

XVIII.—*Remarks on a Section of the Upper Lias and Marlstone of Yorkshire, showing the limited vertical range of the Species of Ammonites, and other Testacea, with their value as Geological Tests.*

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[Read May 25, 1836.]

ON presenting a stratigraphical arrangement of the fossils in the lias formation on the coast of Yorkshire, I wish to offer the following remarks relative to their geological distribution.

The section (p. 221.) refers to that part of the coast between Whitby and Redcar, in which the Loftus and Boulby Alum Works are situated, and was named by General Mudge “Easington Heights.” Its greatest elevation is 681 feet. It includes the inferior with a part of the great oolite series; and the lias is better developed in this place than in any other part of the coast, the upper shale having a thickness of 200 feet, and the marlstone of 160; and there are about 150 of the lower shale also exposed.

With regard to the correctness and universality of the order given to the fossils, the position of no one species was fixed till after several had been extracted from the situation indicated in the section, as well as in various different localities from the Alum Hills, fronting the vale of Thirsk, to the peak near Whitby; and in the majority of instances, from thousands of specimens afforded by the quarrying of the lias shale in the manufacture of alum. Though it would have been easy to have added many more species, the geological situation of which is determined, yet wherever the limits of distribution have not been clearly defined, they have been omitted.

Upper Lias Shale.—Commencing at the surface of this deposit, the first fossil present in any quantity, is the *Nucula ovum* (see section, p. 221.); which, after descending a few feet and entering what is technically called the “hard or cement stone seam,” occurs in great abundance; but below that bed it

becomes gradually scarcer and smaller, so that after a descent of 60 feet, it is rarely met with, and I believe has never been found so low as the jet rock. The *Orbicula reflexa*, and the small, but delicate and beautiful *Plagiosoma pectenoideum* are associated with the *Nucula*, and similarly distributed. It may be worthy of observation, that the *Nucula ovum* is singularly characteristic of that portion of the upper shale used in the manufacture of alum, and that wherever the shale occurs without this shell, it has been found unfit for the remunerative production of the salt*. This is owing to the nature of the shale, the upper part, where calcined, being richest in sulphate of alumina; not, as might be supposed, from containing originally *more sulphur*, but a *less proportion*, the lower strata having such an excess of pyrites and bitumen, that the contents of a kiln made from such schistus, invariably overroasts. A large *Pallustra*, or *Amphidesma*, (the *Amphidesma donaciforme* of Phillips) is also plentiful in the upper part; but it is occasionally found in the lower, and a similar shell occurs in the Marlstone.

But of all organic remains, the Ammonites afford the most beautiful illustration of the subdivision of strata, for they appear to have been the least able, of all the Lias genera, to conform to a change of external circumstances. Of the species, most plentiful in the upper part, scarcely any are found in the lower; except a few doubtful individuals of *A. communis* (the prevailing species in the "hard seam") which are now and then seen so low as the jet rock; and though *A. fimbriatus* and *A. heterophyllus* are found in that stratum, they are always dwarfish, seldom attaining three inches in diameter, whereas in the upper beds, they are met with twenty inches in diameter.

The portion of the series mentioned before as the "Jet Rock," is a very compact and highly bituminous bed, from 20 to 30 feet thick and 150 feet below the surface of the formation. It contains many flattened, pyritous nodules, which generally inclose organic remains. The rock itself is also so very sulphureous, that when a small heap of it was calcined at the Loftus works some time ago, the melted bitumen and sulphur flowed in flaming streams. The whole of the jet used in the manufacture of ornaments, is extracted from this stratum; for when occasionally met with higher up, it is like coal in its fracture, and too brittle to work well; and in the inferior strata, as the marlstone, it forms merely a thin coat, enveloping a lump of fossil wood.

* The Alum Works, of which lias shale is characterized by the *Nucula ovum*, are the Peak, on the extreme east, and Stow Brow, Godeland Banks, Sandsend, Kettleness, Boulby, Loftus, Selby Hogg, and Osmotherly, on the extreme west. Failures have occurred to different works in attempting the calcination of the lower portions of the Upper Lias, or those strata undistinguished by the *N. ovum*.

The seams are sometimes 20 feet long by 6 feet broad, but they are often smaller, and their greatest thickness is 3 inches.

The Jet Rock is also peculiar for containing the remains of the *Teleosaurus*; for though *Ichthyosauri* and *Plesiosauri* appear pretty equally distributed through the upper shale, this (fluviatile?) reptile is rarely found but in, or immediately above, the Jet Rock. Its bones are generally scattered in separate nodules, the upper jaw being scarcely ever united to the lower. With the exception of the specimen in the Whitby Museum, I am not aware of any instance of this animal having been found entire, whereas the other saurians seldom want more than the head or paddles.

