reasons for not accepting entirely the classification of them proposed by Captain Spratt, and followed by Earl Ducie in his Geological Map of the Maltese Islands. He divided the Miocene strata into the following subdivisions:—1. The Upper Limestone; 2. The Sand Bed; 3. The Marl; 4. The Calcareous Sandstone; 5. The Lower Limestone; and again subdivided the Upper Limestone into three parts. Dr. Wright gave diagnoses and detailed descriptions of forty species of *Echinidæ*, four of which are new; and Dr. Adams added a Table showing their stratigraphical distribution.

FEBRUARY 18, 1863.

John Rand Capron, Esq., Guildford; Julius Haast, M.D., Government Geologist, Christ Church, Canterbury, New Zealand; Thomas Hood Hood, Esq., Member of the Legislative Council of Queensland, Australia; John Randall, Esq., Madeley, Salop; and Samuel Wright, Esq., Cockermouth, were elected Fellows.

The following communication was read:—

On the MIDDLE and UPPER LIAS of the DORSETSHIRE COAST.*

By E. C. H. DAY, Esq.

[Communicated by R. Etheridge, Esq., F.G.S.]

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§ I. Introduction.

1. *Sir H. De la Beche's subdivision of the Dorsetshire Lias.*—The only published section giving details of the Lias formation of Dorsetshire, at present in existence, is one made more than thirty

* For an account of the Lower Lias of Dorsetshire, &c., see Quart. Journ. Geol. Soc. vol. xvi. p. 374, &c.; and vol. xvii. p. 494, &c.—EDIT.

years ago by the late Sir Henry De la Beche*. When I undertook the investigation of the geology of the coast in the neighbourhood of Lyme Regis, I soon found that that section, though according well with certain general facts, was, owing to the rapid progress of geological knowledge, and the consequent changes in our system of classification, utterly useless to students. The divisions and subdivisions of De la Beche were founded solely on lithological grounds, whereas those of the present day are based in great measure upon palæontological considerations. He classed all our Upper and nearly half our Middle Lias with the Inferior Oolite Sands†, and he subdivided the Lias, as then understood, accordingly. As he had classed sands with sands, and marls with the Lias, so he divided the latter into "Upper Lias Marls" (which, under the present system, include both the Middle and Lower Lias Marls), "Lias Limestones" (which correspond to a subdivision of the Lower Lias), and "Lower Lias Marls" (which are the "*Avicula contorta* series," no longer regarded even as Liassic).

The section quoted gave to the entire Lias Formation of Dorsetshire a thickness of 600 feet; our present acceptance of the term includes between 1000 and 1100 feet of strata.

The plan which I have adopted, in order to lay clearly before the Society the extent and character of these deposits, is to give, in the first place, a description of them lithologically as they appear in the successive cliffs; and, in the second, to point out, in a generalized vertical section, the palæontological features which characterize the subdivisions and strata. To avoid confusion, I will premise what I understand by the terms Middle and Upper Lias.

2. *The Middle Lias*.—As this term is now accepted, it may be defined as that portion of the Lias Formation which lies between the strata containing *Ammonites raricostatus*, Ziet., as the predominant form below, and those characterized by *Ammonites communis*, Sow., above.

Thus defined, the Middle Lias of this neighbourhood presents a mass of beds which, though including two great and lithologically well-marked subdivisions, is on the whole very distinct, both in its lithological appearance and in most of its fossils, from the beds above and below. The Marlstone and the Middle Lias Sands are generally understood to occupy this interval, or, at least, the greater part of it, throughout the South-west of England; but, in the district under consideration, these beds do not occupy more than two-fifths of the gap, the larger part being filled up by a mass of marls. Throughout the rest of England, moreover, I believe the total thickness of this member of the Lias amounts to much less than in this district, where it includes upwards of 500 feet of strata.

Such an increased development, and other characters very much

* Geol. Trans. 2nd series, vol. ii. 1829; also, Report on the Geology of Cornwall, Devon, and West Somerset, 1839.

† Owing to this classification, fossils from the Middle Lias have been given as from the Inferior Oolite of Bridport (vide *Rhynchonella serrata*, *Pentacrinus gracilis*, &c., in Morris's Catalogue of British Fossils).

in accordance with those of the Continental types, appear to approximate our Middle Lias more closely to foreign equivalents, than that of any other British section hitherto examined; and this is what we might expect to find at the point where our English beds approach nearest in distance to foreign shores; on the other hand, such an approximation in character would lead us to hope that we might here meet with organic forms hitherto supposed peculiar to the Continental Lias.

3. *The Upper Lias*.—This division, as defined by Continental geologists, commences with the strata containing *Ammonites communis*, Sow., and terminates with those containing *A. jurensis*, Ziet. It thus rests upon the zone of *A. spinatus*, Brug., and is in turn covered by that of *A. Murchisonæ*, Sow. Like the Middle Lias, the Upper Lias of Dorsetshire presents us with two lithological subdivisions, the lower one argillaceous, the upper one sandy; but their special characters will be given in the sequel.

§ II. *Descriptions of the Sections.*

1. *Black Ven*.—The first section in which the Middle Lias is seen as we proceed eastward from Lyme Regis, and upwards in the order of stratification, is in a cliff called Black Ven, situated between Lyme Regis and Charmouth. Above the beach, nearly opposite the highest part of the hill, there is a succession of cliffs of Lias capped by Greensand (*a*, fig. 1). The lower portion of these cliffs, to the height of 180 feet, is of a dark slaty-blue colour, and consists of the "Lower Lias Marls" (*l*); it contains the zones of *Ammonites Brookii*, Sow. (the local equivalent of *A. Turneri*, Sow.), *A. obtusus*, Sow., *A. oxyotus*, Quenstedt, and *A. raricostatus*, Ziet., all well defined. Above these beds is a mass of marl, forming a cliff or wall, the dull-grey tint of which strikingly distinguishes it from the darker strata below. This marl, about 90 feet in thickness, is the lower commencement of the Middle Lias, as well as its most westward extension upon this coast.

