PROCEEDINGS

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CONTENTS.

VOL. IV.

SESSION 1842–1843.

1843–1844.

1844–1845.

LIST OF THE FOSSILS FIGURED IN THIS VOLUME.

* The following abbreviations are made use of:—Carb., Carboniferous series; Cret., Cretaceous; and L. G. S., Lower Greensand.—Eocene, f. w. signifies Freshwater beds of the older Tertiary period.

Name of Species.	Formation.	Locality.	Page.
	Mollusca.—*Conchifera.*		
Inoceramus lunatus. Edw. Forbes..	Cret.	Santa Fe	396
Lima reticulata. Lyell and Edw. Forbes	Cret.	New Jersey, U. S.	308
Ostrea subspatulata. Lyell and Sowerby	Cret.	N. Carolina, U. S..........	307
Terebratula Vanuxemiana. Lyell and Edw. Forbes	Cret.	New Jersey, U. S.	308
—— *Wilmingtonensis.* Lyell and G. Sow.	Eocene	Wilmington, N. Carolina, U. S.	565
	Mollusca.—*Gasteropoda.*		
Bulla Mortoni. Lyell and Edw. Forbes. (A cast.)	Cret.	New Jersey, U. S.	309
Cerithium Georgianum. Lyell and G. Sow.	Eocene	Jacksonboro', Georgia, U. S.	573
Melania Hamiltoniana. Edw. Forbes	Eocene, f. w....	Vourla, Smyrna	380
—— *sp.* (Cast)	Eocene, f. w....	Jacksonboro', Georgia ...	573
Natica sp. (Cast)	Cret.	New Jersey, U. S.	309
Oliva sp. (Cast)	Eocene	Wilmington, N. Carolina, U. S.	565
Paludina Stricklandiana. E. Forbes	Eocene, f. w....	Vourla, Smyrna	380
—— *sp.* (Cast)........................	Eocene, f. w....	Wilmington, N. Carolina, U. S.	573
Planorbis Spratti. Edw. Forbes...	Eocene, f. w....	Vourla, Gulf of Smyrna...	380
Tornatella sp. (Cast)	Cret.	New Jersey, U. S.	309
Voluta. (Casts of 3 species)	Cret.	New Jersey, U. S.	309
	Mollusca.—*Cephalopoda.*		
Ammonites Bogotensis. E. Forbes..	Cret.	Santa Fe	395
—— *Buchiana.* Edw. Forbes......	Cret.	Santa Fe	394
—— *Hopkinsi.* Edw. Forbes......	Cret.	Santa Fe	393
—— *Inca.* Edw. Forbes	Cret.	Santa Fe	394
—— *Leai.* Edw. Forbes	Cret.	Santa Fe	395
Ancyloceras Humboldtiana	Cret.	Santa Fe	392
Hamites Orbignyana. Edw. Forbes	Cret.	Santa Fe	392
	Fishes.		
Aspidorhynchus euodus. Egerton. (Part of jaw.)	Oxford Clay ...	Christian Malford.........	438
Corax incisus. Eg. (Tooth.)	Cret.	Pondicherry	385
—— *pristodontus.* (Tooth.)	Cret.	Pondicherry	384
Cyclobatis oligodactylus. Egerton. Pl. 9	Eocene	Lebanon	442
Hybodus basanus. Egerton. (Mouth.) Pl. 8	L. G. S..........	Isle of Wight	414
Lamna complanata. Eg. (Teeth.)	Cret.	Pondicherry	387

MAMMALIA.

EXPLANATION OF THE PLATES.

The Binder should be instructed to pay particular attention to the directions here given concerning the arrangement of the Plates. It will be found convenient to alter with the pen the numbers engraved in the Plates, to correspond with their position in this volume.

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* This Map, though published long after the abstract of the paper, is now inserted in its right place. The small Maps of Cape Breton are referred to at page 280.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY OF LONDON.

Vol. IV. Part I. 1842—1843. No. 92.

Nov. 2.—Josiah Rees, Esq., was elected a Fellow of this Society.

A paper was read, "On the Geology of the Western States of North America." By David Dale Owen, M.D., of Indiana.

The remarks of the author relate chiefly to that part of the western states watered by the rivers Ohio, Wabash, Illinois, Rock, Wisconsin, Cumberland, and Tennessee, lying between 35° and 43° of north latitude, and 81° and 91° of west longitude. It includes the States of Illinois, Indiana, Ohio, Kentucky, Tennessee, and the Dubuque and Mineral Point districts of the territories of Jowa and Wisconsin. The observations recorded are the results of numerous excursions in those provinces, commenced in the year 1834, and continued to the present time by Dr. Owen, sometimes alone, at others accompanied by Dr. Troost and Dr. Locke, the state geologists respectively of Tennessee and Ohio. Though the territory under consideration occupies an area of about half a million of square miles, its geological features are remarkably uniform. With a few partial exceptions its formations belong to the eras of the bituminous coal, the mountain limestone of Europe, and the Silurian rocks of Murchison. The exceptions are the superficial deposits which occasionally cover these up from view, over considerable districts, and which themselves must be referred to the age of the gigantic mammalia and formations of a still more recent date; together with a marl and greensand in the western district of Tennessee, corresponding probably to the greensand and other members of the cretaceous group.

Of the tract described, the formations west of the Tennessee river occupy but a small corner, and the author has had but limited opportunities of examining them in person. The upper part of this group is an argillaceous marl of a light grey colour; the lower (of unascertained thickness) a greenish sandy marl. In no instance, as far as known to the author, has either the greensand or marl been discovered east of the Tennessee river. But it exists, according to Dr. Troost, under the superficial soil in most of the countries west of that river, extending probably west and south, into the states of Missisippi and Alabama. Both the marl and greensand are rich in fossils. In the former the most characteristic shell is the *Exogyra*. Though it is evident, from the character of the fossils imbedded in the marl and greensand beds, that these belong to the cretaceous group, yet hitherto no true chalk has been discovered in Tennessee, nor, so far as I know, in any of the United States.

In the territory described are two coal-fields of great extent. On the west is the great Illinois coal-field, equalling in area the entire island of Great Britain, occupying the greater part of Illinois, about one-third of Indiana, a north-western strip of Kentucky, and extending a short distance into Jowa. It is covered on the north by extensive diluvial deposits, sometimes to the depth of more than a hundred feet. The other coal-field forms a part of at least six states, viz. Ohio, Kentucky, Tennessee, Pennsylvania, Maryland, and Alabama; and its area is estimated at 50,000 square miles. These coal formations consist, as in Europe, of sandstones, shale, slaty clays, seams of coal, and occasionally beds of limestone, these latter usually dark-coloured and bituminous. At the base of the Ohio formation is a conglomerate from 200 to 300 feet in thickness, which has been referred to the millstone grit of England. A similar conglomerate shows itself in one or two localities at the base of the Illinois coal-field.

The thickness of these coal-fields is estimated at from 1200 to 2000 feet. All the coal is of a bituminous character, some of the caking variety, some splint coal, some cannel. Neither of the coal-fields have suffered much from dislocation; no dykes of trap, whinstone, basalt, or greenstone have been met with in either. On the eastern flank, however, of the Cumberland mountains, the coal is occasionally much disturbed, even thrown up nearly vertically. There is a striking analogy between the fossil flora of these western coal-fields and that of the equivalent strata in Europe. The most productive brines discovered in the western states have been procured by boring through the lower members of the coal measures. Immediately below the coal-formations of Indiana, Illinois, Kentucky, and Tennessee, are limestones mostly of a light grey colour and of a compact texture, including occasionally layers and nodules of chert. Some of these limestones assume the appearance of lithographic stone, others present a beautiful oolitic structure. The strata vary in thickness; in Ohio it does not appear to exist, being replaced by the before-mentioned conglomerate. The great mammoth cave of Kentucky is in the upper beds of this limestone, which abound in subterraneous passages. These beds are characterized by two remarkable fossils, the *Pentremites* and the *Archimedes*, and Dr. Dale Owen has designated the group Pentremital limestones, from the abundance of those fossils. The oolitic stratum lies immediately beneath. No workable seam of coal has hitherto been found beneath the beds containing these fossils; *Productæ* and *Terebratulæ* are abundant in them, and a small species of *Calymene* occurs. Dr. Owen regards these limestones as the equivalent of the mountain limestone of Europe. Iron ores occur at the junction of the limestone and coal measures, and galena and fluorspar have been found in the former.

The rocks which succeed to the Pentremital limestone are grey, yellow, and brown siliceous sandstones, soft and fine grained, sometimes argillaceous and free from mica, passing on the one hand into chert and limestone, and on the other into a rock presenting the appearance of Tripoli: interstratified with these are beds of limestone, occasionally oolitic. This group is not rich in organic remains; *Crinoideæ, Polypiferæ* and *Productæ* are most common. The middle and lower beds of this group are regarded by Dr. Owen as probable equivalents of the upper Ludlow rocks.

We next in descending order arrive at a group of bituminous, aluminous shales and associate limestones, the lowest of which affords a valuable water cement. In the shale there are no fossils except a few slight impressions, apparently of seeds or seed-vessels. Where the shale is replaced by indurated clay, Dr. Troost has found Encrinites and Polypifera, and the "encrinital limestone" over the shale in Tennessee is rich in Crinoidea. *Atrypa prisca, Orthis lunata* vel *orbicularis, Terebra sinuosa, Calymene bufo,* and *Asaphus macrurus* occur in the water limestone. The shale, Dr. Owen considers, must probably be referred, as well as the water limestone, to the lower Ludlow, and may be regarded as the equivalent of the Helderberg group and Marcellus shales of the New York geologists. The *encrinital limestone* and the green *ferruginous* rock of Indiana may correspond with the Aymestry limestones.

Next in order is a group consisting almost wholly of compact limestones, lying in thick beds without any interstratified marls or shales. This rock is best developed towards the north-west, and in certain districts becomes a true magnesian limestone upwards of 500 feet in thickness. It closely approximates, both in lithological character, mineral contents, and even proximity to the coal measures, the "scar limestone" of England, and were it not for the organic remains might be mistaken for it. But, says Dr. Owen, the list of organic remains supplies proof hardly contestable, that the rocks in which they occur are equivalents of the Wenlock formation of Murchison. In the upper beds, *Catenipora escharoides* and *Pentamerus huspodus* are very abundant, with numerous other species recorded by the author in his memoir. In the lower hundred feet of this group fossils are scarce. Rich and important lead mines occur in it, the most valuable in the United States. The most characteristic fossil of the lead-bearing strata is the *Coscinopora*.

Next in order follow thin beds of shell limestone, alternating with marl and marlite, occupying a superficial area of about 10,000 square miles. The thickness of this group is greatest about the centre of the Ohio valley, where it is estimated at 1000 feet. In the north-west, at Prairie du Chien, it is but 100 feet, and near the Blue Mounds in Wisconsin, but a few feet in thickness; it abounds in organic remains. Among these are characteristic, *Isotelus gigas, Triarthrus Bechii,* several species of *Conotubularia,* and of *Bellerophon* and *Maclurites*; *Isotelus planus, Lingula Lewisii, Orthis excentrica, Orthis alata,* and *Asterias antiqua.* These fundamental rocks of the Ohio valley Dr. Owen considers the equivalents of the lower Silurian.

No inferior rocks are visible in a north-west direction until the vicinity of the Wisconsin river, where the blue fossiliferous limestone rests conformably on a sandstone succeeded by a magnesian limestone, with few and imperfect fossils, so that its proper place is doubtful. The blue limestone in the south-east, beyond the Cumberland mountains, rests unconformably on the inferior stratified rocks of Tennessee, which dip *towards* the granitic rocks. The author appends extensive lists of fossils.

An extensive series of rocks and fossils from the formations described, with beautiful diagrams in illustration of the memoir, were presented to the Society by Dr. Dale Owen at this meeting.

Nov. 16.—Albert Hambrough, Esq., of Steep Hill Castle, Isle of Wight, was elected a Fellow of this Society.

A paper was read " On the Structure of the Delta of the Ganges, exhibited by the Boring Operations in Fort William, A.D. 1836–40." By Lieut. R. Baird Smith, B.E.

Since the year 1804, a number of boring operations have been conducted in the Gangetic Delta, with a view to supply the deficiency of good fresh water in the vicinity of Calcutta, but, from mechanical obstacles, without success. The geological results of the last of these experiments, commenced in April 1836, and abandoned in 1840, after being carried on to the depth of 480 feet, are detailed by Lieut. Smith in this memoir. After penetrating to the depth of ten feet through the artificial surface soil, a bed of blue clay, close and adhesive in its texture, was entered. As the bore descended, the clay became darker in colour, till, in from thirty to fifty feet, large portions of peat, with decaying fragments of trees, were found. These Dr. Wallich identified with the common *Soondri* of the Sunderbunds, and the roots of some climbing tree resembling *Brædelia*. The stratum of peat and decayed wood was therefore formed from the debris of forests which at a former period covered the entire surface of the Delta, as the existing jungles of the Sunderbunds cover so large a portion of it now. In one instance bones were found in the peat, but they were unfortunately destroyed by the workmen before examination. Succeeding these peat-charged beds, a stratum of calcareous clay, ten feet in thickness, is found, and intermixed with it are portions of the concretionary limestone, commonly known in India as kankur, which Lieut. Smith regards as formed by the segregation of the particles of calcareous matter disseminated throughout the body of the clay with which it is associated, and as nearly contemporaneous in its origin with this clay. Underlying the bed of calcareous clay in which the kankur first occurs, there is a thin bed of green siliceous clay, extending from sixty to sixty-five feet in depth. The clay then loses its colour, and continues to a depth of seventy-five feet, the lower portion of it furnishing nodules of kankur. At seventy-five feet, a bed of variegated, sandy, or arenaceous clay commences, and continues to the depth of 120 feet, occasionally traversed by horizontal beds of kankur. Beneath this is a stratum of argillaceous marl, five feet in thickness; and succeeding it there is a bed only three feet in thickness, of loose friable sandstone, the particles of sand being held loosely together by a clayey cement. Argillaceous marl, twenty feet in thickness, follows the sandstone, terminating at the depth of 150 feet, when it passes into an arenaceous clay, intermixed with water-worn nodules of hydrated oxide of iron. Weathered mica slate is found attached to the clay of this bed, and throughout the entire range of strata penetrated, scales of mica have always been abundantly met with. At 175 feet, a coarse friable quartzose conglomerate occurs, composed of pebbles of different sizes, though none are very large, cemented together by clay. At 177 feet, this conglomerate becomes smaller grained; and at 183 feet 3 inches, it is found to pass into indurated ferruginous clay, which continues, with but little variation, to a depth of 208 feet. Here another layer of sandstone, soft in its upper portion, but becoming more indurated, and assuming the lamellar structure as it is passed through, occurs; the thickness being, however, no more than three feet. Ferruginous sand, with thin beds of calcareous and arenaceous clay, prevail from 208 feet to 380. Kankur, with minute water-worn fragments of quartz, felspar, granite, and other indications of debris from primary rocks, are met with in the lower parts of this sandy deposit, in which were also found three fragments of bones, of which one was considered by Mr. J. Prinsep to be the lower half of a humerus of some small quadruped like a dog, and another the fragment of the carapace of a turtle. At 380 feet, there occurred a thin layer, only two feet in thickness, of blue calcareous clay, thickly studded with fragments of shells; and at 382 feet, this was succeeded by a layer of dark clay, composed almost entirely of decayed wood. From the lower portion of it several fragments of coal, of excellent quality, were brought up. Underneath this stratum, and in the gravelly bed which immediately succeeds it, there were found several other fragments of fossil bones. One was considered to be a caudal vertebra of a kind of lizard, and the rest were fragments of turtles. These were discovered at the depth of 423 feet, and were associated with large rolled pebbles of quartz, both white and amethystine, felspar, limestone, and indurated clay. The gravel, composed entirely of the debris of primary rocks, continued to the depth of 481 feet, where the operations ceased.

The fossils recorded above, observes the author, were found in two distinct deposits, separated from each other by the interposition of a bed of shelly, calcareous clay and a deposit of carbonaceous matter ten feet in thickness, the remnants of some extensive forest which flourished at a period anterior to the deposit of the 380 feet of superincumbent sands and clays. The lithological characters of the superior and inferior fossiliferous deposits differ considerably from each other, the former being a fine and slightly indurated sandstone, the latter a coarse conglomerate, formed of the debris of primary rocks, imbedded in an arenaceous matrix. The fossils of the upper bed, which is about eighty feet in thickness, furnish the only specimens of mammalia obtained during the operations. These were associated with the remains of Chelonians, but no indications of the existence of saurian animals were discovered till the shelly clay and carbonaceous bed were passed through, and from the lower conglomerate no mammalia were obtained. In drawing any conclusions, however, the limited space examined, the diameter of which was not more than six inches, must be borne in mind.

