

4. *On the RHÆTIC BEDS near GAINSBOROUGH.*

By F. M. BURTON, Esq., F.G.S.

At the Meeting of the British Association at Nottingham in 1866, I announced the discovery of the Rhætic beds at Lea (a village about two miles to the south of Gainsborough), which the lowering of the gradients of the Great Northern line from Gainsborough to Lincoln had laid bare. At the time this announcement was made, the cutting at Lea was only partially worked out. Now, however, that the line is in a more complete state, I am enabled to give more accurate sectional and stratigraphical details than I could then.

The following is a section of the various beds in the order in which they occur.

Section of the Rhætic Beds at Lea, near Gainsborough.

No. of bed.	Lithology.	Organic Remains.	Thickness.
			ft. in.
	Drift	Fragments of White Lias, &c.	
20	Black fissile shale	<i>Avicula contorta</i> , <i>Schizodus cloacinus</i> .	2 0
19	Dark-grey stone with veins of black fibrous gypsum.	<i>Pecten Valoniensis</i> , <i>A. contorta</i> , <i>S. cloacinus</i> , <i>Modiola minima</i> .	0 3
18	Black fissile shale, highly fossiliferous, with nests of pyrites, veins of black fibrous gypsum, and septaria.	<i>A. contorta</i> , <i>S. cloacinus</i> , &c.	3 0
17	Dark rubbly sandstone ..	.....	0 2
16	Black fissile shale	<i>A. contorta</i> , <i>S. cloacinus</i> .	1 6
15	Dark highly pyritous sandstone.	.....	0 0½
14	Black fissile shale .....	.....	1 0
13	Dark sandstone .....	.....	0 2
12	Black fissile shale	<i>A. contorta</i> , <i>S. cloacinus</i> , &c.	1 6
11	Dark sandstone .....	.....	0 2
10	Black fissile pyritous shale	<i>A. contorta</i> , <i>S. cloacinus</i> .	0 4
9	Hard grey laminated micaceous sandstone with pyrites.	Casts of <i>A. contorta</i> , <i>Pul-lastra arenicola</i> , <i>Perna</i> —?, <i>M. minima</i> , with teeth, bones, coprolites, ripple-marks, and drift-wood.	1 5
8	Black fissile pyritous shale highly fossiliferous, with septarian nodules.	<i>A. contorta</i> , <i>S. cloacinus</i> , &c.	2 4
7	Hard fine-grained micaceous and highly pyritous sandstone, the mica in some places in large loose scales.	<i>A. contorta</i> , teeth, scales, and coprolites.	0 6
		Carried forward	14 4½

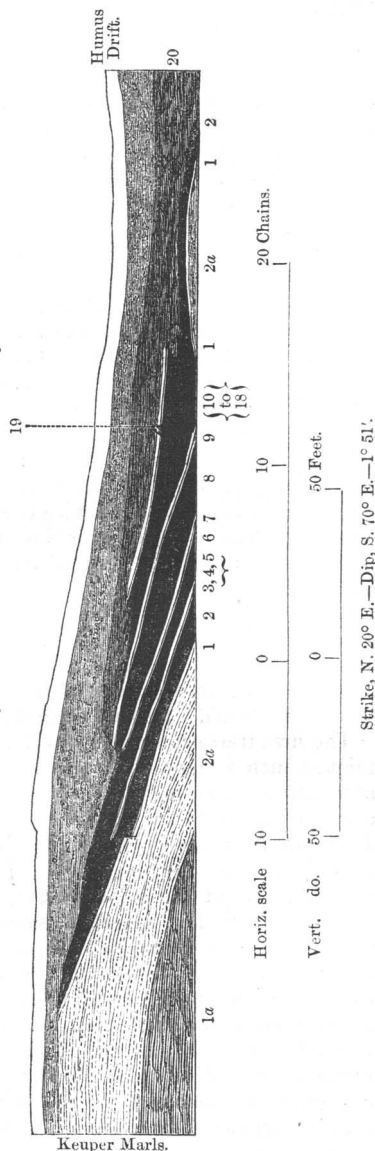
TABLE (*continued*).

