*	*Corbula nucleus.*
——— *retusa.*	*Mactra stultorum.*
Trochus umbilicatus.	——— *subtruncata.*
Scalaria communis.	——— *compressa.*
Patella vulgata.	*Lutraria elliptica.*
Dentalium entalis.	*Solen vagina.*
	—— *ensis.*
	—— *legumen.*

These shells have not all been found entire, but the eye of the conchologist can detect any one of them by the inspection of a small portion.

As they identify our district with the Newer Pliocene epoch, so by attending to the position, number, and habits of these testacea we may determine whether the deposition in which they lie was rapid or slow, and whether they lived in deep water or near the shore. During the process of precipitation each layer appears to have had a sufficient time partially to harden before another was strewn upon it. In this state, the wave, flowing over it, deposited its shells; and frequently we meet with them in such abundance—both old and young ones together—that we cannot but believe that these were undisturbed for some period, whilst they had propagated their species. Besides, others show evidence of having lain on the floor of the ocean after death, before they were imbedded. I have found a cockspur that, after having been pierced by a carniferous mollusk like itself, had floated on the surface of the mud until it had received the impression of a small plant. The oyster and Venus Islandica are not uncommonly covered with serpulæ, and the former with young shells on

the outer surface. I have seen the whelk exhibiting the mark of the acorn shell, which had once adhered to it. In these cases there must have been an interval of clear water, and a space of time must have elapsed between the death of the creature to whose shell it was attached and the burial of the same. But stronger proof is not wanting of slow deposition. Mr. Jelly, of Weston, took from the bottom of a marl pit the trunk of a tree, which he told me was "chock full of cockspurs," more probably pholades, or borers. This colony of borers, which had seized upon the tree, had grown and flourished, and had propagated there their own species, until another periodical deposition imbedded them and their habitation within its mud.

As the deposition of the strata was gradual, so also was the elevation. The process of each required ages. There is no very violent disruption to be seen on the surface of the country, no heaving of one layer over another by earthquakes, those paroxysms of heat. Probably at each change there may have been a "disturbance" which altered the composition, colour, &c., of the superior stratum, all derived, however, from the detritus of the secondary rocks, but the dye from the red sandstone, Let me not be misunderstood to imply that this elevation was one continued, regular heave without depression; there were many oscillations of both, as is evident from the different deposits of shelly marl and clay on the ancient sea beaches and drifted sand. Expansion and contraction, the consequence of heat and cold, would take place during the lapse of ages: now the land would rise, then sink, as the superior argillaceous stratum, a bad conductor, kept in the internal heat, like a top coat, or, when cooled, shrivelled up. During this geological dawn of modern times we have proofs of great changes of level of sea and land, which caused successive periods of diluvial drift, a season of refrigeration and a rafting of innumerable boulders on the glacier and iceberg. At length our orb was to be fitted for the habitation of man. The atmosphere became more genial; our district rose in a dome-like shape, which, as the loaf in the oven, was cracked on the surface by a greater force of heat. Thus the configuration of the Fylde was effected: hence the swelling undulations of its ridges and dales, ever winding from the centre to the Ribble and Wyre, and manifesting to this day the strength and the course of the disturbing element. Thus, too, our rivers received the waters of the district, and their fissures,—previously formed, widened and deepened during ages of oscillation,—became the

channels whereby abraded matter was carried into the basins at their mouths.

But are the changes of elevation still going on? It is the law of nature, say some geologists, accordant with the physical constitution of our planet. Instances of such changes can be verified. I believe that the supposition of Dr. Whittaker concerning the navigation of the Ribble as far as Ribchester in the Roman era, and the uplifting afterwards of its bed, first encouraged the question of continued elevation here. Baines also entertained the idea, as well as the Rev. Mr. Clay of Preston. Just, too, vowed that the earthquake of 1842 changed the level of his house at Bury, and an old gentleman often affirmed that on the day of the Lisbon earthquake our sea suddenly rose and fell and the cliffs moved. I have seen no signs of gradual change of elevation.

Thus the land under review must be classed under the Newer Pliocene deposits. Nor are they uncommon elsewhere. They are found in Cornwall, near the borders of the great estuaries of the Clyde and Forth in Scotland, and in that of the Shannon in Ireland. At Bridgnorth in Shropshire they penetrate sixty miles from the sea. Besides, they rise to a great height. Moel Tryfane in Wales attains the elevation of 1,400 feet, and Preston takes a position 350 feet above the sea.

Such is the tertiary formation of the Fylde: formed under water, washed by the sea during the silence of ages, alternately elevated and depressed, it rose in due time out of the workshop of nature, and has now become the habitation of industry and the theatre of enterprise.