Lieut. Smith remarks the correspondence of the succession of the strata in the Gangetic Delta, at a depth of from 350 to 480 feet, with that observed by Captain Cautley at the base of the Himalaya.

The nature of the fossil remains and the dimensions of the gravel found at 480 feet from the surface of the ground, the greatest depth hitherto attained, were such as to lead Dr. M'Clelland to the conclusion, that when these were originally deposited bold rocky mountains existed in close proximity to the present site of Calcutta; and taking his data from the results of personal observation on the transporting power of rapid currents, he estimates the distance of these mountains at not greater than twenty or thirty miles. Resting on the bed of coarse conglomerate, the entire depth of which is unknown, although it cannot be less than eighty feet, the bore having pierced it to that extent, there are beds of carbonaceous matter and lacustrine clay bearing the clearest evidence of having been quietly deposited on a marshy surface clothed with vegetation. Ere this could have taken place, the powerful currents indicated by the gravel must have been arrested, and as this could only be effected by a great lowering of the inclination of the bed of the river, we may infer the check arose from the entire subsidence of the range of hills above alluded to. The extent to which this took place it is impossible for us to estimate, but the deposits which the river continued to make would repose upon the depressed masses, and were boring operations to be carried on successfully in such localities they would ultimately expose these again to our observation. Supposing then, as without impropriety we may do, that the rocks of which these hills were composed stretched away beneath the conglomerate bed formed by the large gravel borne along by the torrent issuing from them, we are led to believe that had the Fort William boring operations been successfully carried through the entire depth of the conglomerate, the auger would then have impinged on the solid rock, and if so, would the experiment have terminated favourably?

"When we remember," observes Lieut. Smith, "that the conglomerate was almost entirely composed of debris from primary rocks, admitting of the inference that the chain of hills itself was formed of members of this series, there can be but little hesitation in replying in the negative."

"On Pipes or Sandgalls in Chalk." By Joshua Trimmer, Esq., F.G.S.

In a former paper (Proceedings, vol. iii. p. 185) the author described two detrital deposits in Norfolk, which appear to have been produced by powerful currents of water. The lowest of these is marked on the surface with numerous furrows and penetrated by cylindrical and funnel-shaped cavities like those of the chalk, though in general of smaller dimensions. If these have been caused by the mechanical action of water, they indicate a pause between the two deposits of sufficient duration to allow of the consolidation of the lower bed before the other was thrown down upon it. Therefore, to learn the true history of the beds, we must discover the cause of the pipes; the action is so similar in the chalk and the detrital deposits that the one will explain the other.

From recent study of the pipes or sandgalls in the chalk of a part of Kent, Mr. Trimmer has arrived at the conclusion that they are due to the mechanical, not to the chemical action of water; and that this action was the breaking of the sea on a low shore antecedent to the formation of the eocene strata. This opinion he bases on the following grounds.

Having had an opportunity of observing the removal of its covering from the chalk near Faversham, Mr. Trimmer found that the pipes were but the terminations of furrows from six to twenty-four inches deep in the shallowest parts exposed, but widening and deepening as they approached the pipes till they were lost in them.

The diluvial covering spread over the chalk is a strong loam of a reddish brown colour, with numerous unabraded flints dispersed through it. The pipes were filled with loam of a more sandy nature and of a much lighter colour. The few pebbles found in them consisted of chalk flints much water-worn, and contrasting strongly with the unabraded flints of the diluvium. Their sides were lined with clay, tinged black. The lower part of the diluvial deposit, near its junction with the chalk, had in many places the same black tints. None of the pipes terminated downwards in a point, the apices of the inverted cones being three or four inches broad. These facts the author considers indicative of the mechanical action of water.

He observed certain blocks of siliceous sandstone, derived from the sands of the London clay, marked with similar pipes and furrows, though of smaller dimensions, which could not have been formed by the action of acidulated water. In these the pipes occasionally commenced from the opposite sides of the same block, perforating it, therefore not formed by rain. On the sea-shore near Reculver he saw similar blocks, presenting pipes in miniature. The waves charged with small pebbles and sand, wearing the surface with furrows like those of the chalk, the softer parts of the stone then giving way, first hollows are formed, then the rotatory motion of the contents of the hollows, set in action by the influx and reflux of the waves, drills the pipe.

The pipes and furrows in the sandstone blocks Mr. Trimmer considers as having been produced by the same agency, and their perforation, as caused in consequence of their reversion by a violent storm and the drilling operation then going on at the opposite side.

The examination of a chalk bed near Canterbury convinced Mr. Trimmer that the same causes had produced the pipes and furrows in the chalk. He remarks, that the sand with which the pipes were filled contains much calcareous matter, and that it appears impossible that acidulated water, percolating from above, could have acted on the chalk without first removing all carbonate of lime from the sand.

In all cases observed by Mr. Trimmer the sandgalls were confined to the edges of channels which are either now traversed by tidal currents like the trough of the Thames, or appear, like the dry combes, to have communicated with the sea at some remote period.

From the above facts, Mr. Trimmer infers that the pipes in the chalk of the part of Kent examined were formed by the action of the sea on a low shore; that they mark the boundaries of the ante-eocene sea, and that they were subsequently submerged and covered by the London clay.

"On some remarkable Concretions in the Tertiary beds of the Isle of Man." By H. E. Strickland, M.A., F.G.S.

The north extremity of the Isle of Man consists of an arenaceous pleistocene deposit, occupying an area of about eight miles by six, bounded on the west, north and east by the sea, and on the south by the mountains of Cambrian slate which occupy the greater portion of the island. The arenaceous formation attains in some parts a height of about 200 feet above the sea, though the undulations of its surface prove that considerable portions of the deposit have been removed by denudation. This district, comprising about fifty square miles, furnishes perhaps the most extensive example in the British Isles of a marine newer pliocene or pleistocene deposit. In the Isle of Man the sea-cliffs on each side of this tertiary district afford a good insight into its structure and composition. On the north of Ramsey the cliffs average about 100 feet in height, and consist principally of irregularly stratified yellowish sand, sometimes clayey, with interspersed bands of gravel and scattered pebbles. The gravel is chiefly composed of slate-rock, quartz, old red sandstone, granites, porphyries and chalk flints, all of which occur *in situ* in the island except the two last, which may have been drifted, the former from Scotland, and the latter from the north of Ireland. About four miles north of Ramsey the cliffs attain 150 feet. Here the lowest portion, only visible at intervals, is a brownish clay loam, and the remainder of the cliff is sand and coarse gravel, less distinctly stratified than is the case near Ramsey, and containing rudely rounded boulders, some of which are upwards of a ton in weight. They consist of granite, and occasionally of carboniferous limestone.

Organic remains are sparingly diffused in this deposit: Mr. Strickland enumerates twenty species. Of these five, viz. *Crassina multicostata, Natica clausa, Nassa monensis, Nassa pliocena,* and *Fusus Forbesi* are not known in the British seas. *Crassina multicostata* and *Natica clausa* are found living in the Arctic ocean, but the two species of *Nassa* and the *Fusus* are unknown in a recent state*.

* Mr. Strickland gives the following characters of three species of shells found in the newer pliocene beds of the Isle of Man; specimens of which have been examined by several eminent conchologists in London, who all concur in believing them to belong to extinct species.

"1. *Nassa monensis*, Forbes, in Mem. Wern. Soc., vol. viii. p. 62. Small; volutions about six, rounded; suture deep; ribs, nine on the first volution, straight, rather distant, strong, subacute, and slightly oblique. The first volution has thirteen, and the second six, distinct, regular, thread-like, spiral

Between three and four miles north of Ramsey, the beds of this deposit occasionally exhibit a very remarkable concretionary structure. The sand has here been cemented into masses, which are extremely hard, and even sonorous when struck, though the sand in which they are imbedded is perfectly loose. The cementing ingredient, which the application of acid proves to be carbonate of lime, seems to have been influenced in its operations partly by the planes of stratification, and partly by the direction in which the sand has been originally drifted by currents. In the former case the concretions are in the form of flat tabular masses parallel to the stratification, often mammillated on their surfaces, or perforated obliquely by tubular cavities. In the latter case they assume a subcylindrical or spear-shaped form, and occur parallel both to the stratification and to each other. A pebble is frequently attached to the larger end of the concretion, which springs from it as from a root, to the length of a foot or more, and gradually terminates in an obtuse flattened point. All these varieties are sometimes combined together

striæ, crossing alike the ribs and their interstices. Aperture orbicular-ovate, canal very short and oblique, pillar-lip simple, outer lip with about five slight marginal denticles on the inside, and an external rib slightly more developed than the ordinary ribs. Total length, 7 lines; first volution, $3\frac{1}{4}$ lines; breadth, $4\frac{1}{2}$ lines; angle of spire, 40°.

"*Obs.* Resembles the recent *N. macula*, but is larger, more ventricose, has fewer ribs, and the terminal rib is less suddenly developed.

"2. *Nassa pliocena*, Strickland, 1843. Large; volutions about seven, rather flat, with a distinct thread-like suture; ribs, twelve on the first volution, straight, distant, rounded, very slightly oblique; the interstices flat, exceeding the width of the ribs by one-half. The first volution with thirteen, and the second with about nine fine spiral striæ, only visible in the interstices, the ribs being smooth; but this may be due to attrition. Aperture ovate; canal very short and oblique; pillar-lip with about five obscure denticles, and a spiral groove immediately behind the canal, continued into the interior of the shell. Outer lip with about eight internal marginal denticles; no rib at the back. Total length, 1 inch 8 lines; first volution, 8 lines; breadth, 9 lines; angle of spire, 40°.

"3. *Fusus Forbesi*, Strickland, 1843. *Fusus* nov. sp. Forbes, Malacologia Monensis, pl. 3. f. 1. Middle-sized; volutions about six, slightly rounded, suture distinct; ribs, eleven on first volution, straight, rounded, smooth (perhaps from attrition); interstices concave, and hardly wider than the ribs. First volution with about fifteen, and second with about seven distinct, rather irregular spiral striæ, of which those on the first volution are alternately large and small. They are only visible in the interstices of the ribs. Aperture ovate, double the length of the canal, which is straight, and rather oblique to the left. Pillar-lip smooth, with one obscure denticle at the posterior end. Outer lip with about ten small linear denticles within, continued a short way into the mouth, and a well-marked external rib remote from the margin. Total length, 1 inch 3 lines; first volution, 7 lines; breadth, 8 lines; angle of spire, 43°.

"*Obs.* This species belongs to a group of *Fusus* which seems closely allied to *Nassa*. First described by Mr. E. Forbes, from a worn specimen found on the coast of the Isle of Man, and supposed by him to be an existing species, but the discovery of additional specimens *in situ* proves it to be a genuine fossil."

into vast clusters of several tons weight, resembling masses of stalactite, the component portions being nearly parallel to each other. Mr. Strickland supposes that currents of water (or possibly of wind, operating during ebb tide), flowing in a certain direction, may have disposed the sand in ridges parallel to that direction, and the carbonate of lime may have afterwards been attracted into these ridges in preference to the intermediate portions. This view is confirmed by the fact, that these concretions have frequently a pebble attached to the larger end, as though it had protected a portion of sand from the current, and caused it to accumulate in a ridge on the lee side, a circumstance which may frequently be observed where sand is drifted by the wind or water.

Nov. 30.—William Baker, Esq. of Bridgewater, Andrew Roosmalecoeg, Esq. of King's College, Dr. Lyon Playfair of Primrose, near Blackburn, Lancashire, and John Buckman, Esq. of Pittville Street, Cheltenham, were elected Fellows of this Society.

"On the Bala Limestone." By Daniel Sharpe, F.G.S.

Before entering upon his own views, the author quotes the opinions published by others upon the age of the limestones of Bala and Coniston; previous to the labours of Professor Sedgwick and Mr. Murchison, these two calcareous bands were thought to be of the same age, and to be nearly the oldest fossiliferous beds in this country; but the first definite arrangement of them was made by Professor Sedgwick, whose views will be found in our Proceedings (vol. ii. p. 675), placing both these limestones in the Upper Cambrian system, which he stated to lie below the Silurian system of Mr. Murchison, and above the Lower Cambrian system, or old slate series of Carnarvonshire, Cumberland, &c., a view adopted by Mr. Murchison in his work upon the Silurian system, upon the authority of Professor Sedgwick.

In 1839 Mr. James Marshall classed the Coniston limestone with the Caradoc sandstone, upon the evidence of fossils examined by Mr. J. Sowerby, and pointed out that it rested upon the Lower Cambrian rocks; thus omitting the Upper Cambrian system in the North of England (Reports of the British Association, vol. viii. p. 67.)

The second edition of Mr. Greenough's Map adopts Mr. Marshall's view of the age of the Coniston limestone, and omits the Upper Cambrians in the district of the Lakes; but retains them in North Wales, under the name of Upper division of the lower Killas, in which is included the Bala limestone, thus placed in a different system from the limestone of Coniston.

Professor Sedgwick's memoir of November 1841 follows the same view (Proceedings, vol. iii. p. 545); and in a note, p. 551, that author removes all doubt as to his opinions by apologizing for having formerly placed the Bala and Coniston limestones on the same parallel.

Notwithstanding the agreement of our best geologists in placing the Bala limestone in the Upper Cambrian system, Mr. Sharpe was induced to doubt the accuracy of this classification, by observing that everyone admitted that the Bala fossils agreed, as far as they had been examined, with those of the Lower Silurian beds, and that there was no clear line of separation between the Lower Silurian and Upper Cambrian groups: but his attention was particularly drawn to this district by Mr. Bowman's observations on Denbighshire, laid before the British Association in 1840 and 1841, and since published in the first volume of the Transactions of the Geological Society of Manchester, p. 194, which Mr. Sharpe regards as the first indication of the true structure of this part of North Wales; Mr. Bowman classes as Upper and Lower Silurian many beds before mapped as Upper Cambrian, showing that the previous classification of the rocks of North Wales could not be relied upon.

Mr. Sharpe quotes largely from Mr. Murchison's Address from the Chair in February 1842, to show that the Upper Cambrian cannot be separated from the Lower Silurian beds by the help of organic remains, as "Lower Silurian species range through the Upper Cambrian rocks, and throughout the whole of North Wales," and "prevailed during that vast succession of time which was occupied in the accumulation of all the older slaty rocks previous to the Upper Silurian period."

Mr. Sharpe points out, that up to the moment of his taking up the subject no one of the authors quoted had expressed a doubt of the existence of a great thickness of fossiliferous beds below the Caradoc sandstone and Llandeilo flags, although it was admitted that these supposed beds could not be distinguished by their fossils from the Lower Silurian; and he states that the object of his communication is to show the error of this view as relates to the Bala rocks, which he proposes to prove to be the equivalent of the Lower Silurian beds described by Mr. Murchison, and not part of an older series; and he infers from analogy that the same will be found to be the case in other parts of North Wales which he has not visited, where he conjectures that all the rocks containing shells of Lower Silurian species will also prove equivalents of the Lower Silurian beds. Instead of continuing the Silurian system downwards through a vast thickness of slate rocks, Mr. Sharpe proposes to strike out one of its original members, regarding the Caradoc sandstone and Llandeilo flags as one and the same formation which has received different names according to its mineral character; he observes, in confirmation of this view, that both formations are never equally developed in the same district, and that the fossils found throughout are too nearly the same to warrant the separation of the lower beds under a separate name. Still Mr. Sharpe believes that there are in Wales, as in Westmoreland and Cumberland, vast accumulations of slaty rocks below the Silurian system, in which no fossils have been found, and which must retain the appropriate name of Cambrian rocks.

Mr. Sharpe did not map the district in detail, but he traced two sections to show the position of the Bala beds with regard to the Berwyns, as he considered the question to turn upon the accuracy or error of the statement of Mr. Murchison, p. 308, "that the Bala limestone dips under the chief mass of the Berwyns."

The first section begins westward, at the igneous chain of Arenig Mawr, the natural boundary to the district; it crosses the town of Bala, and ends eastward at the Calettwr, where a dark slate, the upper bed of the Bala series, abuts unconformably against the clay-slate of Moel-halog, which is referred to the Cambrian system. This section places the Bala beds in a detached trough, and shows that they do not dip under the Berwyns: but their succession is not well shown, owing to the disturbed state of the surface.