On a closer examination we find, however, that the base of the above-mentioned wall (*h*) is blue and not grey, its real colour being concealed by the crumbling away of the beds above. Nevertheless the Middle Lias, as above defined, commences at the very base, where certain Lower Lias fossils cease and Middle Lias forms appear. This change occurs in some tiers of limestone (*i*, *k*) upon which the wall or cliff rests. Between two of these beds of stone, in about eighteen inches of marl, a great number of compressed and metallic specimens of *A. raricostatus* occur, and this, as far as I know, is the highest limit of that form. The next alternate layer of marl is full of Belemnites; and here I think the Belemnite-beds may be fairly assumed to commence, and with them the Middle Lias.

In the 30 feet of blue marl above (*h*), a very elongated Belemnite, *B. longissimus*, Miller, is the characteristic fossil. This blue marl gives place to some irregular beds of impure semi-indurated limestones of a grey colour (*g*), and these are succeeded by grey marls (*f*), becoming shaly in the upper portion. The shales (*e*), 6 feet thick, are very full of Belemnites, as is also the thin band of limestone

(*d*, the “Belemnite-stone”) by which they are capped. Above this stone there are some 15 or 20 feet more of grey marl (*c*), upon which rests the base of the Cretaceous Series.

Fig. 1.—Vertical Section of the Middle Lias at Black Ven.

The Lias thus terminates in Black Ven at a height of about 270 feet above the sea. The road from Lyme to Charmouth, where it passes through the east “Cuts,” is about 70 feet above the highest of the Lias. From this point the beds are somewhat steeply denuded towards the valley of the Char, so that we soon lose the Middle Lias. The Lower Lias beds dip gently in the same direction, that is, towards the east; and, at the mouth of the river, we find a fault which throws them down some 50 feet more in the same direction.

2. *Stonebarrow Hill and Westhay Cliff*.—The base of the Middle Lias is met with in Stonebarrow Hill at the height of about 80 feet above the sea (*m*, fig. 2), and the Belemnite-stone (*g*) at about 80 feet above that again. At 16 feet over the Belemnite-stone we find the first layer of the “Green Ammonite-beds” (*e*)—thus termed by collectors from the green tint of the calc-spar that fills the chambers of the *Ammonites laticostatus*, Sow., the characteristic fossil. Several layers of these limestone-nodules occur in the next 16 or 20 feet. Some of the layers are more persistent than others, and all are not equally fossiliferous.

Above these nodules the marls continue of the same character as in the upper part of the last section (fig. 1) for 75 feet more (*d*,

fig. 2), and are then succeeded by three tiers of a fine-grained micaceous stone containing more or less lime (c). This is the first appearance of mica in the Middle Lias; and from this horizon upwards it will be found to occur at intervals up to the highest of the Upper Lias Sands. The thickness of the blocks in the "Three Tiers," as I have termed them, varies much, as does likewise that of the intervening marl; in the aggregate they measure from 20 to 26 feet. Above these, in Westhay Cliff, we find some 20 feet more of micaceous marl (b), which is succeeded by Greensand (a). There is thus a thickness of about 220 feet of Middle Lias in this hill; and the best exposure of the beds is to be seen upon Westhay Cliff at, and to the eastward of, a gully called "Breakneck." From this point to the eastward the cliff decreases in height, and the beds dip in the same direction, as far as a little stream called Ridge Water, near which a piece of broken swampy ground conceals a downthrow to the east, of about 40 feet. This brings us to Gabriel's Water, at which commences the fine section of the Golden Cap.

Fig. 2.—Vertical Section of the Middle Lias at Westhay Cliff.

3. *The Golden Cap*.—The principal portion of this hill is based upon the Belemnite-beds (i, fig. 3), and the marls immediately over the beach are those containing the Green Ammonite-nodules. Above these, the "Three Tiers" are here finely developed, and form a remark-

able feature in the cliff, though very uninteresting to the collector. They are succeeded by 160 feet of grey micaceous marl (*d*). Two or three thin bands of mudstone and of occasional nodules occur in the lower part of this mass; and at rather more than 100 feet over the "Three Tiers" a thicker band (*e*), containing shells and calcareous concretions, stands out from the face of the cliff. Underneath this thick band is a curious and persistent layer of small nodules (*f*), containing, chiefly, fragments of Ammonites. The mass of grey marls terminates with a layer made up of shells and fragments of *Pentacrinus*; and this is immediately overlain by a bed of large sandstones from 4 to 6 feet in thickness, which is again succeeded by large nodular masses of indurated sand. Over the nodular layer occur the Middle Lias sands (*a*), grey and marly in the lower part, but gradually becoming brown and more arenaceous in their upper portion. Nodules are plentifully scattered through these ferruginous sandy shales and sands, which are here about 60 feet in thickness, and are succeeded by Cretaceous beds.

Fig. 3.—Vertical Section of the Middle Lias at the Golden Cap.

We have, therefore, in the Golden Cap, about 290 feet of grey marls, capped by about 60 feet of sands with nodules, all belonging to the Middle Lias.

Passing eastwards over a small upthrow, mentioned by De la Beche, there occurs, at the Coastguard-station at Seatown, a power-

ful fault which carries out of sight the marls below the "Three Tiers," the "Three Tiers" themselves, and part of the micaceous marls over them.

4. *Down Cliffs*.—In consequence of the fault just mentioned, the layer of small nodules already noticed in the Golden Cap (*f*; fig. 3) is seen in Down Cliffs at a height of about 25 feet from the beach (3, fig. 4). The overlying shell-containing mudstone (*e*, fig. 3), of the hill to the westward, is here represented by an equal thickness of hard shelly marl (2, fig. 4). The fault has therefore caused a downthrow of about 200 feet, which great effect is not the result of several small downthrows, but of one well-defined fracture.