No. of bed.	Lithology.	Organic remains.	Thickness.
			ft. in.
6	Black fissile shale.....	Brought forward	14 4½
5	Second bone-bed, loose in texture.	<i>A. contorta</i> &c.	2 0
4	Loose grey micaceous sandstone, highly fossiliferous.	Coprolites &c.	0 0½
		Bones, teeth, scales, and coprolites, spines of <i>Hybodus</i> and <i>Nemacanthus</i> , casts of <i>M. minima</i> , <i>Pul-lastra arenicola</i> , &c.	0 4
3	Bone-bed imbedded in a pyritous matrix	Coprolites, worn bones, small pebbles, scales, and spines, portion of jaw of <i>Lepidotus</i> (<i>Giebeli</i> ?), teeth of <i>Hybodus minor</i> , <i>H. plicatilis</i> , <i>Sargodon tomicus</i> , <i>Gyrolepis Alberti</i> , <i>Acroodus minimus</i> , <i>Saurichthys apicalis</i> , <i>Ter-matosaurus Alberti</i> , and <i>Ichthyosaurus</i> .	0 1
2	Black fissile shale with thin veins of grey pyritous stone.	<i>A. contorta</i> , <i>S. stocinus</i> , coprolites, &c.	8 0
1	Loose grey micaceous sandstone.	<i>A. contorta</i> , portion of jaw of <i>Pliosaurus</i> ?, bones, teeth, and coprolites.	1 0
2 ^a 1 ^a }	Blue marl of the Keuper.		
			25 10

The first traces of this Rhætic tract, for it can boast of only a very limited surface-area, occur a little beyond the third bridge, about a mile and a quarter from the new station at the south end of the town of Gainsborough, where the lowest bed of the series, No. 1 in the section, is seen resting unconformably, though with parallel stratification, on the blue marl of the Keuper beneath. This bed consists of a rather loose micaceous sandstone of a greenish grey colour, containing a few specimens of *Avicula contorta*, with worn bones, teeth, and coprolites, and is (where not affected by the unevenness of the underlying Triassic marl, the hollows of which it fills up) on the average about a foot in thickness. In one part, near the outcrop of this lowest bed, lying directly on the blue marl beneath, I found part of the right ramus of the lower jaw of a large Saurian, probably that of *Pliosaurus*. This sandy bed, as a commencement of the Rhætic series, does not seem to be elsewhere of usual occurrence,—the lowest stratum below the bone-bed, in most other localities, being the well-known black shale, of a character more or less indurated, which at Garden Cliff, Wainlode, Coombe Hill, Penarth, and elsewhere, as described by Dr. Wright in vol. xvi.

of the Society's Journal, and at Batheaston and Westbury, as described by Mr. Moore in vol. xvii. of the same publication, forms the base. At Beer Crowcomb, however, as described by the latter, we find a pale-blue stone, 1 foot 2 inches thick, with vegetable-like markings, followed by blue shaly marl, given as the lowest bed of the series, which may be taken as the equivalent of the lowest Gainsborough bed; and perhaps at the well-known Aust Cliff locality, where the bone-bed is described by Dr. Wright as lying abruptly on the Keuper, the stratum of pale arenaceous marl, 1 foot in thickness, which, though placed by him on the top of the Keuper, in texture apparently resembles the lowest Rhætic bed of Gainsborough, may be another of its equivalents. This, however, I hazard only as a conjecture, and on the slight supposition that the fossils of the Rhætic type, should it contain any, are so few as to have hitherto escaped observation. Following the line in a southerly or south-easterly course towards Lincoln, which coincides with the direction of the dip, we find in corresponding order the various beds of the series laid bare, the next of which, No. 2 in the section, consists of a stratum of black fissile shale, 8 feet in thickness, containing nests of pyrites, and having several thin, non-continuous veins of grey pyritous stone imbedded in it. The main bulk of this

Fig. 1.—Section of the Rhætic Beds near Gainsborough.