The other section is in two parts; from the head of the lake of Bala up the Twrch to Bwlch y Groes, and across the Dyfi by Dinas Mowddy and Mallwyd, which line the author recommends to those who wish to study this series, as the rocks are well exposed in the upper part of the valleys of the Twrch and Dyfi: on the west it begins at the northern prolongation of the igneous chain of Arran Mowddy, and continues eastward through a conformable succession of beds up to the Upper Silurian; each section shows the whole of the Bala series, the upper bed of blue slate, which on the Calettwr rests unconformably against the Cambrian clay-slate, being the same which is overlaid conformably beyond Mallwyd by an Upper Silurian series of soft blue or liver-coloured shales alternating with hard, grey grits, without cleavage or fossils, dipping east-south-east, which Mr. Sharpe identifies with the No. 2. of Mr. Bowman's lower division of the Upper Silurians, the probable equivalents of the Wenlock shale.

Mr. Sharpe then describes the Bala series of rocks, beginning with the uppermost beds.

1. *Dark blue slate.*—Worked at Craig Calettwr for good roofing-slates and flags; in one quarry the beds dip W.N.W 35°, and the cleavage planes dip W.N.W 65°; in another the beds dip W. 70° and the cleavage W. 80°. Between Dinas Mowddy and Mallwyd it is largely quarried for good slate and flags; the beds dip S.E. or E.S.E. about 30°; the cleavage is perpendicular, and strikes S.S.W. The lower beds pass into a soft argillaceous slate of no value. The whole is not less than 300 or 400 feet in thickness.

2. *Upper Bala limestone.*—A dark blue bed ten feet thick, accompanied by calcareous slates and soft brown shales, with many fossils, among which are *Orthis canalis* and *O. compressa*, and several new species. Mr. Edward Davis, who accompanied the author, discovered this bed at Pen-y Dall Gwm, four miles south-east of Bala, dipping W.$\frac{1}{2}$S. 70°: it is supposed to follow a line bearing N.N.E., much broken up by faults*.

3. *Rotten argillaceous schist and indurated shale.*—Light grey, weathering to brown, with many joints and few fossils; well exposed in the valley of the Dwm-lach, above its junction with the Dyfi: 400 feet thick.

4. *Bala limestone.*—A dark blue rock similar to No. 2, thirty or forty feet thick, with calcareous shales and grits full of organic remains, among which are *Orthis pecten, anomala, vespertilio* and *bi-*

* Mr. J. B. Morris has since met with the same bed in the valley of the Dyfi at Blaen-y-Pennant.

lobata, Leptæna sericea, duplicata and *depressa,* and *Spirifer radiatus.* This bed is much broken, and difficult to trace, but its general direction from Y-Garnedd, $1\frac{1}{2}$ mile east of Bala, to the upper valley of the Cowarch, is nearly N.N.E. The line of limestone laid down, both in Mr. Murchison's and Mr. Greenough's Maps, is compounded of the beds No. 2. and No. 4.

5. *Grey slaty grits.*—Occasionally streaked or passing into brown, very hard; well seen on both sides of the lake of Bala and in the upper part of the valley of the Twrch; usual dip E.S.E. 45°, but much disturbed about the foot of the lake; the upper bed contains *Orthis canalis, anomala* and *vespertilio.* In the lower part is a bed thirty or forty feet thick of impure grey limestone with many fragments of *Trilobites* and other organic remains, among which Mr. Sharpe recognised *Bumastus Barriensis, Trinucleus Caractaci, Illænus crassicauda, Orthoceras approximatum,* and *Lituites cornu-arietis.* This bed was only seen near Rhiwlas and Llan-y-ci, on the north-west of Bala. The grits below the limestone are similar to those above, and contain *Orthis canalis* and *vespertilio, Leptæna sericea* and *Asaphus tyrannus.* The whole exceeds 500 feet in thickness.

6. *Rotten grey clay-slate,* weathering to brown, forming the moor between Bala and Arenig, and exposed where Cwm Croes joins the valley of the Twrch: supposed to be 500 feet thick.

7. *Dark blue slate,* of poor quality, covers the eastern flanks of Arenig and Arran Mowddy, quarried at Blaen-y-cwm, where the beds dip N.E. 35°, and the cleavage dips E.N.E. 55°: the lowest bed of the series.

As the Bala beds are quite unconnected with the Cambrian rocks of the Berwyns, and are only overlaid by Upper Silurian deposits; as most of their organic remains are known Lower Silurian species, and as the total thickness of the whole series is about the same as has been assigned by Mr. Murchison to the Lower Silurians, Mr. Sharpe concludes that they are the exact equivalents of the Lower Silurian formation, and do not carry the series down below the beds described by Mr. Murchison. Mr. Sharpe considers it as easy to prove their identity with the Caradoc sandstone as with the Llandeilo flags, and again endeavours to show that these must be regarded as the same formation under different names. This classification replaces the dark blue limestones of Bala and Coniston, on the same parallel from which they were separated when Professor Sedgwick adopted Mr. Marshall's view of the Silurian age of the Coniston limestone, but left the Bala limestone in its erroneous position as part of the Upper Cambrians.

Mr. Sharpe adds comparative tables of the Silurian system as exhibited in three different districts:—in Westmoreland, as observed by himself; in Denbighshire and Merionethshire, the upper part taken from Mr. Bowman's memoirs, the lower added by himself; and in Shropshire, &c., as described by Mr. Murchison; but he defers the full comparison of these till he lays before the Society the conclusion of his remarks on Westmoreland.

Mr. Sharpe hopes that he has done away with an objection often made to the Silurian system, that it wanted a definite base, and was not distinctly separated from the Cambrian system; this was not overlooked by Mr. Murchison, who states that the line drawn between the two systems was provisional. The difficulty arose from classing with the Cambrian system many beds belonging both to the Upper and the Lower Silurians, and it will vanish when this is corrected; the lower boundary of the Silurian system will then prove as distinct in North Wales as in Westmoreland and Cumberland; but to produce this result, the country west of Llangollen and Welsh Pool must be remapped. Of the district now coloured as Upper Cambrian a small share will be given to the Ludlow and Wenlock formations, a larger portion to the Lower Silurians, and certain central bosses of older rocks will remain for the Cambrian system: but the Upper Cambrian of Professor Sedgwick, and its representative in Mr. Greenough's nomenclature, the upper division of the Lower Killas, must be struck out of our tables, and the Lower Silurians made to rest on the true Cambrian rocks.

The igneous rocks of Arenig and Arran Mowddy are described as varying compounds of felspar and quartz. The two chains bear nearly north, and their eruption is supposed by the author to have modified the face of the country, and to have caused much of its present complication, the prevailing strike previously having been N.N.E. In the absence of direct evidence on the subject, Mr. Sharpe endeavours to prove that Arenig and Arran Mowddy are at least as modern as the Ludlow rocks, by showing that the upheaving of these chains has broken up the parallelism of the cleavage planes of the slaty rocks resting on them: assuming that these planes had originally a constant direction in each district, their dislocation at any spot would show that it had been disturbed subsequently to the cessation of the cleavage process, and we may thus class igneous eruptions as prior to, or posterior to, the cleavage; and may then connect them with the deposition of the formations, by observing at what epoch the cleavage ceased in the district. In North Wales and in Westmoreland, the cleavage only reaches into the Lower Ludlow formation; in Devonshire and Cornwall it continued later: therefore Arenig and Arran Mowddy must have been upheaved after the epoch of the Lower Ludlow shale.

The memoir concludes with a general list of the species of fossils found near Bala.

"Notice on the discovery of the Remains of Insects in the Lias of Gloucestershire, with some remarks on the Lower Members of this Formation." By the Rev. P. B. Brodie, F.G.S.

The lower beds of the lias, in which these organic remains occur, are extensively developed in the neighbourhood of Gloucester and Cheltenham, and occupy the greater part of the vale. In the upper part of the lower beds, in a hard blue limestone, was found the elytron of a coleopterous insect of the family *Buprestidæ,* apparently a species of *Ancylocheira* of Escholtz. This was the only fossil of the kind met with by Mr. Brodie in this portion of the lias. With this exception, the numerous fossil insects he has obtained occur in the bottom parts of the lower beds near the base of the lias, which are seen at several points in the neighbourhood of Gloucester. At Wainlode Cliff, the lower beds of lias, resting on red marl, form a bold escarpment on the south bank of the Severn, and afford the following section in descending order :—

1. Clay : 3 ft.
2. Blue limestone, with *Ostrea*, &c. (the "bottom bed"): 4 in.
3. Yellow shale with fucoid plants: 6 in.
4. Gray and blue limestone, termed by Mr. Brodie "insect limestone" from its characteristic fossils, passing into yellow shale above, where it is nearly white, and has the aspect of a fresh-water limestone : 3 to 5 in.
5. Marly clay : 5 ft. 3 in.
6. Hard yellow limestone, with small shells like *Cyclas*, plants and *Cypris* : 6 to 8 in.
7. Marly clay : 9 ft. 6 in.
8. Bed with fucoid bodies : 1 in.
9. Shale : 1 ft. 6 in.
10. Pecten bed : 4 in.

Nine feet below this is the bone-bed, 20 feet above which is the yellow *Cypris* limestone, and 26 feet 2 inches the insect limestone. The total height of the cliff is about 100 feet.

The insect remains consist chiefly of elytra belonging to the several genera of Coleoptera, which are not very rare; and a few wings, not unlike the genus *Tipula*, which bear a close resemblance to some Mr. Brodie had previously found in the Wealden; the latter are much rarer than the former. The elytra are generally of a light brown colour and small size; in some cases both the elytra are attached. With these were found abdomens of some insects and larva apparently of the gnat tribe. Shells are not common, but *Ostrea*, *Unio*, and a small species of *Modiola* are the most abundant. The fossils from the yellow limestone, No. 4, bear a close resemblance to those from the Wealden. The real genus of the bivalve resembling *Cyclas* is undetermined. The plants belong to a species of Fucus, apparently an inhabitant of fresh water. At Combe-hill Mr. Brodie also observed both the insect limestone and that containing the small bivalves. To the south-west of this point the insect limestone is well seen, and yielded the greatest number and variety of insect remains. Here the yellow limestone was not traced, and the bone-bed was wanting. The fossil insects are, as at Wainlode Cliff, for the most part remains of small Coleoptera, sometimes tolerably preserved, and in one specimen the eyes were visible. None of the beetles resemble those of the Wealden, but some wings of insects, allied to *Tipula*, are very similar. A few imperfect but large wings of *Libellula* occur: there are also numerous singular impressions of a doubtful nature, many of which may however owe their origin to the partially decomposed bodies of various insects. With these are numerous small plants, some resembling mosses, but very different from those in the yellow *Cypris* limestone, a few seed-vessels and leaves of fern. A small species of *Modiola*, probably *M. minima*, is exceedingly abundant. Remains of Crustacea occur, one of which resembles the genus *Eryon* from the Solenhofen slate.

Near Gloucester the same strata occur at a much lower level. At Westbury, eight miles below Gloucester, the following section is presented :—

1. Bottom bed with *Ostrea*, equivalent to that at Wainlode and other places : 3 in.
2. Insect limestone with numerous small shells (here characteristic) : 4 in.
3. Clay : 5 in.
4. Green, yellow and gray sandy stone, in places becoming a limestone, with the small *Cyclas*-like bivalve, plants and *Cypris*, identical with those at Wainlode, about 1 ft.
5. Shale and clay : 10 ft.
6. Hard grit, bone-bed : 3 or 4 ft.

A little further to the north the beds below this are more developed and are seen resting upon the red marl.

If the *Cypris* found in these beds be of freshwater origin, it forms a new and highly interesting feature in the history of this deposit ; at any rate the occurrence of the remains of such delicate creatures as insects, many of which are well-preserved, and could not, therefore, have been long subject to the action of the waves, or have been carried far out into the water, gives a greater probability to the supposition that this part of the lias may have been formed in an estuary which received the streams of some neighbouring lands, perhaps numerous scattered islands, and which brought down the remains of insects, *Cypris*, and the plants above referred to. The shells usually found in the insect limestone are *Modiola* and *Ostrea*, both of which frequently inhabit estuaries, and are capable of living in brackish water as well as in the open sea. The shells, however, so abundant at Westbury in the same stratum are exclusively of marine origin ; the wing of a dragon-fly from Warwickshire is a solitary instance of its kind. Mr. Brodie observes, that such stray specimens had probably been carried out to sea, which might also have been the case with a small wing he discovered in the *upper lias* at Dumbleton near Tewkesbury ; which also proves the existence of insects during the deposition of the upper portions of this formation.

Thus it will be seen that the remains of insects are of very rare occurrence in the upper beds, and in the higher portions of the lower ones in the lias, while at the base near its junction with the red marl they are abundantly distributed. The discovery of small elytra of coleopterous insects and portions of the wings of *Libellula* in the lower division of the lias near Evesham, by Mr. H. E. Strickland, shows that these fossils are characteristic of the same beds in distant parts of the system.

" On certain impressions on the surface of the Lias bone-bed in Gloucestershire." By H. E. Strickland, M.A., F.G.S.

The singular markings described, which the author in a former communication suggested might be caused by the crawling of crustacea, but which further opportunities and observations have induced him to refer to a different cause, have been noticed only at Wainlode Cliff on the Severn. There they occur on the uppermost surface of the band of micaceous sandstone which represents the "bone-bed," and which appears to have consisted of a fine-grained muddy sand, capable of receiving the most minute impressions, while the pure black clay which forms the superincumbent stratum has preserved this ancient surface in the most unaltered condition. The ripple-marks produced by currents on the surface of this bed of sand are very interesting, from their perfect preservation, and from often exhibiting two sets of undulations oblique to each other, indicating two successive directions in the currents, such as would result from a change of tide.

The impressed markings were evidently produced by living beings, probably by fish or invertebrate animals. To determine their nature Mr. Strickland observed the progression of two species of *Littorina* among Gasteropodous Mollusca, and of *Carcinus Mænas* among Crustacea, but the impressions produced were very different from those under consideration.

The fossil impressions are of four kinds:—

1st. Lengthened and nearly straight grooves, about one-tenth of an inch in width, and several inches long, very shallow, with a rounded bottom. These, Mr. Strickland considers as caused by some object striking the surface of the sand with considerable impetus. They may often be seen to cut through the ridge of one ripple-mark, and after disappearing in the depressed interval, they are again seen pursuing their former direction across the next ridge. They may have been caused by fish swimming with velocity in a straight direction, and occasionally touching the bottom with the under part of their bodies.

2nd. Small irregular pits averaging one-fourth of an inch wide and one-eighth of an inch deep. These might have been caused by some small animal probing the mud and turning up the surface in quest of food. Mr. Strickland conjectures that some of the numerous species of fish found in the bone-bed may have produced them, the heterocene form of tail common to most of which, Dr. Buckland has suggested, enabled them to assume an inclined position with the mouth close to the ground.

3rd. Narrow deep grooves, about one-twelfth of an inch in width, the sides forming an angle at the bottom, irregularly curved and often making abrupt turns, apparently formed by a body pushed along by a slow and uncertain movement, such as might arise from the crawling of Mollusks. Mr. Strickland refers them to the locomotion of Acephalous Mollusca, and supposes that the only shell found in this bed, a small bivalve named by him *Pullastra arenicola*, might have produced them*.

* Mr. Strickland describes this species as follows:—" Its form is nearly a perfect oval, depressed, nearly smooth, but with faint concentric striations

4th. A tortuous or meandering track consisting of a slightly raised ridge about one-tenth of an inch wide, with a fine linear groove on each side. These tracks are analogous to those formed by the crawling of small annelidous worms, as may often be seen on the mud of the sea or fresh water.

About eleven feet above the stratum which presents the impressions above described, a second ossiferous bed occurs at Wainlode Cliff, which escaped Mr. Strickland's notice in the section formerly given (Geol. Proc. vol. iii. p. 586). It is a band of hard, grey, slightly calcareous stone, about an inch thick, containing a plicated shell resembling a *Cardium*, and scales and teeth of *Gyrolepis tenuistriatus, Saurichthys apicalis, Hybodus Delabechei, Acrodus minimus,* and *Nemacanthus monilifer*, all of which occur in the true "bone-bed" below. On the upper surface of that bed are numerous impressions, termed by Mr. Strickland fucoid, consisting of lengthened wrinkled grooves, variously curved, about three quarters of an inch wide, one-eighth of an inch deep, and of variable length. The bone-bed seems to be a local deposit, not being met with in the other localities examined by the author, and being confined to a portion only of Wainlode Cliff, where it constitutes No. 9. in the following corrected section:—

	Ft.	in.
1. Blackish lias clay	3	6
2. Limestone, with *Ostrea* and *Modiola minima* (the bottom bed)	0	4
3. Yellowish shale	1	0
4. Limestone, with remains of insects	0	4
5. Marly shale and clay	5	3
6. Yellowish limestone nodules, with occasional remains of *Cypris*	0	6
7. Yellowish marly clay	6	0
8. Black laminated clay	3	6
9. Stone, with scales and bones of fish, and on the upper surface fucoid impressions	0	1
10. Black laminated clay	1	6
11. Slaty calcareous stone, with Pectens	0	4
12. Black laminated clay	9	0
13. Bone-bed and white sandstone, with casts of *Pullastra arenicola*	0	3
14. Black laminated clay	2	0
15. Greenish angular marl	23	0
16. Red marls with greenish zones	42	0
	98	7

towards the margin. The apex is about halfway between the middle of the shell and the anterior end. The general outline closely resembles that of the recent *Pullastra aurea* of Britain. Maximum length 7 lines, breadth 4½ lines, but the ordinary size is less."