Sixty feet or so over the small nodules, a layer of massive sandstones projects from the face of the cliff. These are the Starfish-stones (*b*, fig. 3, and *i*, fig. 4), so called from the beautiful specimens of *Ophioderma Egertoni*, Broderip, collected from their under surface. Beneath them is a layer of marl, rich in shells (*c*, fig. 3, and *k*, fig. 4); and above them, and occasionally forming part of one huge block, are large shaly nodules; the entire series being identical in character with their equivalents already mentioned in the Golden Cap. As in that hill also, over these beds is a mass of shaly sands with nodules (*h*, fig. 4), here attaining to a thickness of about 85 feet, and capped by a band of blue, micaceous, siliceo-calcareous stone (*g*), which yields most of the specimens of *Ammonites margaritatus*, Montf., sp., that are collected here, and which I therefore term the "Margaritatus-stone." Resting upon this layer is a bed of marl (*f*), the grey or blue tint of which renders it a more prominent feature in the section than its thickness of only 6 feet would lead one to expect. This argillaceous deposit forms a remarkable break in the series of sands, which recur over it (*d*, *e*); above, however, they are less calcareous, quite as micaceous, and of a more decidedly brown colour than those below.

Over these upper sands, which are frequently indurated into massive blocks of sandstone rather than into nodules (*d*), and which, from the "Blue Band" upwards, measure about 70 feet in thickness, is a mass of very micaceous grey marl or clay (*c**), about 18 feet in thickness. This is capped by a remarkable band of stone (1), the lower portion of which is in great part a conglomerate, the pebbles being imbedded in a more or less ferruginous matrix, with oolitic granules. In places, however, this part of the bed assumes more the appearance of the Marlstone of other districts; it is separated from the higher portion of the stone by a seam of iron-ore, seldom more than an inch in thickness, but occasionally becoming thicker, and then containing a remarkable assemblage of *Mollusca* amongst the water-worn pebbles. This "Pleurotomaria-bed," as I have termed it, and the underlying equivalent of the Marlstone appear not to be persistent through the section, but the upper portion of the bed of stone can be traced throughout. This higher part is composed of thin bands of a hard, dense, almost chert-like limestone, separated by thin laminae of yellow ochreous clay; the whole, however, being consolidated into one block. The entire thickness of the associated

Fig. 4.—*Vertical Section of the Middle and Upper Lias at Down Cliffs.*

marlstone and limestone (belonging to the Upper Lias) varies from 2 to 3 feet *. This extraordinary band of stone, thus including the boundary-line of two formations, is interposed between portions of the same great clay-deposit, since above it there is a mass of grey micaceous marl (c) precisely similar in character to that below. This marl is continued upwards for about 70 feet.

We have already seen that blue marl, similar to that of the Lower Lias, is continued some 20 feet into the Belemnite-beds of the Middle division; here, on the contrary, we find the higher limit of the latter, as defined by fossils, carried upwards into a clay-deposit most certainly belonging in the mass to the Upper Lias. We thus see that the organic and inorganic conditions characteristic of two contiguous groups do not always possess the same boundary-line.

Over the great clay-bed last mentioned there are about 140 feet of sands (b)—brown, micaceous, and with close-set tiers of large nodules, and layers of indurated sandstone. These are the sands which, till within the last few years, have been called “the Sands of the Inferior Oolite,” but which are now, as is well known, generally assigned to the Upper Lias. The highest of these beds immediately underlying the Inferior Oolite have been, in the section under consideration, completely denuded, the total height of the hill being completed by a few feet of drift (a). Passing under the height of Thornecombe Beacon, we find the Down Cliffs section sloping away gradually to the eastward. The beds are cut through by the Valley of Eype, but without any fault.

5. *Fourfoot Hill*.—In this hill, at a little distance to the eastward of “Eype’s Mouth,” we come suddenly to a very strong fault, which carries out of sight not only as much of the Middle Lias as is not denuded, on the one side, but, on the other or eastern side, brings down the highest beds of the Inferior Oolite below the level of the beach, with upwards of 200 feet of Fuller’s Earth and Forest Marble resting upon it. As there is a thickness of more than 200 feet of Lias in the one cliff, and as the interval between those beds and the uppermost of the Inferior Oolite cannot be much less than 300 feet, we may estimate this fault as a downthrow of nearly, if not more than, 500 feet, and this too in one great fracture.

The Lias beds of the western side of the fault include the brown sands nearly up to the Upper Lias Stone; but, as the only portion of the section not obscured is to be seen in the faulted face, where the beds are much displaced and coated with the *débris* of the fault, it is difficult to say much about this, the most easterly extension of the Middle Lias on the Dorsetshire coast.

No more of the Lias is seen till we approach Bridport Harbour, where the Upper Lias Sands are brought up again by a fault corresponding to that of Fourfoot Hill, though not equalling it in magnitude.

* R. Etheridge, Esq., of the Geological Survey, being engaged, in the summer of 1861, in making a section of the Lias strata near Lyme Regis, was the first to discover the existence and true position of the Upper Lias in this cliff, though he did not then suspect the character of the under part of the block in which he found the Upper Lias Ammonites.

In the first cliff east of the harbour, there is a thickness of about 120 or 130 feet of sands with nodules, cut into a perpendicular cliff. Probably some of the highest nodules of the sands cap this cliff, as I have seen a few fossils in blocks fallen from the summit, and as the Inferior Oolite is found a very short distance inland.

6. *Burton Cliff*.—In this section there is the same thickness of sands as in the last-mentioned cliff, but here capped by the Inferior Oolite and Fuller's Earth. As much discussion has taken place in England upon the correctness of the classification which assigns these sands to the Upper Lias, and as I believe some amount of doubt was at one time expressed, not only upon the deductions drawn from the assertions made upon this point, but even upon those assertions themselves, I am happy to be able to add my testimony to the truth of one point which was formerly called in question, namely, the existence of a bed containing numerous Ammonites, of species assigned on the Continent to the Upper Lias, lying in the sands a few feet under the lowest beds of the Inferior Oolite. From the geologist who first pointed out this Ammonite-bed, it is frequently called the Cephalopoda-bed of Dr. Wright*; and I have now found it in this district, not only in Burton Cliff, but underlying the Inferior Oolite of Chideock Hill, of Poorstock, and of Stoke Knap, near Broad Windsor.