deposit seems to be entirely wanting in fossil remains; but, after a minute search, it has yielded a few coprolites and specimens of *Avicula contorta* and *Schizodus cloacinus* lying close above the lowest bed No. 1, the presence of these bodies being indicated by layers of iron pyrites, with which mineral the entire series is thickly studded. This black shale is succeeded by the coprolite- or bone-bed (No. 3), a narrow band about an inch thick, entirely composed of worn bones, teeth of various kinds, scales and coprolites, imbedded in a hard cement of sulphuret of iron. Amongst the fossils found in this bed are a portion of the jaw of *Lepidotus Giebeli*, Alb. ?, teeth of *Hybodus minor*, *H. plicatilis*, *Sargodon tomicus*, *Saurichthys apicalis*, *Acrodus minimus*, *Gyrolepis Alberti*, *Termatosaurus Alberti*, and *Ichthyosaurus*, with scales of *Gyrolepis*, spines, and other animal remains, for the naming of which, as well as of most of the other fossils mentioned in this paper, I am indebted to the kindness of Mr. R. Tate, F.G.S. The unbroken condition of the soft coprolite bodies in this deposit points, so far at least as the Gainsborough bed is concerned, to its formation in a moderately deep sea, or, more likely, in a quiet lagoon or semi-inland sea, where the attrition of the waves was not great; and the curious nature of the contents of the bed seems to denote it as simply of faecal origin: nor is this view irreconcilable with the invariably fragmentary nature of the harder animal portions imbedded in it; for, mixed with the faeces, would naturally be found the teeth, scales, and other insoluble fragments of the animals preyed upon: and the idea of its being simply a faecal deposit is borne out further by the occurrence, here and there in the bed, of small smooth pebbles, principally quartz, which in all probability the fishes of those days, like the cod and other fishes of our own, that take their food off the ground, had swallowed, either by chance or purposely (for the sake of the zoophytes and other substances incrusting them). Resting upon this bone-bed we find a stratum of loose grey micaceous sandstone (No. 4 in the section) about 4 inches thick, which is by far the most productive bed for fossils in the series, literally abounding in bones, teeth, scales, and coprolites, with spines of *Hybodus* and *Nemacanthus*, and casts of *Modiola minima*, *Pullastra arenicola*, and other well-known Rhætic fossils. Above this richly fossiliferous bed lies another narrow band of animal debris, No. 5 in the same section, about $\frac{1}{2}$ an inch thick, which may be regarded as a second bone-bed, similar to those found in various other localities. The remains in this band are chiefly coprolites; and, unlike those in the bone-bed below, they are not consolidated in a matrix of pyrites, but lie loose and free in a sandy coating of a composition similar to that of the bed last described, though of a slightly darker colour. This second bone-bed is succeeded by another band of black shale (No. 6), 2 feet thick, containing *Avicula contorta* and other fossils, and that again by a rather hard fine-grained micaceous sandstone (No. 7), 6 inches in thickness, the mica in some parts lying in large loose scales. This bed is highly pyritous throughout, and contains a few teeth, scales, and coprolites, with abundance of *Avicula contorta* on its upper surface. Above

this comes another bed of black pyritous shale (No. 8), 2 feet 4 inches thick, containing immense numbers of compressed *Avicula contorta*, *Schizodus cloacinus*, and other fossils, and having at wide intervals large, flat-shaped, concretionary nodules, of homogeneous texture throughout, imbedded in its mass. In the more fossiliferous parts this bed is very flaky, and separates easily; and the flakes, which may be split up into the thinnest slices, seem to be composed of nothing but dead organisms, of which the shells of *Schizodus cloacinus* form the bulk.

These last-mentioned shales are capped by a band of very hard, compact, laminated, micaceous sandstone (No. 9), 1 foot 5 inches thick, of a light-grey colour, containing numerous casts of *Avicula contorta*, *Pullastra arenicola*, *Modiola minima*, and *Perna*, sp., with teeth, bones, coprolites, and drift-wood. This band forms by far the most important of the stone-beds, and has been used largely for the roadways round the new station at Gainsborough. The fossils in it have not uncommonly a bright pyritous covering, rendering them very distinct and clear in the surrounding matrix of grey. The markings on this stone-bed are most singular, many of the slabs presenting apparently traces of the mollusks and annelids that crawled over and burrowed in them, with smooth wave-ridges and hollows, the latter filled with shells and fish-remains, just as may now be seen on any sandy shore which the retreating tide has laid bare. This is followed again by a bed of shale (No. 10), 4 inches thick, similar in composition to the other shaly strata, containing *Avicula contorta* and *Schizodus cloacinus* in great numbers, above which comes another narrow band of rather dark sandy stone (No. 11 in the section), 2 inches thick. Then another bed of fissile shale (No. 12), 1 foot 6 inches thick, containing the same fossils as before; above which is another band of stone (No. 13), similar to No. 11, 2 inches thick, and above it shale, as before, 1 foot thick (No. 14). Then comes a remarkable narrow band of highly pyritous stone (No. 15), $\frac{1}{2}$ an inch thick, apparently unfossiliferous; and succeeding it is another bed of shale (No. 16) 1 foot 6 inches thick, similar to all the preceding. Then a band of stone (No. 17), 2 inches thick, much broken, resembling in this respect the beds of rubble found at the top of Oolite cliffs. This band, which, so far as I have observed, is wanting in fossils, is followed by another bed of shale (No. 18), 3 feet thick, containing, like No. 8, immense numbers of compressed *Avicula contorta* and *Schizodus cloacinus*, with here and there non-continuous veins of black fibrous gypsum running horizontally through the mass, and having near its surface large oval-shaped nodules of septaria, differing from those in No. 8 (which are of solid and homogeneous texture throughout) in being partly hollow, and having their interstices filled with small crystals of carbonate of lime. It is worthy of remark that, where these septaria occur, the black shales directly beneath them dip for a certain distance, and are rounded and compressed by their weight, while the stone-bed above bulges out in a dome-shaped mass, apparently showing that the concretionary action to which these bodies owed their growth