December 14.—John Samuel Dawes, Esq., of West Bromwich, Staffordshire, Ironmaster; and the Rev. Robert Wallace, of 2 Cavendish Place, Manchester, were elected Fellows of this Society.

A memoir, entitled "On the Ridges, Elevated Beaches, Inland Cliffs and Boulder Formations of the Canadian Lakes and Valley of St. Lawrence," by Charles Lyell, Esq., V.P.G.S., F.R.S., was commenced.

January 4, 1843.—The Rev. William Wilson, B.D. Oxon., Vicar of Walthamstow; James Edward Davis, Esq., of the Middle Temple, Barrister; John Moreton, Esq., of Chester Hill, near Uley, Gloucestershire; and Sir George Lefevre, of No. 2 Porchester Place, Oxford Square, were elected Fellows of this Society.

The reading of Mr. Lyell's memoir, commenced on the 14th of December, was resumed.

After adverting to his former paper on the Recession of the Falls of Niagara, and the observations which he made jointly with Mr. Hall in the autumn of 1841*, Mr. Lyell gives an account of additional investigations made by him in June 1842; in the course of which he found a fluviatile deposit similar to that of Goat Island, on the right bank of the Niagara, nearly four miles lower down than the great Falls. The freshwater strata of sand and gravel here alluded to occur at the Whirlpool. They are horizontal, about forty feet thick, plentifully charged with shells of recent species, and are placed on the verge of the precipice overhanging the river. They are bounded on their inland side by a steep bank of boulder clay, which runs parallel to the course of the Niagara, marking the limit of the original channel of the river before the excavation of the great ravine. Another patch of sand, with freshwater shells, was detected on the opposite or western side of the river, where the Muddy Run flows in, about 1½ mile above the Whirlpool. From the position of these strata it is inferred that the ancient bed of the river, somewhere below the Whirlpool, must have been 300 feet higher than the present bed, so as to form a barrier to that body of fresh water in which the various beds of fluviatile sand and gravel above-mentioned were accumulated. This barrier was removed when the cataract cut its way back to a point further south. The author also remarks, that the manner in which the freshwater beds of the Whirlpool and Goat Island come into immediate contact with the subjacent Silurian limestone, no drift intervening, shows that the original valley of the Niagara was shaped out of limestone as well as drift. Hence he concludes that the rocks in the rapids above the present Falls had suffered great denudation while yet the Falls were at or below the Whirlpool.

Mr. Lyell thinks that the form of the ledge of rock at the Devil's Hole, and of the precipice which there projects and faces down the river, proves the Falls to have been once at that point. An ancient

* See Proceedings, vol. iii. p. 595.

gorge, filled with stratified drift, which breaks the continuity of the limestone on the left bank of the Niagara at the Whirlpool, was examined in detail by the author, and found to be connected with the valley of St. Davids, about three miles to the north-west. This ancient valley appears to have been about two miles broad at one extremity, where it reaches the great escarpment at St. Davids, and between 200 and 300 yards wide at the other end, or at the whirlpool. Its steep sides did not consist of single precipices, as in the ravine of Niagara, but of successive cliffs and ledges. After its denudation the valley appears to have been submerged and filled up with sand, gravel, and boulder clay, 300 feet thick.

A description is next given of certain modern deposits, containing freshwater shells, on the western borders of the Niagara, above the Falls, and in Grand Island, in order to show that the future recession of the Falls may expose patches of fluviatile sediment similar to those in and below Goat Island.

The author then passes to the general consideration of the boulder formation on the borders of Lakes Erie and Ontario, and in the valley of the St. Lawrence, as far down as Quebec. Marine shells were observed in this drift at Beauport, below Quebec, as first pointed out by Captain Bayfield, and also near the mouth of the Jacques Cartier river, and at Port Neuf and other places; also at Montreal, where they reach a height probably exceeding 500 feet above the sea, the summit of Montreal mountain being 760 feet high, according to Bayfield's trigonometrical measurement, and the shells being supposed to be 240 feet below the summit. These shells, therefore, being more than 300 feet above Lake Ontario, we may presume that the sea in which the drift was formed extended far over the territory bordering that lake. The most southern point at which the author saw fossil shells belonging to the same group as those of Quebec was on the western and eastern shores of Lake Champlain, viz. at Port Kent and Burlington, in about lat. 44° 30′. Here, and wherever elsewhere the contact of the drift is seen with hard subjacent rocks, these rocks are smoothed, and furrowed on the surface, in the same manner as beneath the drift in northern Europe. The species of shells occurring in the drift, to which Mr. Lyell has made some additions, are not numerous, and are all, save one, known to exist, but are inhabitants, for the most part, of seas in higher latitudes. Many of them are the same as those occurring fossil at Uddevalla and other places in Scandinavia, and they imply the former prevalence of a colder climate when the drift originated. At Beauport there are large and far-transported boulders, both in beds which overlie and underlie these marine shells.

The author next describes the ridges of sand and gravel surrounding the great lakes, which are regarded by many as upraised beaches. He examined, in company with Mr. Hall, the "Lake ridge," as it is called, on the southern shore of Lake Ontario, and other similar ridges north of Toronto, which were formerly explored by Mr. Roy*,

* See Proceedings, vol. ii. p. 537.

and which preserve a general parallelism to each other and to the neighbouring coast. Some of these have been traced for more than 100 miles continuously. They vary in height from ten to seventy feet, are often very narrow at their summit, and from fifty to 200 yards broad at their base. Cross stratification is very commonly visible in the sand; they usually rest on clay of the boulder formation, and blocks of granite and other rocks from the north are occasionally lodged upon them. They are steeper on the side towards the lakes, and they usually have swamps and ponds on their inland side; they are higher for the most part and of larger dimensions than modern beaches. Several ridges, east and west of Cleveland in Ohio, on the southern shore of Lake Erie, were ascertained to have precisely the same characters. Mr. Lyell compares them all to the osars in Sweden, and conceives that, like them, they are not simply beaches which have been entirely thrown up by the waves above water, but that many of them have had their foundation in banks or bars of sand, such as those observed by Capt. Grey running parallel to the west coast of Australia, lat. 24° S., and by Mr. Darwin off Bahia Blanca and Pernambuco in Brazil, and by Mr. Whittlesey near Cleveland in Lake Erie. They are supposed to have been formed and upraised in succession, and to have become beaches as they emerged, and sometimes cliffs undermined by the waves. The transverse and oblique ramifications of some ridges are referred to the meeting of different currents and do not resemble simple beaches.

The base-lines of the ridges east and west of Cleveland, are not strictly horizontal according to Mr. Whittlesey, but inclined five feet and sometimes more in a mile. Those near Toronto are said by Mr. Roy to preserve the same exact level for great distances, but Mr. Lyell does not conceive that our data are as yet sufficiently precise to enable us to determine the levels within a few feet at points distant several hundred miles from each other. No fossil shells have been obtained from these ridges, and the author concludes that most of them were formed beneath the sea or on the margin of marine sounds. Some of the less elevated ridges, however, may be of lacustrine origin, and due to oscillations in the level of the land since the great lakes existed, for unequal movements, analogous to those observed in Scandinavia, may have uplifted freshwater strata above the barriers which divide Lake Michigan from the basin of the Mississippi, or Lake Erie from Ontario, or the waters of Ontario from the ocean. Considerable differences of level may have been produced in the ancient beds of these vast inland bodies of freshwater, while the modern deposit and the subjacent Silurian strata may to the eye appear perfectly horizontal.

The author then endeavours to trace the series of changes which have taken place in the region of Lakes Erie and Ontario, referring first to a period of emergence when lines of escarpment like that of Queenstown, and when valleys like that of St. Davids were excavated; secondly, to a period of submergence when those valleys and when the cavities of the present lake-basins were wholly or partially filled up with the marine boulder formation; and lastly, to the re-emergence of the land, during which rise the ridges before alluded to were produced, and the boulder formation partially denuded. He also endeavours to show, how during this last upheaval the different lakes may have been formed in succession, and that a channel of the sea must first have occupied the original valley of the Niagara, which was gradually converted into an estuary and then a river. The great Falls, when they first displayed themselves near Queenstown, must have been of moderate height, and receded rapidly, because the limestone overlying the Niagara shale was of slight thickness at its northern termination. On the further retreat of the sea a second fall would be established over lower beds of hard limestone and sandstone previously protected by the water; and finally, a third fall would be caused over the ledge of hard quartzose sandstone which rests on the soft red marl, seen at the base of the river-cliff at Lewistown. These several falls would each recede further back than the other in proportion to the greater lapse of time during which the higher rocks were exposed before the successive emergence of the lower ones. Three falls of this kind are now seen descending, a continuation of the same rocks on the Genesee River at Rochester. Their union, in the case of the Niagara into a single fall, may have been brought about in the manner suggested by Mr. Hall*, by the increasing retardation of the highest cataract in proportion as the uppermost limestone thickened in its prolongation southwards, the lower falls meanwhile continuing to recede at an undiminished pace, having the same resistance to overcome as at first.

Mr. Lyell considers the time occupied by the recession of the Falls from the Whirlpool to be quite conjectural, but assigns a foot rather than a yard a year as a more probable estimate; thus he shows the Mastodon, found on the right bank near Goat Island, though associated with shells of recent species, to have claim to a very high antiquity, since it was buried in fluviatile sediment before the Falls had receded above the Whirlpool.

"Notice on a Suite of specimens of Ornithoidicnites, or foot-prints of Birds on the New Red Sandstone of Connecticut." By Gideon Algernon Mantell, LL.D., F.R.S.

These specimens were accompanied by a letter from Dr. James Deane of Greenfield, Massachusetts, the original discoverer of the Ornithoidicnites, of which more than thirty varieties had been found, bearing a striking resemblance to the foot-prints of birds. In this letter Dr. Deane gives an account of his discovery of the impressions eight or nine years ago, and which he then communicated to Professor Hitchcock. He remarks, that "the footsteps are invariably those of a biped, and occur on the upper surface of the stratum, while the cast or counter-impression is upon the lower. In some instances we may follow the progress of the animal over as many as ten successive steps." He has seen a course of steps twelve inches in length by eight in breadth, extending several rods. The intervening space

* Boston Journ. of Nat. Hist., 1841.

was uniformly four feet. One impression of a foot was fourteen inches in length. The impressions are accompanied by those of rain-drops.

Extract of a Letter from W. C. Redfield, Esq., on newly discovered Ichthyolites in the New Red Sandstone of New Jersey. Communicated by Charles Lyell, Esq., V.P.G.S.

Mr. Redfield has found two distinct fish-beds in the new red sandstone of New Jersey, both containing ichthyolites of the genus *Palæoniscus*. In the sandstone between the fish-beds he discovered an Ornithoidicnite, and observed numerous slabs exhibiting impressions of rain-drops and ripple-marks. The rain-marks appear as if the rain had been driven by a strong wind, and the direction of the impressions indicated that the wind blew from the west, a quarter from which violent squalls or thundergusts are still prevalent in these latitudes.

A Letter was read from Mr. Charles Nicholson, accompanying some fossil bones found imbedded in the banks of the Brisbane River (New South Wales).

Also an extract of a Letter from his Excellency George Grey, Governor of Adelaide, to Mr. Lyell, accompanying a section of the country between the eastern shore of St. Vincent's Gulf and Lake Alexandrina (New South Wales), and noticing some fossils obtained from that district.

January 18th.—Henry Hope, Esq., of Deep Dene; William Stevens Richardson, of the Temple, Barrister-at-Law; and Thomas Page, Esq., Member of the Institution of Civil Engineers, and Acting Engineer at the Thames Tunnel, were elected Fellows of this Society.

"On the Silurian Rocks of the South of Westmoreland and North of Lancashire." By Daniel Sharpe, Esq., F.G.S.

This communication is in continuation of a paper read by the author on the 2nd of February, 1842*, a second visit to the district having enabled him to correct some errors committed on his first examination, and to extend his observations into Lancashire.

On both occasions Mr. Sharpe took for his base-line the bed of Coniston limestone described by Professor Sedgwick†, being convinced that Mr. Marshall has rightly considered that limestone as the lowest bed of the Silurian system in this district‡, and in all his descriptions he adheres to the ascending order.

1st. *Coniston Limestone.*—It is doubtful whether this bed is continuous at its western extremity, or occurs only in detached patches. The two western portions of limestone at Water Blain and Low House are a mile and a quarter south of the bearing of the

* See Proceedings, vol. iii. p. 602.

† Geol. Trans. Second Series, vol. iv. p. 47.

‡ Report of the British Association, 1839, Sections, p. 67.

line of the bed east of the latter place, but are exactly on a line with the strike of the bed beyond Coniston; a great fault between Low House and Greystone House being counterbalanced by the whole of the smaller faults between that spot and Coniston, which are pointed out in Professor Sedgwick's memoir. Mr. Sharpe gives a list of fossils collected in this bed and the shales above it at Torver Fell, Coniston, Long Sleddale, &c., in which are several of the species of *Orthis, Spirifer,* and *Leptæna,* found by Mr. Murchison in the Lower Silurian deposits, and several undescribed species.

2nd. *Slates, Shales, and Flagstones.*—These are well exposed on Torver Fell, where the following series may be seen:—

a. Brown shale.

b. Dark blue slate of good quality; the beds dip E.S.E. 40°, and the cleavage dips S.S.E. 80°; it contains many fossils, much compressed and distorted, nevertheless a few Lower Silurian shells are made out.

c. Indurated brown shale.

d. Blue flagstone rock, a bed well known in the district, and mentioned by Professor Sedgwick and Mr. Marshall; at Torver, where it gives good roofing-slate as well as flags, the beds dip south-east 45°, and the cleavage south-east 80°. To the eastward of Windermere this bed and the lower bed of slate *b* run together, and the whole of the Lower Silurian formation diminishes in thickness.

e. Indurated shale.

f. Shear Bed, which supplies brownish-blue flags, taken along the bedding of the rocks, which is free from slaty cleavage.

This series of slates, flagstones, and shales, may be traced above the Coniston limestone from the Dudden to Shap Fells, although the separate beds cannot always be distinguished.

3rd. *Grey Slaty Grits,* described in Mr. Sharpe's former paper as the "Lower division of the Windermere rocks," but now classed as part of the Lower Silurian formation; they consist of a great thickness of hard gritty grauwacke, variously affected by cleavage, and may be traced from the Dudden, below Broughton, to Shap Fell.

4th. *Blawith Limestone,* "the second band of calcareous slate" of Professor Sedgwick; a bed only found in two localities, at Meer Beck and a wood behind Low Hall, on the east of the road from Ireleth to Kirkby Ireleth, where it is a dark-blue limestone very like that of Coniston, dipping east 40°, of which only about a thickness of twelve feet is laid open; and at Turtle-bank Heights, south-west of Blawith, where it has been quarried near the top of the south-east face of the hill, and is a dark gray limestone, twenty feet thick, striking north-east and dipping perpendicularly; from this spot it runs by Cockin's-hill to the side of Coniston Water, half a mile north of Water Gate. The fossils found by Mr. Marshall in this bed near Blawith were identified as Lower Silurian species.