Only the highest nodules of the sands are fossiliferous, and the uppermost tier of all is a persistent bed of sandstone, containing much lime and densely charged with the casts of Ammonites and other shells. Under Burton Cliff, on the occasion of a visit thither in the company of my friends Dr. Wright† and Robert Etheridge, Esq., we found the bed of stone here mentioned still attached to the base of the limestone containing *Ammonites Humphriesianus*, Sow.; the zone of *A. Murchisonæ*, Sow., being here absent. In the other localities above given, I have found the same bed underlying the zone last mentioned, the absence of which, in Burton Cliff, appears to be the exception in this district.

7. *Generalized Section*.—With the last section ends my description of the lithological characters of the Middle and Upper Lias of this coast, which divisions I have thus traced, from the first appearance of the lower, in the cliffs of Black Ven, to the point of disappearance of the upper, near the village of Burton-Bradstock.

I now propose to condense these several sections into one generalized diagram, in which I shall endeavour to point out how the fossils are distributed through the successive beds of varying lithological character.

Commencing from below, there is first a great mass of marls containing more or less persistent beds of limestones, or limestone-nodules, but all without a trace of mica. This mass, nearly 200 feet in thickness, as seen in Westhay Cliffs, is terminated by a deposit of lime, sand, and mica, forming the "Three Tiers." Over this

* See Quart. Journ. Geol. Soc. vol. xii. p. 292, and vol. xvi. p. 3.

† I have to thank Dr. Wright, with whom I first visited some of the sections described, for his kindness in determining many specimens, which I submitted to him, illustrative of these strata.

is a series, 180 feet thick, of grey marls, which are micaceous, but without sand. Capping these, in Down Cliffs, is the Starfish-bed, above which begin the Middle Lias Sands; at first these are very argillaceous, but higher up, and over the intercalated band of blue marl, they become more purely siliceous. This mass of sand, above and below the band of marl, is altogether 170 or 180 feet in thickness. A great clay-deposit next succeeds, the lower 20 feet of which belong to the Middle, and the remaining 70 feet to the Upper Lias; the boundary of the two divisions, as I before explained, being discoverable in an intercalated band of stone. Over the clay-deposit, I include in my section some 150 feet or more of siliceous sands, densely charged with nodules, the highest tiers of which are slightly calcareous, and capped by a solid bed of stone containing also some proportion of carbonate of lime. These latter, the Cephalopoda-beds, underlie another formation.

§ III. *Distribution of the Organic Remains.*

1. *The Belemnite-beds.*—The lower portion of the great mass of marl without mica includes these beds, in some of which Belemnites occur more abundantly than in any other bed of the Lias; in the words of De la Beche, “seams composed of little else than their remains are seen on ledges, dry at low tide, at the foot of the Golden Cap.” The lowest portions of these beds contain chiefly the *Belemnites longissimus*, Miller, but in the higher ones many species are intermingled; and it is more especially these higher beds, immediately underlying the Belemnite-stone, and that band itself, which deserve attention. In the beds below, excepting Belemnites, fossils in a recognizable form are rare; compressed Ammonites and their impressions are abundant, but not in a state to be of much service to the palæontologist. I cannot therefore pretend to give any precise information as to the characteristic Ammonite of this zone. I believe, however, that fragments of *A. Henleyi*, Sow., do occur throughout it. In the Belemnite-shales and -stone, however, there is an abundance of recognizable fossils. The only place where anything like a full and speedy insight into the contents of these beds can be obtained is on the beach between the Golden Cap and Seatown when a favourable wind has cleared away the shingle which generally conceals them. *Belemnites elongatus*, Miller, is, perhaps, the most common form. Another very frequently occurring species is *B. clavatus*; but I suspect that some, at least, of the specimens known by this name are only the young of other species. *B. longissimus*, Miller, is also a form of frequent occurrence. Of other varieties there would appear to be many; but, in the present state of our knowledge regarding these fossils, I may be excused from venturing on further determinations. One fossil, however, found in the stone, calls for special investigation. I allude to the fossil figured and described by De la Beche (Geol. Trans. 2nd series, vol. ii. pl. 4. fig. 4) as an *Orthoceras* *. My specimens indicate that it is more closely

* In his ‘Report,’ p. 224, De la Beche records it again as “*Orthoceratites? elongatus*.”

allied to the Belemnite,—De la Beche's determination having been founded, as his figure shows, upon a very imperfect specimen. Allied though it be to the Belemnite, yet I think that it must be looked upon as generically different, since it not only differs in the outward form, but also in the internal structure of the guard. The very elongated proportions of the phragmacone also differ from any that I have seen associated with true Belemnites*.

In these layers of shale there are also considerable numbers of *Rhyncholites*, which are assigned by local collectors to the animal of the Belemnite. As they differ considerably from those of the *Nautilus* found in the Lower Lias, I am inclined to think that the local assignment of these to the dibranchiate Cephalopods may be correct; but more evidence is required upon this point.

Associated with the above remains occur very many Ammonites and Nautili. Amongst the former are large and crushed specimens of *A. fimbriatus*, Sow., old and young specimens of *A. Bechei*, Sow., and occasionally one of *A. Loscombii*, Sow.; this is likewise the chief horizon of *A. Henleyi*, Sow., which however occurs also in the overlying marls. Many forms of small pyritized Ammonites are found in these beds, and several species of *Nautilus* are also to be met with herein.