was at work at the time the shales in which they are imbedded were deposited, and before the overlying stratum was formed. Above this bed of shale we have a thin band of dark-grey stone (No. 19), varying from 1 inch to 3 inches in thickness, containing *Pecten Valoniensis*, *Avicula contorta*, *Schizodus cloacinus*, *Modiola minima*, and what appear to be worm-tracks, or casts of the traces of crawling mollusks or crustaceans. This stone band, the only one in the series where (owing to the indefatigable researches of my friend Mr. Waugh, of the Great Northern staff, to whom I owe the accurate diagrams accompanying this paper) I have met with the well-known *Pecten Valoniensis*, so common in other similar localities, lies just above the septarian nodules in the shales below, sometimes reclining on them; and where these bodies occur, the stone assumes, as just stated, a dome-shaped curve, being thinnest on the raised summit of the nodules, and thickest in the intervening spaces, while, resting on the stone, in the hollows between the swellings caused by the septaria, lie veins of black fibrous gypsum similar to those described in the shale-bed (No. 18) below. Next in order comes another bed of black fissile shale (No. 20) from 1 foot to 3 feet thick, similar in character to all the others, and forming the highest bed of the series in this locality, all above it being, as far as the railway-cutting extends, denuded and worn down by the drift, which, at a distance of about 90 yards above Lea-bridge, suddenly cuts clean through all the intervening beds down to the main stone band (No. 9), crushing and distorting the various strata, and making the smooth slippery surfaces of the shales appear as if they had been polished*. At this point also the strata from beneath rise again, and the grey Keuper marl becomes visible at the base of the cutting, showing the form of the Rhætic beds in this locality to be that of a shallow synclinal basin. That higher beds of the series existed in these parts is evident from the clean-fractured uneven fragments of White Lias which are found in the overlying drift, containing *Myacites musculoides*, *Cardium Rhæticum*, and other fossils, with the old perforated tubes of boring mollusks, the latter pointing, as Mr. Moore, in his paper already cited, observes, to a quiet period of deposition, when such delicate operations could take effect. One of the most remarkable characteristics of the Gainsborough beds is the presence of the immense quantity of iron pyrites found in the different strata, all of them, whether shale or stone, being literally filled with this mineral. In the shale it occurs as a simple cube, or number of cubes, and in the stone as a bright metallic layer or streak; and so filled is the entire series with this substance, that I have seen, after heavy rains, the sides of the cutting in places stained yellow, as if with rust, completely effacing the lines of bedding. How far the surface-limits of this Rhætic tract extend it is not easy to ascertain with exactness; judging, however, from the contour of the surrounding land, an estimate of its size and position may, I think,

* Since this paper was read, I have discovered, in the old undisturbed parts of the cutting, traces of strata *in situ* belonging to the Rhætic series higher than those described.