5th. *Flagstones and Slates of Kirkby Ireleth.*—These are placed by Professor Sedgwick below the Blawith limestone, No. 4, but as Mr. Sharpe considers erroneously: nevertheless, although no fossils have been found in them, he considers them to be the uppermost bed of the Lower Silurian series, because they are always conformable to the undoubted Lower Silurian beds below them, and are not equally conformable to the beds above. As this southern edge forms the boundary line of the Lower Silurian formation, Mr. Sharpe traced them carefully along their whole course, from their first appearance rising from under the mountain limestone, on the east of Ireleth, till they are hidden by the old red sandstone of Birkbeck-beck. Near Ireleth it is only used for building-stone, but at Kirkby Ireleth are quarries extending for a mile and a half along the range of the bed, supplying dark-blue slates of very good quality. At Horse Spital Quarry the beds dip south-east 80°, and the cleavage dips south-east 55°, both sets of planes striking north-east: this coincidence in the strike of the bedding and cleavage planes is common in all this district; yet at Lord Quarry, close to the last-mentioned, the beds dip N.N.E. 20°, while the cleavage dips S.S.E. 70°. Further east the rock is of inferior quality, and is rarely worked for roofing-slate: its usual course is north-east, passing by Suberthwaite, Blawith, Nibthwaite, at the foot of Coniston Water, where much building-stone has been quarried, and the rock is well exposed, being a dark-blue flagstone streaked with gray: between Oxen Park and Satterthwaite it dips north 50°, and N.N.W. 70°, and is lighter and more striped than usual; at Force Mill it strikes E.N.E. and dips N.N.W. 65°, and the cleavage has the same strike but is perpendicular: at Satterthwaite the dip is north 45°: between Esthwaite and the Ferry on Windermere the road runs near the upper edge of the bed, which is well exposed close to the Ferry House, north of which spot it reaches more than a mile up the shore of the lake. On the east side of the lake it has been quarried north of Bowness.

Eastward of Bowness, Mr. Sharpe corrects an error which he committed in laying down this line too far south: he now traces it nearly E.N.E. by Ing's Chapel, Row Gill, and Hugill Hall, dip south-east 60°; Monument Hill on the west side of Kentmere, dip S.S.E. 80° to Fellfoot in Kentmere. The flagstone crosses Long Sleddale at the Chapel, where it was found not worth working for slate: at Bonnisdale-head Farm it gives a slate of fair quality, the beds dip south-east by south 65°, and the cleavage dips in the same direction 80°; from here it crosses into High Borrowdale half a mile above High House, dipping south-east by south 50°; a fault down this valley throws the bed below High House on the east side of the valley: in the next Fells it is much concealed by the vegetation, but it is seen at a cutting of the road from Shap to Kendal on Hurd's Brow, between the ninth and tenth mile-stone, dipping south-east 75°, and the cleavage dipping north-west 85°. Near the Borrow the beds are thrown into several anticlinal ridges bearing north-east, by faults which disturb the cleavage planes as well as the bedding of the rock: this slate has also been worked in the upper part of Bretherdale. The boundary thus laid down nearly corresponds with that given in the new edition of Mr. Greenough's map.

The lowest beds of the slate in High Borrowdale are calcareous, and may perhaps represent the Blawith limestone, which has not been found in conjunction with the slate eastward of Blawith.

In High Furness, the district of Lancashire consisting of Lower Silurian rocks, the principal valleys run from south-west to north-east, parallel to the strike of the beds, each ridge of hills representing the outcrop of a particular bed: this is not the case with the same formation in Westmoreland, where the valleys of Coniston Water, Esthwaite, Windermere, Troutbuk, Kentmere, Long Sleddale, Bannisdale, High Borrowdale, and Brethesdale, all follow great faults across the strike of the stratification: these faults are continued through the Windermere rocks, and sometimes into the Lower Ludlow rocks, but are lost before entering the Upper Ludlows.

It is in High Furness that the Lower Silurian formation is best exposed to observation, and has a greater thickness than in Westmoreland, the beds gradually diminishing in their course eastward. In the same district of Lancashire the slaty character of the rocks is more developed than we find it in Westmoreland; it is especially between Coniston, Old Mere and Kirkby Ireleth, that the crystallizing agency which has changed the rocks into slate has acted most powerfully, many beds in that district supplying good slate, which will hardly split up at all elsewhere.

From the prevailing parallelism long known to exist between the planes of slaty cleavage over considerable areas, Mr. Sharpe considers it nearly certain that these planes had a uniform direction in each district, and that the cases of exceptions which are found are due to disturbing forces acting after the cessation of the cleavage action. In the district under consideration the mean dip of the cleavage planes is considered to be S.S.E. 70°, and the cleavage action is thought to have ceased before the formation of the Upper Ludlow rocks.

Windermere Rocks.—The beds formerly classed by the author as the lowest division of this series are now placed in the Lower Silurian formation, and the middle and upper divisions are thrown together, for want of any distinct line of division between them, and some considerable corrections are made in their geographical boundaries. They rise, near Ulverston, from below the mountain limestone of Low Furness, dipping E.S.E. at high angles, and disappear in Westmoreland beyond Bannisdale, during which course they rest on the Kirkby Ireleth slate; but their southern boundary can only be understood from the map, as to the west of Windermere they are overlaid by large patches of mountain limestone, and in their range eastward are gradually covered up unconformably, and concealed by the Lower Ludlow rocks. In some places the similarity of the rocks of the two formations, and the absence of fossils in both, makes it difficult to determine the boundary between them, the best guide being the dip and strike of the rocks. In Mr. Sharpe's first map a portion of the Lower Ludlow rocks on the north-east of Kendal was erroneously coloured as belonging to the Windermere series; the error was pointed out by Cornelius Nicholson, Esq., of Cowan Head, who assisted the author materially in mapping the neighbourhood of his residence.

The upper boundary of the Windermere rocks begins on the south-west at the lower point of Witherslack, and is marked by a great fault which crosses the valley between that hill and Whitbarrow, and appears to pass under the mountain limestone of Whitbarrow, then runs north-east through Underbarrow, by the Chapel, to Mountjoy: on the west side of this fault the Windermere rocks form high ridges of hard slaty grits of dark grey colour, with lighter streaks, dipping N.N.W., while on the east side of the fault is a gritty rock of uniform grey colour dipping E.S.E., overlaid with beds containing the fossils of the Ludlow beds. From Mountjoy the line turns to the north-west, and passes round Crook Chapel, which stands on a ridge of the Windermere grits; at Crook Common it turns to the north-east, and follows that direction to near Borrowdale, where the formation is lost, being completely hidden by the Ludlow rocks, which there rest on the Lower Silurians. Crook Common is thrown into great confusion by the meeting of two lines of elevation, one coinciding with the E.N.E. strike of the Lower Silurian rocks, the other coming up from the S.S.W. through Cartmel Fell.

At Backbarrow, below Newby Bridge, the upper beds of this series are slaty, with a wavy cleavage dipping N.N.E. 80°, the beds dipping south-east 80°; these beds contain irregular calcareous nodules in great abundance, and *Orthoceras articulatum* was found in them.

Mr. Sharpe refers to his former memoir for the description of the Windermere rocks on the east of the Lune, which extend to Greyrigg Forest, Whin Fell, and Howgill Fell; in these Fells are several axes of elevation which require further examination.

Ludlow rocks.—These were described in the author's former paper; the area covered by them is larger than was there stated, their lower boundary being now carried more to the north, and their eastern portion being extended in a sort of trough between the Lower Silurian slates of Shap Fell and the Windermere rocks of Whin Fell, crossing Barrowdale between High and Low Barrowbridge.

In the lowest beds of the series in Fawcett Forest were found *Leptæna lata* and *Turritella conica,* in a slaty rock. The *Terebratula navicula* is found thinly scattered throughout all the lower part of the formation, and occurs in vast numbers in a bed which forms about the middle of the Ludlow series. Mr. Murchison has told us that this little shell is usually found in such numbers as to form a bed which lies above the Aymestry limestone, and it serves to mark the place of that rock where it is wanting: and Mr. J. E. Davis informed the author, that at Stapleton, near Presteign, where there is no Aymestry limestone, this species is found throughout the whole of the Lower Ludlow shales. Mr. Sharpe has made use of this shell in dividing the Upper from the Lower Ludlow rocks in Westmoreland, classing all the beds containing it in the lower series. The bed in which it occurs in greatest abundance was traced through Underbarrow, by Tullithwaite Hall and High Cray, across the west end of Rather Heath and a little south of Cowan Head, and also in Lambrigg Park; it is usually accompanied by *Atrypa affinis, Spirifer octoplicatus, Leptæna lata* and *depressa, Orthis lunata,* and *Terebratula nucula*: the *T. navicula* seems to have died out suddenly, as it is not found in the Upper Ludlow beds.

The same division of the Ludlow rocks may be obtained by attending to the direction and dip of the beds; the lower series partakes of the north-east strike, which runs through the older Silurian rocks in these counties, and is traversed by many of the same faults as those formations, but the Upper Ludlow beds are thrown up in anticlinal ridges with a different direction.

Mr. Sharpe gives a list of the organic remains found in each division of the formation, which includes forty-four of the species described in Mr. Murchison's work from the old red sandstone and Upper Ludlow, fourteen of those from the Aymestry limestone, and twenty-two of those from the Lower Ludlow beds. Of the species of shells placed by Mr. Murchison in the old red sandstone*, all but two have now been found low in the Ludlow beds, proving that the red beds containing these species in Herefordshire must be classed with the Upper Ludlow formation.

Old Red Sandstone.—The only addition to the former paper which relates to this formation, is in mapping it in the upper valley of the Lune, where the tile-stones reach above the hamlet of Langdale, dipping N.N.E. 10°.

The age of the large masses of gravel of a brown or red colour noticed in the valley of the Lune between Sedberg and Casterton, and of the Kent and Sprint, was before left uncertain; the author now regards them as a modern surface drift.

Mountain Limestone.—The description of this formation did not enter into Mr. Sharpe's plan, but he examined the portion of it which occurs in Low Furness, to ascertain the geological position of the Ulverston iron ore.

The ore occurs in veins usually perpendicular, and bearing W.N.W., which cut through the limestone, but are not continued into the Silurian rocks. The following veins are mentioned:—

Plumpton Hall; now abandoned.

Lindal Moor vein; an exception to the usual condition, as it runs between the mountain limestone and the Windermere grits, striking north-west and dipping south-west 45°; it is the principal and most profitable vein of the district.

Stainton; three veins separated by a few yards of clay, spar, and limestone, perpendicular, and bearing W.N.W.

Lindal Court; several perpendicular veins near together, bearing W.N.W.

Crosthwaite; a poor vein bearing W.N.W., thought to be the continuation of that at Stainton.

Wet Flat; the rocks near are much disturbed, and the vein, after running W.N.W., turns down a fault in the limestone to N.N.W., but soon thins out.

* Silurian System, p. 603. and t. 3.

Trap Rocks.—These are rare in the district; Professor Sedgwick has laid down some masses of igneous rocks at Shap Fells, on the south side of the high road; one of them consists of red felspar with some mica, quartz, and hornblende. The slate rocks are much disturbed in the neighbourhood, and the faults have broken up the cleavage planes as well as the bedding of the rocks, from which Mr. Sharpe infers that the trap is more modern than the eruption of the Shap granite, which took place before the cleaving of the slates, as the cleavage planes run through all the faults connected with that eruption.

At Biglands, south of Newby Bridge, there is a trap dyke running north-east, which has also disturbed the parallelism of the cleavage, and must be considered as of a modern date: it is not well exposed on the surface.

The author concludes by a comparison of all the beds with those described by Mr. Murchison in the border counties of Wales, and adopted as the types of the Silurian system, and with those of Denbighshire and Merionethshire, to which his attention was directed by Mr. Bowman's papers on Llangollen; he points out the closest resemblance between the Silurian formation in North Wales and in Westmoreland, while in mineral character they differ most materially from those of Siluria: nevertheless the principal divisions of the Silurian system laid down by Mr. Murchison can be traced in each district by the evidence of the organic remains.

"On the Stratified Rocks of Berwickshire and their imbedded Organic Remains." By Mr. William Stevenson, of Dunse. Communicated by the President.

In this memoir the author gives an account of the characteristic features, the order of succession, and the nature of the organic remains of the stratified rocks of Berwickshire. The lowest of these are greywacke and greywacke slate, forming an extensive system of arenaceous and argillaceous strata of various colours, gray predominating, found almost everywhere among the Lammermuirs, of which chain they constitute the fundamental rock. In the rocks of this system no undoubted organic remains have been found, but some curious markings occur on slabs, for which it is difficult to account without supposing the influence of organic agency. The greywacke presents the uniform appearance of a deep sea deposit, perhaps laid down upon the bottom of a wide-spreading ocean of great profundity, and therefore removed from the disturbing action of wind and tides. The thickness of these strata, as displayed among the Lammermuirs, is very great, but the series is far from being complete, there being no appearance of the older strata on the one hand, and on the other their junction with the newer formations is always unconformable. The materials of which they are composed were probably derived from the disintegration of the granites and primary schists to the westward.

2. The formation next in order is the upper division of the old red sandstone, the members of which rest unconformably upon the upturned ends of the greywacke. The lowest member of it is an

old red sandstone conglomerate, consisting of fragments of grey-wacke and felspathic rocks, cemented by a paste which is generally arenaceous, sometimes calcareous. It varies much in thickness.

3. Red and greenish white sandstones succeed with soft red argillaceous strata. Part of these seem to have been formed in a shallow sea, since they exhibit ripple-marks, and contain remains of *Holoptychius* and *Dendrodus*. Another portion contains few traces of fossils, and was probably deposited in deeper water. Some curious spindle-shaped concretions and the impressions called Kelpie's feet occur, also traces of *Fuci*. Two localities near Preston-Haugh, and one at the foot of the Knock-hill, are all in which organic remains have as yet been found.

4. After the deposition of the strata containing the remains of the *Holoptychius*, &c., a subsidence to a considerable extent took place, after which a succession of strata of great thickness was deposited above them. These rocks seem to have been formed in deeper water than the ichthyolitic beds. They consist of red and greenish white sandstones interstratified with beds of a softer and more argillaceous character, and of a deep red colour. They seem to contain no organic remains except vegetable impressions (Algæ ?) which occur in abundance in a bed of red sandstone, perhaps 100 feet above the strata containing the animal remains.

5. Above the soft, red and white sandstones are calcareous shales, sandstones and cornstones, or impure concretionary limestones, without fossils. The junction of these with the sandstones is not seen, being cut off by faults and trap dykes.

6. The lower portion of the coal-measures succeeds, consisting of shales, marls, clays, and sandstones containing ironstone bands and gypsum, and abounding in vegetable fossils, consisting of *Coniferæ*, *Stigmariæ*, *Lepidodendra*, and other coal plants. This formation is well developed over the greater part of the Merse of Berwickshire.

7. Next in order are some thick beds of reddish sandstone, underlying

8. Carboniferous strata, consisting of sandstones, shales, &c., including three or four coal-seams.

9. The encrinal limestone, seen a little north of Berwick.

Mr. Stevenson remarks that the Berwickshire carboniferous strata appears to correspond with the lower beds of the Fife and Lothian coal-fields, considered by Mr. Milne and others to belong to the mountain limestone, and to be considerably lower than the Newcastle coal strata. With regard to the inquiry whether new red sandstone exists in Berwickshire, Mr. Stevenson is inclined to answer it in the negative. He regards the beds at Cumledge, described by Mr. Milne as such, as old red, and considers the soft red clays and sands at Lintlaw, derived from the disintegration of the old red sandstone, referred by Mr. Milne to the new red sandstone, to be of undetermined age, from want of sufficient evidence in the absence of organic remains. The exact position of the greywacke strata of the Lammermuirs is for the same reason indeterminate. The author concludes by pointing out the great gap which occurs between the greywacke and the upper division of the old red sandstone in Berwickshire, the middle and lower divisions of the old red and the whole of the Silurian system being deficient. Another circumstance worthy of remark is the absence of any formations more recent than the coal-measures, if we except alluvial deposits and the undetermined red strata formerly mentioned.

February 1.—W. Johnston, Esq., of Grosvenor Granite Wharf, and of Richmond, Surrey; James Baber, Esq., of 1, South Place, Knightsbridge, London; and Evan Hopkins, Esq., were elected Fellows of this Society.

A paper was read "On the Tertiary Strata of the Island of Martha's Vineyard in Massachusetts." By Charles Lyell, Esq., V.P.G.S., &c.

The most northern limit to which the tertiary strata bordering the Atlantic have been traced in the United States is in Massachusetts in Martha's Vineyard, lat. 41° 20′ north, an island about twenty miles in length from east to west, and about ten from north to south, and rising to the height of between 200 and 300 feet above the sea. The tertiary strata of this island are, for the most part, deeply buried beneath a mass of drift, in which lie huge erratic blocks of granite and other rocks which appear to have come from the north, probably from the mountains of New Hampshire. The tertiary strata consist of white and green sands, a conglomerate, white, blue, yellow, and blood-red clays and black layers of lignite, all inclined at a high angle to the north-east, and in some of their curves quite vertical. They are finely exposed near Chilmark on the southwest side of the island, and in the promontory of Gay Head at its south-western extremity, where there is a vertical section of more than 200 feet in height.