Gasteropodous shells are common, the most frequent species being the *Trochus Gaudryanus*, D'Orb., and *Pleurotomaria expansa*, Sow. sp. Amongst the Conchifera, *Crenatula ventricosa* and *Nucula variabilis* (?) are the most abundant forms. Brachiopoda are likewise abundant, but so crushed and deformed as to render identification difficult. Upon a specimen of *Ammonites Henleyi* in my possession, from these beds, there is a numerous colony of very small *Cranix*; and in several other instances I have observed the same form upon fragments of the same species of Ammonite, as likewise upon a specimen of *Ammonites Bechei* from the beds above.

Of the Vertebrata, good specimens of both Saurians and Fish have, I am told, been obtained from these beds, though I have been unable to find any authentic specimens. The Saurian of which bones are most frequently found is the *Ichthyosaurus tenuirostris*, Conyb.; *I. communis*, Conyb., also occurs. Both of these species are likewise met with far down in the Lower Lias.

Of Fish, I have seen fragments of the genus *Echmodus* from these beds.

Pentacrinus basaltiformis, Miller.
Terebratula numismalis, Lam.
Rhynchonella.
Cranix, upon *Ammonites Henleyi*.
Crenatula ventricosa, Sow.
Hinnites velatus, Goldf.

Plicatula spinosa, Sow.
Pecten, several species.
Cucullæa.
Nucula variabilis (?), Sow.
Pleurotomaria anglica, Sow.
 — *expansa*, Sow.

* Since writing the above, I have been fortunate enough to obtain the pen of the creature, associated with the phragmacone and guard. This not only fully corroborates my supposition that the animal was generically different from the Belemnite, but presents us with an unknown and extraordinary modification of pen-structure, which Professor Huxley has kindly undertaken to explain in a description of the new fossil.

Trochus imbricatus, Sow.
 — *Gaudryanus*, D'Orb.
 Turbo.
Chemnitzia Periniana, D'Orb.
Ammonites Bronnii, Röm.
 — *furticarinatus*, Quenst.
 — *Nodotianus*, D'Orb.
 — *Grenouillouxi*, D'Orb.
 — *Henleyi*, Sow.
 — *Bechei*, Sow.
 — *laticostatus*, Sow.
 — *Loscombii*, Sow.
 — *fimbriatus*, Sow.
 And several undetermined species.

Nautilus inornatus, D'Orb.
 — *semistriatus*, D'Orb.
Belemnites clavatus, Blainv.
 — *longissimus*, Miller.
 — *elongatus*, Miller.
 — *acuarius*, Schloth.
 — *brevirostris*, D'Orb.
Rhyncholites.
Xiphoteuthis Bechei, Huxley, MS.
Geoteuthis, sp.
Echmodus.
Ichthyosaurus communis, Conyb.
 — *tenuirostris*, Conyb.

2. *The Green Ammonite-beds*.—These beds, and the higher portion of the non-micaceous marls, contain an assemblage of fossils having many species in common with the beds below. Peculiar to them amongst the Cephalopoda are *Ammonites laticostatus*, Sow., and its aged and extraordinary variety *A. heterogeneous*, Y. & B. (*A. hybridus*, D'Orb.), a species locally known as *A. brevispina* (but not of Sowerby, nor yet I think a mere variety of *A. laticostatus*), and *A. Davcei*, Sow., which is one of the most scarce Ammonites of our locality.

Inoceramus, n. sp.
Chemnitzia Carrucensis, D'Orb.
Pterocera liasina, D'Orb.
Acteonina, sp.
Straparollus, sp.
Ammonites Bechei, Sow.
 — *Loscombii*, Sow.
 — *laticostatus*, Sow.
 — *heterogeneous*, Y. & B.

Ammonites Davcei, Sow.
 —, sp.
Nautilus semistriatus, D'Orb.
Belemnites compressus, Voltz.
 — *longissimus*, Mill.
Aptychi of Ammonites.
Ichthyosaurus.
Plesiosaurus.

3. *The Three Tiers*.—These beds are very unfossiliferous, especially in the Golden Cap. The bones of Saurians are, however, occasionally met with, as also Belemnites and the casts of phragmites, and occasionally an impression or fragment of *Ammonites margaritatus*, *A. Loscombii*, or of *A. fimbriatus* occurs in some of the blocks.

In the marls over them traces of but few fossils are seen, until we come to the layer of small nodules, which contain Ammonites of several species, and other shells. The shelly mudstone above contains, as far as I can judge, the same forms as occur again in the Shell-bed.

4. *The Shell-bed*.—This bed underlies the Starfish-stone, and in it I have found a rich collection of Mollusca, chiefly Conchifera. The only two species of Ammonites which I have obtained from it are *A. margaritatus* and *A. Thouarsensis*, D'Orb. One or two species of Belemnites complete the list of Cephalopoda. Some small species of *Pleurotomaria*, *Trochus*, and *Chemnitzia* occur not unfrequently; but the most abundant shells are those peculiar to this zone, which extends from the small nodules to the Starfish-stone. Numerous genera are represented, as the accompanying list shows. Fragments

of *Pentacrinus* and the spines of *Cidaris* contribute largely to make up the bed. *Cidaris Edwardsii*, Wright, a species very frequent in the Lower Lias, occurs here.

Pentacrinus Johnsonii, Austin.
Cidaris Edwardsii, Wright.
 Crania.
Terebratula cornuta, Sow.
 — *numismalis*, Lam.
Rhynchonella furcillata, Theod.
Avicula novemcosta, Brown.
Lima pectinoides, Sow.
Hinnites velatus, Goldf.
 Modiola.
Hippopodium, young.
Cucullæa elongata, Sow.
 — *inaequivalvis*, Goldf.
 — *cancellata*, Phill.
Sanguinolaria vetusta, Phill.
Cardinia, sp.
Pholadomya, sp.

Nucula aurita, Quenst.
Unicardium cardioides, Phill.
Lucina.
Astarte.
Pullastra.
Venus pumila?, Oppel.
Isocardia.
Pleurotomaria anglica, Sow.
 — *araneosa*, Desl.
 — *expansa*, Sow.
Nerinea.
Cerithium.
Chemnitzia.
Ammonites Thouarsensis, D'Orb.
 — *margaritatus*, Montf.
Belemnites clavatus, Blainv.
 Teeth of *Hybodus*.