On inspection of the section, it will be perceived, that the Jet Rock has its peculiar suite of *Ammonites*, and here, as was before observed, *A. heterophyl-lus* and *A. fimbriatus* make their first appearance, being about the size of a half-crown, while in the "hard seam" they attain the enormous magnitude of 1 and 2 feet in diameter. The *Ammonites Crassulus*, (*n.s.*) common to the whole upper lias, on the other hand, has its greatest development in the Jet Rock, gradually diminishing from $1\frac{1}{2}$ inches to $\frac{1}{2}$ an inch in the overlying beds. An interesting, though perhaps it may appear trifling, circumstance attending this fossil is, that as it decreases in size it becomes more numerous, many hundreds being then found together.

The lowest bed of the upper shale is hard, compact and sandy, and is singular for its great barrenness of fossils, occurring as it does immediately beneath one so prolific as the Jet Rock. This scarcity, combined with the arenaceous nature of the stratum, may perhaps afford some hints for elucidating, hereafter, the anomaly of fluviatile reptiles being mixed up with pelagian shells and fishes. It is a plausible speculation, that during the formation of the upper lias, the bottom of the sea in which it was deposited, was gradually settling. This conjecture is supported, by the greater prevalence of vegetable matter and fluviatile (?) reptiles in the lower part, and the increase in number of the larger species of *Ammonites*, *Nautili*, and *Belemnites* in the upper. This conjecture is further supported by the mineralogical nature of the schistus, silex being more abundant in the inferior parts, and alumina in the superior, an arrangement which would naturally take place, if the coast during that epoch gradually sunk, and the land, the detritus of which afforded the material for the lias, as gradually receded; the finer argillaceous sediment being consequently carried into the deeper and more and more distant parts.

Marlstone.—On entering this series, we at once perceive a striking contrast to the upper lias, for independently of the decided mineralogical difference,

not only the species and genera, but the *order* of Testacea have undergone a total revolution. Instead of a preponderance of Cephalopods and a scarcity of bivalves, we now have an overwhelming majority of the latter, some of the beds being almost constituted of *Cardia* and *Gryphytes*, which have also an extensive vertical distribution. *Avicula Cygnipes*, *A. inaequivalvis* and *Pul-lastra antiqua* are equally abundant in the whole series; but other shells, as *Cardium truncatum*, occur more plentifully in the inferior strata, whilst *Terebratula triplicata* and *T. trilineata* crowd the superior.

The species of Ammonites, though few in number, are, however, highly characteristic; thus we find *A. vittatus* about the centre of the series, confined to a very small range, associated in nodules with the *Cardium multicos-tatum*, *Turbo undulatus*, and *Pecten planus*; but the two latter occur in other parts of the formation. The *A. maculatus*, is constantly found at the junction of the *marlstone* with the *lower lias*, which here pass so gradually into each other, that it is impossible to determine where the sandstones end and the blue shale begins. I have long sought for *A. maculatus* in the upper and central portions of the *marlstone*, but have never found it many feet above the junction beds; and though this and other Ammonites from unequal geographical distribution, may be more abundant in one place than in another (*A. maculatus* is in greatest number at Staithes, *A. Hawskerensis* at Hawskerbottoms), yet they constantly maintain an invariable relative position. *A. Hawskerensis* I believe to be also a junction Ammonite, but from its rarity in other situations, than that mentioned, it is not entered in the table.

The above description may not, in some instances, exactly accord with previous statements, but one great source of error has hitherto been, the collecting of specimens from the debris of the whole formation, accumulated at the foot of cliffs or other similar situations, where they have long laid, and the inferring of their position from the nature of the matrix. A strong temptation to this method arises from the facility it affords of obtaining finer fossils than can possibly be procured from newly quarried nodules, the hard nature of which renders it very difficult to extract the fossil entire, without long exposure to air and moisture.

Annexed is a systematic list of the fossils found in the upper lias and marl-stone, and noticed in the section.

the Upper Lias and Marlstone of Yorkshire.

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List of Fossils found in the Upper Lias and Marlstone*.