Attention was first called to this formation by Prof. Hitchcock in 1823, who appears to be the only American geologist who has examined them personally. He compared the beds at Gay Head to the plastic and London clays of Alum Bay in the Isle of Wight, to which, lithologically, they bear a striking resemblance, consisting in both cases of variously and brightly coloured clays and sands with lignite, all incoherent and highly inclined. Various opinions, however, have been put forth as to the relative age of the Martha's Vineyard strata, which were assigned by Prof. Hitchcock, at a time when the tertiary formations of the United States were less known, to the Eocene period, while Dr. Morton supposed them to be in part only tertiary, and that they rested on greensand of the cretaceous period.

The section at Gay Head is continuous for four-fifths of a mile, the beds dip to the north-east generally at an angle of from thirty-five to fifty degrees, though in some places at seventy degrees. The clays predominate over the sands. In one place Mr. Lyell found a great fold in the beds, in which the same osseous conglomerate and associated beds of white sand, on the whole fifty feet thick, were so bent as to have twice a north-easterly and once a south-westerly dip.

In the yellowish and dark brown clay near the uppermost part of the section at Gay Head, and in the greensand immediately resting upon it*, Mr. Lyell found the teeth of a shark, that of a seal, vertebræ of Cetacea, crustacean remains and casts of *Tellina* and *Mya*. These prevail at intervals through a thickness of nearly 100 feet, and are followed by beds of sand and clay with lignite. Mr. Lyell found no remains in the red clays. Many rolled bones were found in the osseous conglomerate.

In the section at Chilmark similar strata to those at Gay Head occur, but the general dip is south-west. Some of the folds, however, give anticlinal dips to the north-east as well as the south-west, and there are many irregularities, the beds being sometimes vertical and twisted in every direction. Several faults are seen and veins of ironsand, which intersect the strata like narrow dykes, as if there had been cracks filled from above. One bed of osseous conglomerate at Chilmark, four yards in thickness, is vertical, and its strike is well seen to be north 25° east, so that the disturbances have evidently been so great that it would be difficult without more sections to determine positively the prevailing strike of these beds. The incumbent drift is very variable in thickness, and large erratics, from twenty to thirty feet in diameter, are seen resting on quartzose sand. The author saw no grounds for concluding that any cretaceous strata occur anywhere in the island, nor could he find any fossils which appeared to have been washed out of a cretaceous formation into the tertiary strata, as some have suggested.

Mr. Lyell proceeds to the consideration of the organic remains collected by himself in Martha's Vineyard.

Mammalia.—1. A tooth, identified by Prof. Owen as the canine tooth of a seal, of which the crown is fractured. It seems nearly allied to the modern *Cystophora proboscidea*.

2. A skull of a walrus, differing from the skulls of the existing species (*Trichecus rosmarus*, Linn.), with which it was compared by Prof. Owen, in having only six molars and two tusks, whereas those of the recent have four molars on each side, besides occasionally a rudimentary one. The front tusk is rounder than that of the recent walrus.

3. Vertebræ of *Cetacea*, some of which are referred by Prof. Owen to the Whalebone-whales, and others to the Bottle-nosed (*Hyperoodon*).

Pisces.—Teeth of sharks resembling species from the Faluns of Touraine, viz. *Carcharias megaladon*, *Oxyrhina xiphodon*, *O. hastulis*, and *Lamna cuspidata*. With these were large teeth of two species of *Carcharias*, one resembling *C. productus*, a Maltese fossil. With the exception of the two last, Mr. Lyell found the same species in miocene strata near Evergreen, on the right bank of James River in Virginia.

Crustacea.—A species considered by Mr. Adam White as probably belonging to the genus *Cyclograpsus*, or the closely allied *Sesarma* of Say, and another, decidedly a *Gegarcinus*.

* Nos. 5 and 6 of Prof. Hitchcock's section.

Mollusca.—1. Casts of a *Tellina* allied to *T. biplicata*, a miocene fossil, and of another near *T. lusoria*. 2. Cast of a *Cytherea* resembling *C. Sayana*, Conrad. 3. Three casts of a *Mya*, one of which bears a close resemblance to *Mya truncata*.

Mr. Lyell concludes, from the various evidence here given, that the strata of Martha's Vineyard are miocene. The numerous remains of Cetacea of the genera *Balæna* and *Hyperoodon* are adverse to the supposition of their being Eocene, while such fossils abound in the miocene beds of America. The other fossils all point to a similar conclusion.

Letter from J. Hamilton Cooper, Esq., to Charles Lyell, Esq., V.P.G.S., "On Fossil bones found in digging the New Brunswick Canal in Georgia."

Mr. Cooper prefaces his communication by a description of the country surrounding the locality in which the bones were found. The portion described is that part of the sea-coast of Georgia which lies between the Alatamaha and Turtle rivers in one direction, and the Atlantic Ocean and the head of tide water on the other. For twenty miles inland the land is low, averaging a height of from ten to twenty feet, and reaching, in some instances, forty feet, and consisting of swamps, salt-marshes, sandy land, and clay loam. It then suddenly rises to the height of seventy feet, and runs back west at this elevation about twenty miles, at which point there is a similar elevation of between sixty and seventy feet. The whole of this district is a post-tertiary formation, and is composed of recent alluvium, and a well-characterized marine post-pliocene deposit. The recent alluvium is divided into inland-swamp, tide-swamp, and salt-marsh. The two last occupy a shallow basin having a depth of about twelve feet, the bottom and sides of which are the post-pliocene formation. This the author divides into three groups, in the last of which, constituting the elevated sand hills, no organic remains have been found; in the two former marine shells of existing species occur.

The fossil bones of the land mammalia discovered by Mr. Cooper, were found resting on the yellow sand and enveloped in the recent clay alluvium. Their unworn state and the grouping together of many bones of the same skeleton, render it highly probable that the carcasses of the animals falling or floating into a former lake or stream, sank to the sandy bottom, and were gradually covered to their present depth by the sedimentary deposits from the water. Among them were remains of the megatherium, *Mastodon giganteum*, mammoth, hippopotamus and horse. The fossil shells found in the post-pliocene, were species at present existing on the neighbouring shores.

The facts narrated by Mr. Cooper lead to the following conclusions :—1st. That the post-pliocene formation extends further south than Maryland, to which it has hitherto been limited. 2nd. The co-existence of the megatherium with the mammoth, mastodon, horse, bison, and hippopotamus. 3rd, That the surface of the country has undergone no sudden or violent change since those animals inhabited it, which is proved by the absence of all traces of diluvial action in the enveloping alluvium or surrounding country. 4th. That whatever changes of temperature may have taken place since that time, fatal to the existence of those mammalia, the identity of the fossil with the existing species of the marine shells of the coast shows that the temperature of the ocean at a period prior to the existence of the megatherium, the mastodon, and the hippopotamus was such as is congenial to the present marine testacea of Georgia.

"Description of some Fossil Fruits from the Chalk-formation of the South-east of England." By Gideon Algernon Mantell, LL.D., F.R.S., &c.

The fruits described are three in number, viz.—

1. *Zamia Sussexiensis*, Mantell.—From the greensand. A cone allied to the *Zamia macrocephala*, a greensand fossil from Kent, figured in Lindley and Hutton's 'Fossil Flora,' pl. 125, from which it differs in form and in the number, size, and shape of its scales, which are more numerous, smaller and more oblong than in the Kentish species. It is five inches long, and at the greatest circumference measures six inches. It was found about two years ago in an accumulation of fossil coniferous wood in a sand-bank at Selmeston, Sussex, at the junction of the Shanklin sand with the gault. Dr. Mantell having sent a cast of the only specimen found to M. Adolphe Brongniart, that distinguished botanist suggested that it might be either the stem of a young cycadaceous plant or the fruit of a *Zamia*, but the situation and small size of the stalk at the base and the appearance of the scales, induce Dr. Mantell to refer it to the latter.

2. *Abies Benstedi*, Mantell.—From the greensand near Maidstone, Kent. A beautiful cone found by Mr. W. H. Bensted in the quarry in which the remains of the Iguanodon were discovered in 1834, where it was associated with *Fucus Targionii*, and some indeterminate species of the same genus; stems and apparently traces of the foliage of endogenous trees allied to the *Dracæna* (*Sternbergia*), and of trunks and branches of *Coniferæ*. The wood occurs both in a calcareous and siliceous state. The cone found is in every respect such a fruit as the trees to which the wood belonged might have borne. It bears a close resemblance to a fossil from the greensand of Dorsetshire, discovered by Dr. Buckland, and figured in the 'Fossil Flora' of Great Britain under the name of *Abies oblonga* (Fos. Fl. pl. 1.). Unfortunately the outer surface is so much worn that the external figure of the scales cannot be accurately defined; but the sections show their proportionate thickness. There is an opening at the base of the cone occasioned by the removal of the stalk, and an accidental oblique fracture exhibits the internal structure. In the longitudinal section thus exposed the scales are seen to be rounded and broad at their base and to rise gradually, and become thin at their outer terminations. The seeds are oblong, and one seed is seen imbedded within the base of each scale. Mr. Morris considers

it to have a great affinity to *Abies oblonga* of Lindley and Hutton, but it is more spherical, and the scales are smaller, more regular and numerous.

3. *Carpolithes Smithiæ*, Mantell.—From the white chalk of Kent. An account of an imperfect specimen of this fruit was formerly given by Dr. Mantell in his 'Illustrations of the Geology of Sussex.' He lately detected a second and more perfect example in the choice collection of Mrs. Smith of Tunbridge Wells, in honour of whom he has named it. Dr. Mantell remarks, that a slight inspection was sufficient to determine its vegetable origin, for several seeds were imbedded in its substance, and others had been detached in clearing it from the chalk. Dr. Robert Brown suggested that the original was probably a succulent compound berry, the seeds appearing to have been imbedded in a pulpy substance like the fruit of the mulberry, which is a spurious compound berry, formed by a partial union of the enlarged and fleshy calices, each inclosing a dry membranous pericarp.

From the occurrence of the cones above described with the drifted remains of land and freshwater reptiles peculiar to the Wealden, Dr. Mantell infers that these fruits belong to the flora of the country of the *Iguanodon*.

"Notice on the fossilized remains of the soft parts of Mollusca." By Gideon Algernon Mantell, LL.D., F.R.S., &c.

Substances presenting the same general appearance and composition with coprolites, but destitute of the spiral structure, are thickly interspersed among the shells which abound in the rocks of firestone or upper greensand at Southborne in Sussex, sometimes occurring in the state of casts of shells of the genera *Cucullæa*, *Venus*, *Trochus*, *Rostellaria*, &c., from the soft bodies of which testacea Dr. Mantell considers them to have originated. They abound also in the layers of firestone which form the line of junction with the gault, and are not uncommon in the gault itself in several localities in Surrey and Kent.

Dr. Fitton, in his memoir 'On the Strata below the Chalk' (Geol. Trans. vol. iv. part 2. p. 11), has given an account of similar concretions from Folkstone, where he observed them in some cases surrounding or incorporated with fossil remains, and filling the interior of Ammonites. Dr. Mantell has observed them also in the Shanklin sand in Western Sussex, in Surrey, near Ventnor in the Isle of Wight, and in Kent, and they especially abound in the Iguanodon quarry of Kentish rag near Maidstone, belonging to Mr. W. H. Bensted.

Mr. Bensted having long paid attention to this subject, more than two years ago submitted to Dr. Mantell specimens of fossil shells, the cavities of which were filled with a dark brown substance in every respect identical with the nodular and irregular concretions of coprolitic matter which abound in the surrounding sandstone. Mr. Bensted expressed his belief that the carbonaceous substance was derived from the soft bodies of the Mollusca, and that the concretionary and amorphous portions of the same matter dispersed throughout the sandstone of this bed, were masses of the fossilized bodies of the animals which had become disengaged from their shells, and had floated in the sea till enveloped in the sand and mud, which is now concreted to the coarse sandstone called Kentish Rag. In proof of this opinion reference is made to an account published in the 'American Journal of Science' for 1837, of the effects of an epidemic among the shell-fish of the Ohio, which, killing the animals, their decomposed bodies rose to the surface of the water, leaving the shells in the bed of the stream, and floating away covered the banks of the river. Mr. Bensted points out that nearly the whole of the shells in the Kentish rag of his quarry appear to have been dead shells, and infers that their death might have been owing to a similar cause with that which destroyed the *Uniones* in America; while their bodies intermingling with the drift wood on a sand-bank furnished the concretions described in this communication.

The Rev. J. B. Reade submitted some of the substance of these bodies to an analysis by Mr. Rigg, who confirmed Dr. Mantell's suspicion of the presence of animal carbon in it, and states that the darker portion of the substance contains about 35 per cent. of its weight of carbon in an organized state.

Dr. Mantell adds, that a microscopical examination with a low power detects innumerable portions of the periosteum and nacreous laminæ of the shells of extreme thinness intermingled with the carbonaceous matter, together with numerous siliceous spiculæ of sponges, very minute spines of *Echinodermata*, and fragments of *Polyparia*, and remarks that these extraneous bodies probably became intermingled among the soft animal mass before the latter had undergone decomposition. He proposes to term the substance *Molluskite*, and states that it constitutes the dark spots and markings in the Sussex and Purbeck marbles.

"On the Geological position of the *Mastodon giganteum* and associated fossil remains at Bigbone Lick, Kentucky, and other localities in the United States and Canada." By Charles Lyell, Esq., V.P.G.S.

With a view to ascertain the relations of the soil in which the bones of the Mastodon are found, to the drift or boulder formation, whether any important geographical or geological changes had taken place since they were imbedded, and what species of shells are associated with them, Mr. Lyell visited a number of places where they had been obtained. In this paper he gives the result of his researches.

The most celebrated locality visited was Bigbone Lick, in the northern part of Kentucky, distant about 25 miles to the S.W. of Cincinnati, situated on a small tributary of the river Ohio called Bigbone Creek, which winds for about 7 miles below the Lick before joining the Ohio. A "Lick" is a place where saline springs break out, generally among marshes and bogs, to which deer, buffaloes, and other wild animals resort to drink the brackish water and lick the salt in summer. The country around Bigbone Lick, and for a considerable distance on both banks of the Ohio, above and below it, is composed of blue argillaceous limestone and marl, constituting one of the oldest members of the transition or Silurian system. The strata are nearly horizontal and form flat table-lands intersected by numerous valleys in which alluvial gravel and silt occur; but there is no covering of drift in this region. The drift is abundant in the northern parts of Ohio and Indiana, but disappears almost entirely before we reach the Ohio.

Until lately herds of buffaloes were in the habit of frequenting the springs, and the paths made by them are still to be seen. Numbers of these animals have been mired in the bogs, and horses and cows have perished in like manner. Along with their remains are found innumerable bones of Mastodon, Elephant, and other extinct quadrupeds, which must have visited these springs when the valley was in its present geographical condition in almost every particular, and which must have been mired in them as existing quadrupeds are at present. The mastodon remains are most numerous and belong to individuals of all ages. The mud is very deep, black, and soft. In places it is seen to rest upon the limestone, and at some points it swells up to the height of several feet above the general level of the plain and of the river. It is occasionally covered by a deposit of yellow clay or loam, resembling the silt of the Ohio, which is from 10 to 20 feet thick, rising to that height above the creek and often terminating abruptly at its edges. This loam has all the appearance of having been deposited tranquilly on the surface of the morass and of having afterwards suffered denudation. The Mastodon and other quadrupeds have been mired before the deposition of the incumbent silt, for a considerable number of fossil bones have been found by digging through it. Accompanying the bones are freshwater and land shells, most of which have been identified by Mr. Anthony with species now existing in the same region.

Mr. Lyell observes that the surface of the bog is extremely uneven, and accounts for it partly by the unequal distribution of the incumbent alluvium which presses with a heavy weight on certain parts of the morass, from which other portions of the surface are entirely free. He also attributes it in part to the swelling of the bog where it is fully saturated with water near the springs.

The author is of opinion that the fossil remains of Bigbone Lick are much more modern than the deposition of the drift, which is not present in this district. But although the date of the imbedding of these mammalian fossil remains is so extremely modern, considered geologically, it is impossible to say how many thousand years may not have elapsed since the Mastodon and other lost species became extinct. They have been found at the depth of several feet from the surface, but we have no data for estimating the rate at which the boggy ground has increased in height, nor do we know how often during floods its upper portion has been swept away.

Ohio.—The Ohio river immediately above and below Cincinnati is bounded on its right bank by two terraces consisting of sand, gravel and loam, the lower terrace consisting of beds supposed to be much newer than those of the upper. In the gravelly beds of the higher terrace teeth both of the Mastodon and elephant have been met with. Mr. Lyell was assured that a boulder of gneiss, 12 feet in diameter, was found resting on the upper terrace, about 4 miles north of Cincinnati, and that some fragments of granite had been found in a similar situation at Cincinnati itself. These facts show that some large erratics have taken up their present position since the older alluvium of the Ohio valley was deposited. In travelling northwards from Cincinnati towards Cleveland, Mr. Lyell found the northern drift commence in partial patches 25 miles from the former city and about 5 miles N.E. of Lebanon, after which it continually increased in thickness as he proceeded towards Lake Erie.