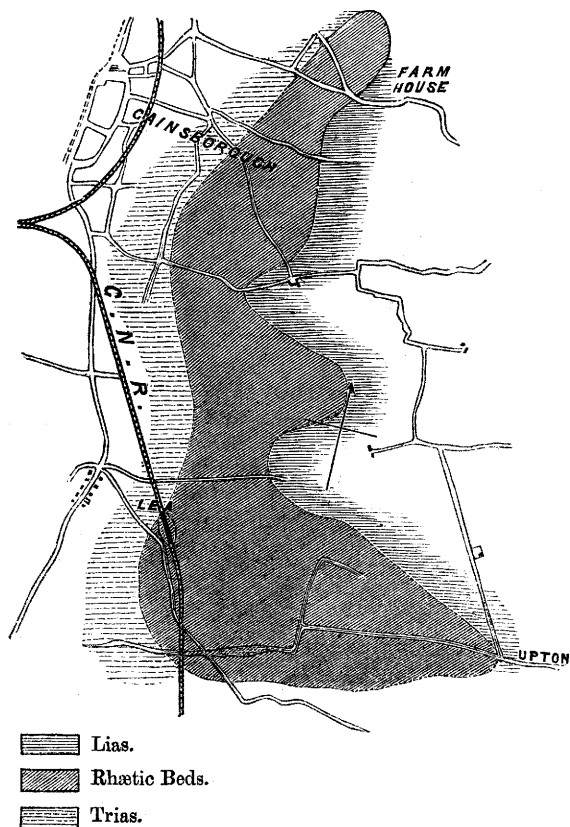
1867.]

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with some degree of probability be made out; and I have endeavoured in the accompanying map, taken from the Ordnance Survey, to define them. To the east of the Triassic escarpment, extending from the Rhætic cutting at Lea northwards towards Gainsborough, the land lies in a gentle slope, rising again, though very slightly, at a distance of less than a mile on the average, with an outcrop of Liassic clays; and in the hollow between these ridges, judging from

Fig. 2.—*Sketch Map showing the extent of the Rhætic Beds near Gainsborough.*



the direction of the dip, and the general trend of the land, it appeared to me likely that the Rhætic beds would be found on the surface; and hearing that a well had been dug in the line of this depression, near a farm-house marked on the map, about 3 miles north of the Lea-beds, I examined the earth thrown up, and found, as I anticipated, the various stones and shales of the Rhætic zone,

undiminished to all appearance in size and thickness, the main stone band and the other prominent strata, with their accompanying fossils and stock of pyrites, seeming all to be present as at Lea.

Taking the entire depression between the Keuper and Lias outcrops, and presuming it to be occupied with the Rhætic beds, as in all probability it is, we get an area of from 3 to 4 miles long, and from $\frac{1}{2}$ a mile to 2 miles broad, as the surface-extent of this northern deposit; but whatever its size may actually be now, there can be no doubt that it once formed part of the north-western boundary of a vast Rhætic sea, which extended, it may be, from Norway*, across the German Ocean, to Ireland, and southwards down the continent of Europe, and which, save in such patches as these, has long since been swept off the earth's surface, or buried beneath more modern deposits; and it is from such considerations, and the light the discovery of these outlying strata casts on what would otherwise be vague and obscure, that the interest and value of their examination mainly depend.

JUNE 5, 1867.

SPECIAL GENERAL MEETING.

The following addition to the Bye-laws was proposed by Mr. S. R. Pattison, seconded by Mr. J. W. Flower, and adopted by ballot, with one dissentient:—

Section XIX. 5. The Society shall not and may not make any dividend, gift, division, or bonus in money, unto or between any of its members.

ORDINARY GENERAL MEETING.

Augustus Wollaston Franks, Esq., F.R.S., F.S.A., Keeper of Antiquities, British Museum, W.C., was elected a Fellow.

The following communications were read:—

1. *The ALPS and the HIMALAYAS: a GEOLOGICAL COMPARISON.*

By HENRY B. MEDLICOTT, Esq., A.B., F.G.S.

[The publication of this paper is postponed.]

(Abstract.)

CURRENT opinions on Alpine geology are first fully discussed by the author, especially as regards the abnormal nature of the actual boundary of the Molasse with the rocks of the higher Alps, including the explanation usually given of this phenomenon, and of the contortion of the inner zone of Molasse—namely, the direct upheaval of the main mountain-mass. Mr. Medlicott then describes some of the

* The probable existence of the Rhætic beds on the Island of Bornholm, and in the province of Schoonen, is indicated on Dittmar's map showing the distribution of the formation; but at present there is no fossil-evidence to prove with certainty the age of the beds in question.