5. *The Starfish-bed*.—Besides the *Ophioderma Egertoni*, Broderip, this stone affords a closely allied species, or variety, *O. tenuibrachiata*, Forbes. These Echinoderms are collected, as I have already stated, from the under side of the large blocks; in reality the layer beneath which they occur is but a portion, a few inches thick, of the entire stone, and this portion is a more pure sandstone than the part above. As far as one can judge, the thin deposit of purer sand is as local as the occurrence of the imbedded Starfish, and hence the two phenomena appear attributable to the same cause. This consideration, the peculiar situation of the Echinoderms, and the positions in which they occur in the stone, lead me to imagine that we have in this case a true instance of a sudden and accidental deposit and destruction of life, in contradistinction to the gradual and regular mode in which most geological masses were accumulated.

6. *The Grey and Brown Sands with Nodules*.—In these we find here and there a considerable number of organic remains; in some places, lumps composed chiefly of the joints of the stems and arms of *Pentacrinus Johnsonii*, Austin; in others, masses of *Rhynchonellæ* of small size. Intermingled with these are small Gasteropoda and Conchifera, together with fragments of larger shells. The latter, such as *Gryphæa Maccullockii*, Sow., and *Pecten æquivalvis*, Sow., occur very perfect and fine in these sands. *Plicatula spinosa*, Sow., which is found in every collection of fossils from the Belemnite-beds upwards, is here abundant and fine.

In the topmost layer of the nodules, or the "*Margaritatus-stone*," *Ammonites margaritatus* occurs very large, and occasionally well preserved; as is also *A. fimbriatus*, with which it is associated. From the overlying blue marl I have scarcely seen a fossil, so that I cannot say whether it belongs palæontologically to the sands below or to those above.

Terebratula cornuta, Sow.
 — *quadrifida*, Lam.

Rhynchonella tetrahedra, Sow.
Lingula Beanii, Phill.

Crania, sp.
Gryphæa Maccullochii, Sow.
Avicula novemcosta, Brown.
Lima, sp.
Plicatula spinosa, Sow.
Pecten æquivalvis, Sow.

Chemnitzia, sp.
Nautilus semistriatus, D'Orb.
Ammonites fimbriatus, Sow.
 — *margaritatus*, Montf.
 Fragments of Crustacea.

7. *The Brown Sands and Sandstones*.—In these, masses of fossils occur, chiefly collected from the outside of the blocks of sandstone. *Ammonites spinatus*, Brug., is now the characteristic Ammonite, and with it are associated some peculiar *Phasianella* and the magnificent *Pinna Hartmanni*. I have two crushed fragments of *Ammonites Bechei* from this zone, and one of *Nautilus semistriatus*, D'Orb.

Ammonites spinatus, Brug.
 — *Bechei*, Sow.
Nautilus semistriatus, D'Orb.
Belemnites, sp.
Phasianella, two species.

Pinna Hartmanni, Ziet.
Goniomya rhombifera, Quenst.
Avicula, sp.
Pecten, sp.
Plicatula spinosa, Sow.

In the 18 feet of clay over the sands I have found no fossils.

8. *The Marlstone with its Pleurotomaria-bed*.—These beds amply atone for the poverty of the bed beneath. *Ammonites spinatus* is still the characteristic Ammonite, occurring here in great variety. Associated with this most variable and truly Middle Lias form I have obtained specimens of several Upper Lias Ammonites, such as *A. communis*, Sow. and its several closely allied forms, *A. radians*, Schlotheim, and even *A. serpentinus*, Rein.; the first-named species, though not so plentiful, is represented by far larger individuals than in the Upper Lias stone itself. Beautiful as are the Ammonites of this bed, the Gasteropoda are still more remarkable. They are most perfectly preserved, but, owing to the character of the matrix, they are very difficult of extraction. My list, as given below, includes many species of *Pleurotomaria* and *Trochus*, with several of *Turbo*, *Straparollus*, *Phasianella*, *Chemnitzia*, &c. Amongst these are included many of those beautiful shells, figured and described by Deslongchamps and D'Orbigny, from the Middle and Upper Lias of Calvados. Nor are the Conchifera much less remarkable, though even fewer good specimens are obtainable. Many appear to be undescribed species, whilst some are forms but rarely met with; such are *Sanguinolaria cuneata* and *S. vetusta*, figured by Professor Phillips from the Yorkshire coast.

The shells and the pebbles of the conglomerate are coated with *Serpula*, and the water-worn stones are perforated by *Lithodomi*.

Brachiopoda are also well represented. *Spirifera Walcottii*, Sow., and *S. rostrata*, Schloth., occur, though rarely. *Terebratula Edwardsii*, Dav., is common, and *T. subpunctata*, Dav., very fine. Several other Marlstone species are represented: *T. resupinata*, Sow., however, which is common in this zone in many localities, is here altogether absent; *T. cornuta*, Sow., elsewhere abundant, is here scarce, being apparently replaced by its variety *T. quadrifida*, Lam., which latter here appears also to have attained to a greater size than elsewhere in England, thus approaching to its Continental types. *Rhynchonella serrata*, Sow., rare elsewhere, is here not uncommon.

Nor is this bed, so valuable in the abundance of its palæontological evidence, less suggestive of physical facts. The thin and interrupted bed which I consider to be the representative of the Marlstone, the pebbles and small boulders imbedded therein, the perforations of the *Lithodomi*, the masses of shells here and there collected into hollows, as it were, of the underlying rock, the *Serpulæ* covering the shells and pebbles, and the very intermixture of Upper Lias species, all point to a sea-bottom upon which, for a long period, little or no deposit took place; the water-worn fragments which lie upon it, on the contrary, indicating that, during that period, previously formed strata were again destroyed. From what I have seen of the junction of the Middle with the Upper Lias, both here and at Glastonbury in Somersetshire, I have been led to believe that, immediately previous to the deposition of the Upper Lias, some disturbing cause for a time changed the direction of the currents which had brought here the mud and sand of the Lower and Middle divisions, and that, in place of continuing gently to lay down these deposits, the action of the water was for a time, and over certain districts, confined to the destruction of beds previously formed and consolidated*.