New York—Niagara Falls.—In a former paper Mr. Lyell alluded to the position of the remains of Mastodon, 12 feet deep, in a freshwater formation on the right bank of the river Niagara at the Falls. He remarks that if we had not been able to prove that the cataract had receded nearly four miles since the origin of the fluviatile strata in question, we should have been unable to assign any considerable duration of time as having intervened between the inhumation of the Mastodon in marl full of existing shells and the present period. The general covering of drift between Lakes Erie and Ontario is considered to be of much higher antiquity than the gravel containing the bones of the Mastodon at the Falls.

Rochester.—In the suburbs of this city remains of the *Mastodon giganteum* were found associated with existing species of Mollusca in gravel and marl below peat.

Genesee.—Here remains of the *Mastodon giganteum* were found with existing shells in a small swamp in a cavity of the boulder formation, so that the animal must have sunk after the period of the drift when a shallow pond fed by springs was inhabited by the same species of freshwater mollusca as now live on the spot.

Albany and Greene Counties.—Mr. Lyell examined, in company with Mr. Hall, two swamps west of the Hudson River, where the remains of Mastodon occurred in both places at a depth of four or five feet, precisely in such situations as would yield shell marl, and peat, with remains of existing animals in Scotland. Cattle have recently been mired in these swamps.

According to Mr. Hall the greatest elevation at which Mastodon bones have been found in the United States is at the town of Hinsdale, situated on a tributary of the river Allegany in Cattaraugus county in the State of New York, where they occur at an elevation of 1500 feet above the level of the sea.

Maryland.—In the museum at Baltimore, Mr. Lyell was shown the grinder of a Mastodon, distinct from *M. giganteum*, and which had been recognised and labelled by Mr. Charlesworth as *M. longirostris*, Kaup. It was found at the depth of 15 feet from the surface in a bed of marl near Greensburgh, in Carolina County, Maryland, and is considered by Mr. Lyell as a miocene fossil.

Atlantic border.—Between the Appalachian mountains and the

Atlantic there is a wide extent of nearly horizontal tertiary strata, which at the base of the mountains are 500 feet and upwards in height, but decline in level nearer the ocean and at length give place to sandy plains and low islands skirting the coast, in which strata containing marine shells of recent species are met with, slightly elevated above the sea. Occasionally deposits formed in freshwater swamps occur, below the mean level of the Atlantic or overflowed at high tide. In this district Mr. Nuttall discovered, on the Neuse 15 miles below Newburn, in South Carolina, a large assemblage of mammalian bones, including those of the *Mastodon giganteum*, resting on a deposit containing marine shells of recent species. Mr. Conrad presented Mr. Lyell with the tooth of a horse covered with barnacles, from this locality. Professor Owen has examined it and could find no corresponding tooth of a recent species, but considers it as agreeing with the horse-tooth brought by Mr. Darwin from the north side of the Plata in Entre Rios in South America.

South Carolina.—Remains of the Mastodon were found in digging the Santee Canal, in a spot where large quadrupeds might now sink into the soft boggy ground.

Georgia.—Bones of the Mastodon and Megatherium occur in this district in swamps formed upon a marine sand containing shells of species now inhabiting the neighbouring sea.

Mr. Lyell in conclusion offers the following observations :—

1. That the extinct animals of Bigbone Lick and those of the Atlantic border in the Carolinas and in Georgia belong to the same group, the identical species of Mastodon and elephant being in both cases associated with the horse, and while we have the Mylodon and Megatherium in Georgia, the Megalonyx is stated by several authors to have been found at Bigbone Lick.

2. On both sides of the Appalachian chain, the fossil shells, whether land or freshwater, accompanying the bones of Mastodons, agree with species of Mollusca now inhabiting the same regions.

3. Under similar circumstances Mr. Darwin found the Mastodon and horse in Entre Rios, near the Plata, and the Megatherium, Megalonyx and Mylodon, together with the horse, in Bahia Blanca in Patagonia; these South American remains being shown by their geological position to be of later date than certain marine Newer Pliocene, and Post-pliocene strata. Mr. Darwin also ascertained that some extinct animals of the same group are more modern in Patagonia than the drift with erratics.

4. The extinct quadrupeds before alluded to in the United States lived after the deposition of the northern drift, and consequently the coldness of climate which probably coincided in date with the transportation of the drift, was not as some pretend the cause of their extinction.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY OF LONDON.

VOL. IV. PART I. 1843. No. 93.

AT THE

ANNUAL GENERAL MEETING,

17*th of February*, 1843.

THE following Report from the Council was read :—

In presenting their Annual Report on the state of the Society, the Council have to notice as one of the most gratifying occurrences of the past year, the addition of His Majesty the King of Prussia to the number of royal personages Members of the Society. The gracious manner in which His Majesty condescended to take his place as a Member of this Society, was noticed by our President in his Address at the last Anniversary.

In calling attention to the present state of the Society, the Council have the satisfaction of being able to announce a continued increase in the number of its Fellows. At the end of 1841 there were 784 Fellows, 28 Honorary Members, 50 Foreign Members, and 3 Personages of Royal Blood, making a total of 865. During the year 1842, 26 new Fellows were elected and admitted, and 3 Fellows were admitted who had been elected in former years, making, with the admission of His Majesty the King of Prussia, a total addition of 30 new Fellows. On the other hand, there have been 17 deaths, 7 resignations, and 1 removal, besides 1 Honorary Member and 1 Foreign Member deceased, making a loss of 27, to be deducted from the increase of 30, leaving a total increase of 3.

The income of the Society during the year 1842 has exceeded the expenditure by the sum of £297 3*s.* 5*d.*, but in the year's expenditure a considerable portion of the cost of the Second Part of Vol. VI. of the Transactions, amounting to £558 4*s.*, has not been included.

In consequence of the great expense attending the publication of the last Volume of the Transactions, the Council have deemed it expedient to delay funding the compositions of the three Fellows who compounded during the year 1842; the value of the funded property of the Society has therefore only increased by the variation in the price of stock from £2410 (the calculated value last year) to £2544. The number of existing compounders at the close of 1842 was 118, and the amount of compositions received from them in lieu of Annual Contributions was £3717, making a difference of only £1173 between the amount received from existing compounders and the value of the funded property.

The Council have further to announce, that the Second Part of Vol. II. of the Transactions has been published during the past year, and that the Third Vol. of the Proceedings has been completed. The Index to the latter is printed, and will be ready for publication in a few days.

It is with much regret that the Council have to announce the retirement of Mr. Lonsdale, who has been compelled during the last year, by the state of his health, to resign his office of Curator to the Society. It is unnecessary for the Council here to enlarge on the serious loss which the Society has incurred by this event, but they are unwilling to forgo this opportunity of testifying the high opinion they entertain of his valuable services and great scientific merits. In recording the election of his successor, the Council cannot omit to congratulate the Society on having secured the services of such a distinguished Naturalist as Mr. E. Forbes.

In consequence of events which occurred during the last year, the Council have found it necessary to change their Collector of Annual Contributions, and have to announce that Mr. H. T. Woodfall has been appointed in the room of Mr. J. W. Hamond.

The Council have resolved that a Wollaston Gold Medal be presented to M. Pierre Armand, Dufrénoy, Inspector of the School of Mines, and another to M. Elie de Beaumont, Professor of Natural History in the College of France, both Members of the Institute, and Foreign Associates of the Society, for their contributions to the advancement of Geological Science, more especially for their joint work, the Geological Map of France, and the Memoirs that accompany it; and that the sum of £11. 0*s*. 11*d*., the balance of the Annual Proceeds of the Fund, be granted to Mr. Morris, to assist him in his intended publication of a tabular view of British Organic Remains.

Report of Museum Committee, 1843.

It has been the duty of former Museum Committees to report to the Council on the additions and general progress in arrangement, which may have been made in the Society's collections during the intervals between the Annual General Meetings; but these duties have in the present instance been somewhat lightened, owing to the limited time which elapsed between the unusually full examination made by your last Committee and Mr. Lonsdale's retirement; since which the Museum has remained, with the following exceptions, in the state in which the energy, zeal and admirable method of your late Curator placed it.

The Minute of the Council of the 6th of December, 1841, has been partly carried into effect: four boxes of rock specimens from

Mexico, Bolivia, Peru and Chili; and three boxes of British granitic and trappean rocks have been arranged, whereby 40 additional drawers have been gained for the fossil collection; we recommend that Mr. Woodward should continue to carry out this arrangement, and that the Australian collection be removed from the Cabinets, that the fossil be separated from the rock specimens, and the former placed in the Foreign Museum.

Owing to the size of the boxes in which these rock specimens have been placed, and the nature and close arrangement of their contents, their weight is very great: your Committee are of opinion that some caution will be requisite as to the position in which all such boxes should be placed; and that four, which now occupy the centre of the floor of the upper Museum, should be immediately removed, as that portion of the building is evidently not calculated to carry them.

The donations made to the Society's collection during the past year have been fewer than usual; under a suggestion made by Mr. Lonsdale, an account of the fossil shells so presented has been given in the last Numbers of the Society's Proceedings; all the specimens there recorded have been incorporated with the general collection: of these is an interesting suite of shells from the faluns of Touraine (in which the collection was deficient), presented by Mr. Lyell.

As the present Report is the first which the Council will receive from a Museum Committee since the retirement of an officer under whose direction the Museum had continued for so many years, we feel that we should be greatly remiss did we not call attention to the very important nature of your late Curator's arrangements in this particular department.

During Mr. Lonsdale's connexion with this Society the bearing of fossil organic remains on many points of geological inquiry was of a kind which imparted to them a new value, and gave a perfectly different character to many of its investigations; it was towards this, and especially in the vast subject of fossil conchology, that he rendered most valuable services to this Society: in reporting, for the first time, on the general result of these labours, we confidently state that the assistance which the Museum collection can offer to those who may consult it, cannot be too highly estimated; by such it will be found that our cabinets contain an enormous number of species accurately determined, and that whenever the means at his disposal would admit, he has not only presented them under various aspects, but exhibited their geographical distribution, together with those variations which result from age and local conditions.

The following table represents with tolerable accuracy the relative and gross numbers of named species contained in the Society's collection :—

	Plantæ.	Zoophytes.	Radiaria.	Annulata.	Conchifera.	Mollusca.	Crustacea.	Pisces.	Reptilia.	Total.
Crag	...	...	...	...	...	...	...	...	...	400*
Upper freshwater formation	...	...	...	...	1	11	...	...	...	12
Upper marine formation	...	...	...	...	2	12	...	...	...	14†
Lower freshwater formation	1	...	...	...	6	11	...	...	1	17
London clay	...	...	...	2	46	100	...	9	1	150‡
Chalk and chalk marl	...	8	18	5	21+6	5+10	1	15+1	...	89
Upper green sand	1	1	8	2	23	10	...	...	...	45
Gault	...	1	1	1	16	37	...	3	2	61
Lower green sand	...	1	...	2	47	10	...	...	...	60
Green sand, black	...	1	...	2	39	14	...	...	...	56§
Weald clay	...	...	...	...	6	4	4	...	...	14
Hastings sand	...	...	...	...	11	4	1	...	...	16
Purbeck stone	...	...	...	...	5	3	2	...	...	10
Portland oolite	...	1	...	1	13	9	...	...	...	24
——— sand	...	...	...	1	13	4	...	...	...	18
Kimmeridge clay	...	...	...	1	7	...	...	...	...	8
Coral Rag	...	2	5	2	22	10	1	...	...	42
Calcareous grit	...	...	2	1	17	9	...	...	...	29
Oxford clay	...	...	...	1	12	5	...	...	...	18
Kelloway rock	...	...	...	...	5	3	...	...	...	8
Cornbrash	...	2	3	1	23	2	...	...	...	31
Forest marble	...	2	1	1	6	1	...	...	...	11
Bradford clay	...	3	3	3	5	...	...	...	...	14
Great oolite	...	...	6	4	29	8	...	7	2	56
Fuller's earth	...	...	3	...	23	2	...	...	...	27
Inferior oolite	...	...	4	6	38	28	...	...	...	76
Alum shale	...	...	...	...	2	6	...	...	...	8
Marl stone	...	...	...	...	14	8	...	...	...	22
Lias	...	...	8	1	30	35	1	7	9	91
Coal measures	120	...	...	...	2	...	...	2	...	124
Carboniferous limestone	...	10	14	...	38	23	1	3	...	89
Upper Ludlow	...	4	3	1	26	15	...	2	...	51
Aymestry limestone	...	6	...	...	11	5	1	...	...	23
Lower Ludlow	...	2	...	...	11	24	3	1	...	41
Wenlock limestone	...	43	...	...	18	13	6	...	...	30
——— shale	...	6	...	...	24	5	1	...	...	36
Caradoc sandstone	...	6	...	...	48	14	7	...	...	75
Llandeilo flagstone	...	6	...	...	13		11	...	...	20

* *Vide* S. Wood's Catalogue.
† Includes the Bagshot sand.
‡ Many drawers not named.
§ These should not be kept distinct.

In addition to these, the British collection also includes a large number of specimens, to which no specific names are affixed: there are notes attached to some of these, showing that Mr. Lonsdale has ascertained them to be new and undescribed: in most instances the localities are recorded. Your Committee have to recommend with respect to this portion of the Society's collection,—

First. That all the new species be described and named by Mr. Forbes, and the account published in the Society's Proceedings.

Second. Considering that the Museum of this Society is the only one which can be considered as fairly available to those engaged in Geological inquiries, that a Catalogue should be published of all the species named, and arranged with reference to the cabinets, and to the localities from whence procured; as they feel confident that such a list will be of great use to members of the Society and geologists generally, and tend much to lessen the difficulties and doubts which most must have experienced with respect to the identification of fossil species, of which the descriptions are spread through numerous and expensive works: separate portions of such a Catalogue could be published from time to time.

Besides the reasons assigned above, the Society's collection is well fitted to be made one of general reference, owing to the great care which the late Curator devoted to the determination of species, as also from the results which may confidently be expected from Mr. Forbes's labours; because it also contains many of the original specimens from which the characters of species have been taken, such as of some of those of Sowerby's 'Mineral Conchology,' and also all those which are described and figured in Mr. Murchison's 'Silurian System.'

Your Committee are aware that it may be objected to this suggestion, that the Geological collection is very rarely consulted; but this, they are of opinion, arises mainly from a disinclination to undertake the trouble of an examination of so large a collection, without some guide as to what it contains. The cost and labour of such a catalogue as we now recommend would be very trifling, for which we feel assured that the Society would be amply compensated: it is well known that many parts of the collection present great deficiencies; the most certain way by which these may be supplied, is by making known, indirectly, wherein they consist.

The state of the collection of foreign fossils contained in the upper Museum is very unsatisfactory when compared with the order and arrangement of the British suite; it is rich in interesting specimens, which at present are wholly unconsultable. We therefore recommend that Mr. Forbes should be particularly requested to direct his attention to this portion of the Museum.

The only remaining point upon which your Committee are aware they have anything to which to direct the attention of the Council, is to that of the duplicate specimens; these have become exceedingly numerous; your Committee recommend that these should not be allowed any longer to remain buried in the cellars of the Society's apartments, but should be carefully examined and catalogued; that a selection be made for the Society, with ultimate reference to a systematic as well as a stratigraphical collection; and that the Curator be empowered to effect exchanges with the remainder, to supply deficiencies in the Society's collection, either with the managers of public institutions at home or abroad, or even with private persons.

The Library has been increased by the donation of about two hundred volumes and pamphlets. The Board of Ordnance continues to present to the Society the maps of the Trigonometrical Survey of Great Britain and of the Townland Survey of Ireland. The charts published by the Admiralty and the Dêpot Général de la Marine of Paris, respectively, have likewise been received.

CHA. LYELL.
H. T. DE LA BECHE.
ROBERT A. C. AUSTEN.

Comparative Statement of the Number of the Society at the close of the years 1841 *and* 1842.

	Dec. 31, 1841.		Dec. 31, 1842.	
Compounders		117		118
Residents		251		243
Non-residents		416		427
		784		788
Honorary Members	28		27	
Foreign Members	50		49	
Personages of Royal Blood	3		4	
		81		80
		865		868

General Statement explanatory of the alteration in the Number of Fellows, Honorary Members, &c. at the close of the years 1841 and 1842.