Genus. . . . Species.	Reference.	Formation.
<i>Ophiura Milleri</i>	Phill. T. xiii. fig. 20†	Marlstone.
<i>Pholadomya obliquata</i>	Phill. T. xiii. fig. 15.....	_____
— <i>ambigua</i> (<i>Lutraria Y. & B.</i>)	Sowerby‡, Y. & B. T. viii. fig. 4§	_____
<i>Amphidesma?</i> <i>donaciforme</i>	Phill. T. xii. fig. 5.....	Upper lias.
— <i>rotundatum</i>	Phill. T. xii. fig. 6.....	_____
<i>Pullastra antiqua</i>	Phill. T. xiii. fig. 16	Marlstone.
<i>Cardium truncatum</i>	Sowerby, Phill. T. xiii. fig. 14.....	_____
— <i>multicostatum</i>	Phill. T. xiii. fig. 21	_____
<i>Nucula ovum</i>	Sowerby, Phill. T. xii. fig. 4.....	Upper lias.
<i>Modiola scalprum</i>	Sowerby, Phill. T. xiv. fig. 2	Marlstone.
<i>Inoceramus dubius</i>	Sowerby, Phill. T. xii. fig. 14	Upper lias.
<i>Avicula cygnipes</i>	Phill. T. xiv. fig. 3. <i>Pecten Y. & B. Pl. ix. fig. 3</i>	Marlstone.
— <i>inæquivalvis</i>	Sowerby, Phill. T. xiv. fig. 4	_____
<i>Plagiostoma pectenoïdeum</i>	Sowerby, Phill. T. xii. fig. 13	Upper lias.
— <i>Hermannii</i>	Voltz	Marlstone.
<i>Pecten æquivalvis</i>	Sowerby, T. cxxxvi.	_____
— <i>sublaevis</i>	Y. & B. Pl. ix. fig. 9. Phill. T. xiv. fig. 5 ..	_____
<i>Gryphaea depressa</i>	Phill. T. xiv. fig. 7	_____
<i>Terebratula acuta</i>	Sowerby, Phill. T. xiii. fig. 25	_____
— <i>bidens</i>	Phill. T. xiii. fig. 24	_____
— <i>compressa?</i>	Y. & B. T. viii. fig. 14	_____
— <i>tetrædra</i>	Sowerby, T. lxxxiii. fig. 4	_____
— <i>trilineata</i>	Y. & B. T. viii. fig. 17	_____
— <i>triplicata</i>	Phill. T. xiii. fig. 22	_____
<i>Orcibula reflexa</i>	Sowerby, T. vi. fig. 1	Upper lias.
<i>Dentalium giganteum</i>	Phill. T. xiv. fig. 8	Marlstone.
<i>Turbo undulatus</i>	Phill. T. xiii. fig. 18	_____
<i>Belemnites compressus</i>	De Blainville , Phill. T. xii. fig. 21	Upper lias.
— <i>elongatus</i>	Miller¶, Y. & B. Pl. xv. fig. 1	_____
— <i>trifidus</i>	Voltz**	_____
<i>Nautilus astacoides</i>	Y. & B. T. xiii. fig. 2	Upper lias.
<i>Ammonites angulatus</i>	Sowerby, T. cvii.	_____
— <i>annulatus</i>	Sowerby, T. ccxxii.	_____
— <i>Boulbiensis</i>	Y. & B. p. 267.	_____
— <i>communis</i>	Sowerby, T. cvii. fig. 2. Y. & B. Pl. xii. fig. 3	_____
— <i>concavus</i>	Sowerby, T. xciv. low. fig.	_____

* In the table, those species only are enumerated of which figures have been published. Where two references are given, the first is to the author who named the fossil; the second to the work in which a Yorkshire specimen is figured.

† Phillips, Illust. Geol. Yorkshire, part i. 1829. ‡ Sowerby, Mineral Conchology, 1812—1829.

§ Young and Bird, Geol. Survey of Yorkshire Coast, 2nd edition, 1828.

|| Mémoires sur les Belemnites, 1827. ¶ Observations on Belemnites, Geol. Tr. 2d Ser. vol. ii.

** Observations sur les Belemnites, 1830.

Genus.	Species.	Reference.	Formation.
Ammonites	crassus	Phill. T. xii. fig. 15, tuberculated var.....	Upper lias.
—	elegantulus.....	{ Y & B. p. 267 (? elegans Phillips, but not } { Min. Con.).....	—
—	exaratus.....	Y. & B. Phill. T. xiii. fig. 7	—
—	fibulatus.....	Sowerby, T. cccvii. fig. 2	—
—	fimbriatus.....	Sowerby, (cornucopia) Y. & B. T. xii. fig. 8..	—
—	heterophyllus.....	Sowerby, T. cclxvi	—
—	Lythensis.....	Y. & B. p. 267. Phill. T. xiii. fig. 6	—
—	Mulgravius	Y. & B. T. xiii. fig. 8	—
—	ovatus	Y. & B. xiii. fig. 4. Phill. T. xiii. fig. 10	—
—	sigmifer	Phill. T. xiii. fig. 4	—
—	subarmatus	Sowerby, T. cccvii. fig. 1	—
—	subcarinatus	Y. & B. Phill. T. xiii. fig. 3	—
—	Walcottii	Sowerby, T. cvi. Y. & B. xii. fig. 1	—
—	Clevelandicus.....	Y. & B. T. xiii. fig. 7	Marlstone.
—	maculatus	Y. & B. xiv. fig. 9. Phill. T. xiii. fig. 11	—
—	vittatus	Y. & B. T. xiv. fig. 11. Ph. T. xiii. fig. 1 variety	—
Lepidotus	gigas	Agassiz*	Upper lias.
Ichthyosaurus	communis.....	Conybeare† and De la Beche	—
—	platyodon.....	Conybeare and De la Beche	—
Plesiosaurus	Conybeare‡	—
Teleosaurus	Chapmanni	Y. & B. Pl. xvi. fig. 1	—

* Recherches sur les Poissons Fossiles. † Geol. Trans. 1st Ser. vol. v. 2nd Ser. vol. i.

‡ Geol. Trans. 1st Ser. vol. v. 2nd Ser. vol. i.

Section of the Upper Lias and Marlstone at Rockliff, near Whitby (Easington Heights, Mudge's Survey), showing the limited Distribution of certain Species of Testacea, and the Order Cephalopoda in particular, Local Dip S.W. One Foot in Ten Feet.