Serpula, two species.

Apiocrinites ?

Pentacrinus ?

Holæctypus hemisphæricus, *Desor*.

Thecidea Moorei, *Dav*.

Terebratula punctata, *Sow*.

— *subpunctata*, *Dav*.

— *numismalis*, *Lam*.

— *quadrifida*, *Lam*.

— *Moorei*, *Dav*.

— *cornuta*, *Sow*.

— *Edwardsii*, *Dav*.

Rhynchonella tetrahedra, *Sow*.

— *serrata*, *Sow*.

— *subconcinna*, *Dav*.

— *furcillata*, *Theodor*.

— *Moorei*, *Dav*.

— *cynocephala*, *Richard*.

— *acuta*, *Sow*.

Spirifera rostrata, *Schloth*.

— *Walcottii*, *Sow*.

Lingula, sp.

Perna, sp.

Lima punctata, *Sow*.

— *antiquata*, *Sow*.

Pecten dentatus, *Sow*.

— *textorius*, *Schloth*.

—, sp.

Hinnites velatus, *Goldf*.

Gryphæa Maccullochii, *Sow*.

Gryphæa gigantea, *Sow*.

Myacites unionides, *Goldf*.

—, two other species.

Mytilus, sp.

Modiola, several species.

Goniomya, sp. (*aspera*, *Etheridge, MS.*).

Isocardia, sp.

Cypricardia, sp.

Ceromya, sp.

Cardinia concinna, *Stutchb*.

— *cuneata*, *Stutchb*.

— *Listeri*, var. *hybrida*, *Stutchb*.

Cardita, sp.

Unicardium cardioideum, *Phill*.

Sanguinolaria vetusta, *Phill*.

— *cuneata*.

Mytilus hippocampus, *Y. & B*.

Cardium truncatum, *Sow*.

—, sp. (*Dayii*, *Etheridge, MS.*).

Area, sp.

Cucullæa inæquivalvis, *Goldf*.

Pholadomya ambigua, *Sow*.

Lithodomus, sp.

Trochus Gaudryanus, *D'Orb*.

— *monoplicus*, *D'Orb*.

— *epulus*, *D'Orb*.

— *Emylius*, *D'Orb*.

— *Eolus*, *D'Orb*.

— *Mariae*, *D'Orb*.

* Since the above passage was written, I have found a notice of this bed, which I had previously overlooked, in a paper by Buckland and De la Beche, "On the Geology of the Neighbourhood of Weymouth, &c." It shows clearly to what formation these beds were in those days assigned, and that the conglomerate-bed and its meaning had been studied years ago by those eminent observers. (See *Geol. Trans.* 2nd ser. vol. iv. p. 31.)

Turbo Itys, *D' Orb.*
 — Nireus, *D' Orb.*
 — Midas, *D' Orb.*
 Pleurotomaria mirabilis, *Desl.*
 — precatoria, *Desl.*
 — bitorquata, *Desl.*
 — sulcosa, *Desl.*
 — rustica, *Desl.*
 — procera, *D' Orb.*
 — pinguis, *D' Orb. (?)*
 — rostriformis.
 — expansa, *Sow. sp.*
 Straparollus sinister, *D' Orb.*
 —, *sp.*
 Phasianella, two species.

Turritella, two species.
 Chemnitzia, *sp.*
 Pitonillus, *sp.*
 Ammonites crassus, *Phill.*
 — communis, *Sow.*
 — Holandrei, *D' Orb.*
 — spinatus, *Brug.*
 — fimbriatus, *Sow.*
 — serpentinus, *Rein.*
 — radians, *Rein.*
 — Raquinianus, *D' Orb.*
 Belemnites, several species.
 Ancyloceras, *sp.*
 Fish-scales and fragments of Crustacea.

9. *The Upper Lias Limestone.*—In the lower part of the Upper Lias Limestone, that is, immediately over the ferruginous seam, I have found *Ammonites serpentinus*, *Rein.*, in some abundance, though badly preserved.

In the upper part of the same stone occurs *Ammonites bifrons*, *Brug.*, which I have not met with below, associated with several other Upper Lias species of Ammonites, Gasteropoda, and Brachiopoda.

Terebratula, a small species.
 Rhynchonella Bouchardii, *Dav.*
 — Moorei, *Dav.*
 Leptæna liassina, *Bouchard.*
 Crania, *sp.*
 Cardinia, *sp.*
 Astarte elegans, *Sow.*
 Trochus trimonilis, *D' Orb.*
 — Ægion, *D' Orb.*

Ammonites bifrons, *Brug.*
 — Raquinianus, *D' Orb.*
 — radians, *Rein.*
 — communis, *Sow.*
 — serpentinus, *Rein.*
 — complanatus, *Brug.*
 — Holandrei, *D' Orb.*
 Nautilus, *sp.*

In the Upper Lias Clay I have found no fossils, and it may be observed that I have not met with any trace of the fish-bed of Ilminster and Dumbleton in our series of beds.

10. *The Cephalopoda-beds.*—The lower and greater portion of the Upper Lias sands have afforded me no fossils, excepting a few impressions of *Ammonites radians*; but in the topmost part, or Cephalopoda-beds, I have found several species of Ammonites. *A. Jurensis*, *Ziet.*, *A. opalinus*, *Quenstedt*, and *A. variabilis*, *D' Orb.*, are all forms assigned to the 'Jurensis-stage' of Continental geologists, and the fossils of other classes associated with these Ammonites all belong rather to the Upper Lias than to the Inferior Oolite.

Ammonites Jurensis, *Ziet.*
 — variabilis, *D' Orb.*
 — opalinus, *Quenst.*
 Nautilus latidorsatus, *D' Orb.*
 Belemnites, two species.
 Myacites unionides?, *Goldf.*

Goniomya, *sp.*
 Pecten barbatus, *Sow.*
 Terebratula, *sp.*
 Rhynchonella tetrahedra?, *Sow.*
 — cynocephala, *Richard.*

11. *Conclusion.*—If we now review the chief features of the different lists of fossils given above, we shall be able to obtain a better idea of the vertical distribution of particular forms (see fig. 5).

To begin with the Ammonites. These, with some exceptions, have more or less restricted ranges, and in no case does the range of an Ammonite equal that of some of the most widely distributed Con-

chifera. *Ammonites Henleyi*, Sow., *A. laticostatus*, Sow., and several other species characterize the Belemnite-beds and some of the beds immediately above them. *Ammonites Davcei*, Sow., occurs only in the Green Ammonite-beds, in the uppermost layer alone of which is found the form locally known as *A. brevispina*. *A. margaritatus*, Montf., appears with the sand and mica in the "Three Tiers," and disappears again with a deposit of marl; its place is, however, on the recurrence of sand, supplied by a closely allied form, *A. spinatus*, Brug. This species is succeeded by *A. serpentinus*, Rein., and that again by *A. bifrons*; after which is a wide gap assignable to no particular form. Above this interval *A. Jurensis* occurs, underlying the zones of the Inferior Oolite. But though these and most Ammonites have their zones well marked and restricted, it is not so with all. For instance, *A. Loscombii* appears with *A. Henleyi*, abounds with *A. laticostatus*, and goes some way up into the range of *A. margaritatus*, where it makes its last appearance in the layer of small nodules below the shelly marl. It thus passes through most of the grey marls, but does not reach to the permanent appearance of the sand. *A. fimbriatus* and *A. Bechei* are still less restricted, the latter appearing in the Belemnite-beds, and showing itself, in occasional specimens, as far up as the sands of the 'Spinatus-zone'; the former ranging still more widely, from the same starting-point up to the very summit of the Middle Lias. These forms are thus found not only in strata some hundreds of feet apart, but in the highest and lowest of a series of at least four of the more restricted ranges.

But if the ranges of the Ammonites are not very limited, neither I apprehend are those of some of the other Cephalopoda; *Nautilus semistriatus* I find ranging coextensively with *Ammonites Bechei*, and I cannot distinguish some of the Belemnites of the Marlstone from those of the Belemnite-beds.

In the Gasteropoda and Conchifera we find the vertical ranges of several species of very various extent; but they do not appear to me to coincide so much with the distribution of particular Ammonites as with other accidental circumstances. The Conchifera of the Belemnite-beds occur also in the Green Ammonite-marls, but not in the shell-bed under the sand, excepting such a ubiquitous form as *Plicatula spinosa*, Sow. Some of the Gasteropoda, on the other hand, occur also in the Pleurotomaria-bed associated with *Ammonites spinatus*.

The Shell-bed under the Starfish-bed has, as I have said before, many forms peculiar to a zone lying above the frequently mentioned "layer of small nodules" and below the sands, but many of its species occur again above, and these are represented by far finer specimens in the sands. It would thus appear that *Ammonites margaritatus* occurs in two faunas, which, though blending together at their junction, are yet very distinct. In the lower part of the 'Spinatus-zone' there appears to be a different fauna from that of the sands below, and in its upper portion occurs the most remarkable collection of Mollusca of any in the Lias. Along with many new and curious forms are others that I have observed in some one or other of the Middle Lias beds below. And yet, with all the diversity in the extent

of the various ranges, we cannot help feeling surprised at meeting here with species that occur far down in the Lower Lias. Such however are, amongst others, *Lima punctata*, Sow., *Lima pectinoides*, Sow., *Cardinia hybrida*, Stutchb., and *Spirifera Walcottii*, Sow., all of which I have myself found in the 'Angulatus-beds' to the west of Lyme. What makes the appearance of these forms so high up the more remarkable is that I have not found them in intermediate strata. The few fossils that I have cited from the Upper Lias and the Cephalopoda-beds do not justify any observations beyond those I have already made—at least, not on the present occasion.

The higher forms of life—fish and reptilia—occur so sparingly in our Middle Lias, that in these likewise there are no materials upon which to generalize.

The questions which arise upon the facts of the distribution of fossils, as herein given, are to my mind of the greatest interest and importance. It would be impossible, however, to treat of such questions in a satisfactory manner without extending my observations beyond the scope of the present paper. In a future communication I hope to lay before the Society some speculations upon the history of the Lias, which have originated in a consideration of the distribution of inorganic materials and organic forms throughout that formation in this district. The details into which I have entered in this paper have been for the purpose of describing some of the less-known facts upon which I have based my theoretical views.

I cannot conclude this paper without expressing my obligations to my friend Robert Etheridge, Esq., F.R.S.E., F.G.S. The sections which he had made, and the knowledge which he had acquired upon the spot before I began my work, he kindly placed at my disposal for reference and comparison; the many fossils which I have entered on my lists have all been submitted to his examination; and before I completed my paper, he kindly went over the various sections with me, so as the more authoritatively to give me the support of his judgment as to the correctness of my measurements and descriptions.

MARCH 4, 1863.

Francis Drake, Esq., Leicester; Il Commendatore Devincenzi, Member of the Italian Parliament, Ministry of Agriculture and Commerce, Turin; Cav. C. Perazzi, Royal Corps of Mining Engineers, Turin; O. C. Marsh, Esq., M.A., 14 Linkstrasse, Berlin; and John Watson, Esq., Whitby, were elected Fellows.

The following communication was read:—

1. *On the PERMIAN ROCKS of NORTH-EASTERN BOHEMIA.* By Sir RODERICK I. MURCHISON, K.C.B., F.R.S., F.G.S., &c., Director-General of the Geological Survey of the United Kingdom.

Lithological Characters.—The Permian rocks of Bohemia differ from those of North-western Germany in not comprising a calcareous