Number of Fellows, Compounders, Contributors, and Non-residents, 31st December, 1841				784
Add, Fellows elected during former years, and paid in 1842	Residents	1		
	Non-residents	2		
			3	
Fellows elected during 1842, and who paid	Residents	8		
	Non-residents	18		
			26	
				29
				813
Deduct, Compounders deceased			2	
Residents ,,			4	
Non-residents ,,			11	
Resigned			7	
Removed			1	
				25
Total number of Fellows, 31st Dec. 1842, as in last page				788

Number of Honorary Members, Foreign Members, and Personages of Royal Blood, 31st December, 1841		81
Add, Personage of Royal Blood elected		1
		82
Deduct, Honorary Member, deceased	1	
Foreign Member, deceased	1	
		2
Total as in last page		80

Number of Fellows liable to Annual Contribution at the close of 1842, with the Alterations during the year.

Number at the close of 1841		251
Add, Elected in previous years and paid in 1842		1
Elected during 1842 and paid		8
Non-residents who became Residents		4
		264
Deduct, Deceased	4	
Resigned	7	
Compounded	3	
Become Non-resident	6	
Removed	1	
		21
Total as in last page		243

Deceased Fellows:—

Compounders (2): Sir William Alexander; Alexander Melville, Esq.

Residents (4): Richard V. Barnewall, Esq.; Rev. E. T. Daniell; William Harrison, Esq.; Earl of Munster.

Non-residents (11): James O. Anstie, Esq.; Rev. T. Arnold, D.D.; Sir Charles Bell, K.C.H.; Francis Ellis, Esq.; Thomas Edington, Esq.; Alexander Haliburton, Esq.; Armand Levy, Esq.; Rev. J. M'Enery; David Pennant, Esq.; J. D. Phelps, Esq.; John Yelloly, M.D.

Honorary Member (1): Francis Lord Gray.

Foreign Member (1): Don J. B. de Andrada y Silva.

Fellow removed from the Society (1): James Haliburton, Esq.

Personage of Royal Blood elected during 1842: His Majesty the King of Prussia.

The following Persons were elected Fellows during the year 1842.

January 5th.—Charles Tremenheere, Esq. of the Bombay Engineers; William Kennett Loftus, Esq. of Caius College, Cambridge; and John Scandrett Harford, Esq. D.C.L., F.R.S., Blaise Castle, Bristol.

February 2nd.—Captain William E. Delves Broughton, Royal Engineers, New Kingston, Surrey; and George O'Gorman, Esq. Baker Street, Portman Square.

February 23rd.—Alexander Busby, Esq. Cassilis, Hunter's River, New South Wales; and Hugh Falconer, Esq. A.M., M.D., Superintendant of the East India Company's Botanic Garden at Saharunpore.

March 9th.—Benjamin Best, Esq. Corngreaves.

March 23rd.—William Wroughton Salmon, Esq. Devizes, Wiltshire; Henry Stevens, Esq. Duffield, near Derby; Francis Downing, Esq. of the Priory, Dudley; and Thomas W. Fletcher, Esq. F.R.S., P.S.A., Dudley.

April 6th.—Joseph Dickinson, Esq. Mining Engineer, Dowlais, in the county of Glamorgan; Colonel Alexander Fisher Macintosh, K.H. of Antermoney, near Glasgow; John Birkett, Esq., Demonstrator of Anatomy at Guy's Hospital; and Josiah Rees, Esq. of the Ordnance Geological Survey of Great Britain.

April 20th.—Alexander John Sutherland, M.D. Fludyer Street, Westminster.

May 4th.—Arthur Marshall, Esq. Headingley, near Leeds; William Stutfield, Esq. Montague Place; and H. L. Pattinson, Esq. Bensham Grove, Gateshead.

May 18th.—Joseph Colthurst, Esq. Parliament Street.

June 1st.—William Ghrimes Kell, Esq. Bedford Row.

June 29th.—Charles Turton Kaye, Esq. Sandywell Park, Andoversford, Gloucestershire.

November 16th.—Albert Hambrough, Esq. Steep Hill Castle, Isle of Wight.

November 30th.—William Baker, Esq. Bridgewater; Andrew Roosmalecoeq, Esq. of King's College; Dr. Lyon Playfair, Primrose, near Blackburn, Lancashire; and James Buckman, Esq. Pittville Street, Cheltenham.

December 14th.—John Samuel Dawes, Esq. Westbromwich, Staffordshire; and Rev. Robert Wallace, 2 Cavendish Place, Manchester.

The following Donations to the MUSEUM have been received since the last Anniversary:—

British and Irish Specimens.

Fossils from the Kelloway Rock of Wiltshire, and Inferior Oolite of Burton, near Bridport, and Vertebra of Ptychodus from the Chalk near Maidstone; presented by E. H. Bunbury, Esq. Sec. G.S.

Ammonites falcifer, *Hildensis* and *annulatus* from the Alum Shale, and *Pecten æquivalvis* from the Marlstone of Ilminster, Somerset; presented by Charles Moore, Esq.

Casts of Crinoideans and Trilobites from Dudley; presented by John Gray, Esq. of Dudley.

Remains of Crustaceans from the Lias of Lyme Regis, and a Lithodendron from the Carboniferous Limestone on the shores of Lough Gill, County Sligo; presented by the Earl of Enniskillen, F.G.S.

Group of three Basaltic Columns from the Giant's Causeway; presented by John Wiggins, Esq. F.G.S.

Fossils from the Chalk, Upper Greensand and Oxford Clay of Wilts; the Greensand of Faringdon, Berks; the Great Oolite of Minchinhampton; and the Carboniferous Limestone of Whatley, near Frome, Somerset; presented by Miss Benett of Norton House.

Graptolites from the County of Fermanagh, Ireland; presented by Captain Portlock, R.E., F.G.S.

Crystals of Greenockite from near Bishopton, Renfrewshire; presented by Lieut.-Gen. Lord Greenock, F.G.S.

Fossils from the Carboniferous Limestone of Ireland; presented by W. J. Henwood, Esq. F.G.S.

Series of Rocks from Jersey; presented by H. C. White, Esq. F.G.S.

Fossils from the Inferior Oolite of Leckhampton Hill, near Cheltenham, and a Specimen of *Stromatopora concentrica* from the Wenlock Limestone; presented by W. V. Guise, Esq. F.G.S.

Cast of *Asaphus Buchii* from Snowdon; presented by G. W. Ormerod, Esq. F.G.S.

Ammonites sublævis and *Callovicensis* from the Kelloway Rock of Christian Malford, Wilts; presented by Thomas Weaver, Esq. F.G.S.

Fossils from the Great Oolite near Bath; presented by W. Walton, Esq.

Specimens of the Ludlow "Bone-bed" from beneath the Downton

Castle Building-stone, Brindgwood; presented by the Rev. T. T. Lewis.

Fossils from the Inferior Oolite near Gloucester; presented by R. B. Grantham, Esq. F.G.S.

Goniatites Gibsoni from the Carboniferous Shales of the Vale of Todmorden; presented by Mr. S. Gibson of Hebden Bridge.

Devonian Fossils from Whitesand Bay near Plymouth; presented by the Rev. W. S. Hore, F.G.S.

Clay containing small bones from a superficial deposit near Duffield; presented by H. Stevens, Esq. F.G.S.

Crioceratite from the Kelloway Rock, and other Fossils from the Oxford Clay near Chippenham; presented by Mrs. Lowe.

Caryophyllia centralis and *Terebratula plicatilis* from the Norwich Chalk; presented by Mr. T. G. Bayfield.

Valvata antiqua and *Unio Pictorum* from the Pleistocene deposit at Grays, Essex; presented by Edward Stock, Esq. of Poplar.

Fossils from the Carboniferous Limestone and Silurian Rocks in the neighbourhood of Kendal; presented by Daniel Sharpe, Esq. F.G.S.

Asaphus Buchii from the Llandeilo Flags and Porites from the Wenlock Limestone; presented by William Day, Esq. of Shrewsbury.

Land and Freshwater Shells from the Pleistocene deposit at Copford, near Colchester; presented by John Brown, Esq. F.G.S.

Remains of Insects and other Fossils from the Lower Lias near Cheltenham; presented by the Rev. P. B. Brodie, F.G.S.

Specimens of *Producta gigantea* from the Carboniferous Limestone near Hexham; presented by Gilpin Gorst, Esq. F.G.S.

Specimens of *Voluta Lima* from Hordwell; *Orthis canalis* and *Cyclolites* from the Wenlock Shale; and casts of vertebræ of *Streptospondylus Cuvieri* from the Lias of Whitby, and two ungual phalanges of Iguanodon from the Wealden formation at Horsham; presented by Mr. James Tennant, F.G.S.

Schist with tortuous impression from Killarney, and Calcareous Earth from Lough Derg; presented by Joseph Parker, Jun., Esq. F.G.S.

Graptolites and Rock Specimens from Scotland; presented by the Earl of Selkirk, F.G.S.

Foreign Specimens.

Specimens from the Islands of the Southern Pacific between Easter Island and New Caledonia; presented by W. H. Cunningham, Esq.

Specimens collected at Bermuda by Vice-Admiral Sir Charles Adam, and Specimens from the Falkland Islands; presented by Captain Beaufort, R.N. Hon. Mem. G.S., by direction of the Lords of the Admiralty.

Graptolites from the neighbourhood of Christiania; presented by G. W. Norman, Esq. F.G.S.

Fossils from the Lias at Fontaine Etoupefour, near Caen; presented by Ashurst Majendie, Esq. F.G.S.

Shells of recent Species from the upraised beds at Uddevalla, specimen of *Nautilus plicatus* from Trouville, and Fossils from Les Moutiers, near Caen; presented by E. H. Bunbury, Esq. Sec.G.S.

Fossil Corals from Paros; presented by Captain Graves, R.N.

Fossils from South Australia; presented by Lieut.-Col. Gawler.

Casts from Specimens of Sandstone discovered at Bajntz in Transylvania, and of the Footsteps of *Testudo Mydas*; presented by the Rev. Prof. Buckland, D.D., F.G.S.

Specimens of two Species of Crania from the Chalk of the Baltic; presented by the Rev. W. Bilton, F.G.S.

Specimens of Anthracite and Bituminous Coal, Iron, Copper and Lead Ores, Fluviatile Shells, &c. from Pennsylvania and Cuba; presented by R. C. Taylor, Esq. F.G.S.

A Fragment from one of the Columns of the Temple at Puzzuoli, with Specimens of Lithodom, Fossils, &c. from Sicily; presented by Sir Woodbine Parish, K.C.H., F.G.S.

Slab of Limestone with Orthoceras from Lake Champlain, United States; presented by Captain Nelson, R.E.

Fossils from the Western part of Ohio; presented by John Locke, Esq. of Cincinnati.

Sand-tubes formed by Lightning, from South America; presented by Charles Darwin, Esq. F.G.S.

Recent Freshwater and Land Shells from Chusan; presented by Dr. Cantor of Calcutta.

A Series of Specimens of Obsidian; presented by Capt. J. Vetch, R.E., F.G.S.

Specimen of *Palæonisas Brongniarti* (Milne Edwards) from the Tertiary of Le Puy, Auvergne; presented by the Profs. Administrateurs of the Jardin du Roi.

Specimens from North America; presented by Charles Stokes, Esq. F.G.S.

Specimens found on the Sandbanks of the rivers Essequibo and Takutu; presented by R. H. Schomburgk, Esq.

Spirifer from the *Kupfer Schiefer* of Mansfield; presented by the Earl of Enniskillen, F.G.S.

Specimens from the Falkland Islands; presented by Capt. Beaufort, R.N., Hon. Mem. G.S.

Collection of Rock-specimens, Minerals, and Fossils, from the Cretaceous Deposits, and Carboniferous and Palæozoic Strata of Ohio: also specimens of recent Unios and *Lepidosteus osseus* from the Wabash River; presented by Dr. Dale Owen of New Harmony.

Infusorian earth and bricks made of the same material from Berlin; presented by A. Krantz, Esq.

Collection of Rocks, Minerals and Fossils, from the Coast of China, California, &c.; presented by Capt. Edw. Belcher, R.N., F.G.S.

Palæozoic Fossils from the banks of a Rivulet near St. Petersburg; presented by Sir John Lubbock.

Fossils from America; presented by the Earl of Selkirk, F.G.S.

Miscellaneous.

Cone of *Encephalartos horridus*; presented by the Horticultural Society.

Model of Mount Ætna by M. Elie de Beaumont; presented by M. Elie de Beaumont, For. Mem. G.S.

Charts and Maps.

Sheets Nos. 80, 81 and 90, of the Ordnance Map, in continuation of the Trigonometrical Survey of Great Britain; presented by the Master-General and Board of Ordnance.

Ordnance Townland Survey of the Counties of Kilkenny, 49 sheets; and of Clare, 77 sheets; presented by Col. Colby, by direction of the Lord Lieutenant of Ireland.

The Charts, &c. published by direction of the Lords Commissioners of the Admiralty during the year 1841; presented by Capt. Beaufort, R.N., by direction of the Right Honourable the Lords Commissioners of the Admiralty.

Pilote Française, 5ième partie; Carte de l'Entrée de la Mer Rouge; Cartes des Côtes d'Arabie et de Perse; Carte des Côtes de l'Hindoustan; Carte du Golfe du Bengale; Carte de la Partie du Grand Archipel d'Asie; Carte des Iles Philippines Célèbes et Moluques; Carte des Côtes Orientales des Chine; and Carte des Mers Australes; presented by the Director-General of the Depôt for the Marine of France.

Map of Bohemia, Moravia and Silesia, coloured geologically by M. Leopold Von Buch; presented by R. I. Murchison, Esq. Pres.G.S.

Geological Map of Denmark, in 2 sheets, by Dr. George Forchhammer; presented by Dr. Forchhammer, For. Mem. G.S.

Sections XVIII. and XIX. of the Geological Map of Saxony; presented by the Council of Mines of Freyberg.

A Coloured Map of Switzerland, by M. G. Bauerkeller, and one in relief; a Coloured Map of the Mont Blanc, by M. J. Dubois, and one in relief; presented by M. G. Bauerkeller.

Gardner's Geological Map of England and Wales (second edition); presented by Mr. J. Gardner.

The Diametric Section of the Principles and Theories of Geology, by Charles Moxon; presented by Mr. C. Moxon.

Impressions of 4 Plates of Trilobites and Crinoidea from specimens in the Cabinet of John Evans, Esq., of Worcester; presented by John Evans, Esq.

Grundplan und Längenprofil des Kanales von der Donan zum Marine. Entworfen von dem K. B. Oberbaurathe Freyherrn von Pechmann, in 4 sheets; presented by the Royal Commission of Public Works of Bavaria.

Four Lithographic Impressions of a Fossil Jaw, found in the Black band Ironstone at Cleland, Lanarkshire; presented by Lieut.-Gen. Lord Greenock, F.G.S.

Puits Artésien de l'Abattoir Grenelle; presented by R. Hutton, Esq. F.G.S.

The following LIST contains the Names of all the Persons and Public Bodies from whom Donations to the Library and Museum were received during the past year.

Academy of Sciences of Paris.
Admiralty, The Right Hon. the Lords Commissioners of the.
Agassiz, Prof. L., For. Mem. G.S.
American Philosophical Society held at Philadelphia.
Athenæum, Editor of.

Bauerkeller, M. G.
Bayfield, Mr. T. G.
Beaufort, Capt. R.N., Hon. Mem. G.S.
Belcher, Capt. R.N., F.G.S.
Benett, Miss.
Bilton, Rev. W., F.G.S.
Birmingham Philosophical Institution.
Boston Society of Natural History.
Bouchard-Chantereaux, M.
Bowerbank, J. S., Esq., F.G.S.
British Association for the Advancement of Science.
Brodie, Rev. P. B., F.G.S.
Brongniart, Prof. A., For. Mem. G.S.
Brown, John, Esq., F.G.S.
Buckland, Rev. Prof., D.D., F.G.S.
Bunbury, E. H., Esq., Sec. G.S.
Busk, G. Esq.

Cambridge Philosophical Society.
Cantor, Dr.
Charpentier, M. Jean de.
Cooper, D., Esq.
Craig, John, Esq.
Crane, G., Esq., F.G.S.
Cunningham, W. C., Esq.

Darwin, Charles, Esq., F.G.S.
Daubeny, Prof., M.D., F.G.S.
Day, W., Esq.
De Koninck, M. L.
Depôt Général de la Marine de France.
Des Moulins, M. Chas.
Desor, M. E.
De Tchihatchoff, M. Pierre.
D'Hombres-Firmas, M. le Baron.
D'Orbigny, M. Alcide.
Dumont, Prof. A. H., For. Mem. G.S.

East India Company.
Egyptian Society.
Elie de Beaumont, M. L., For. Mem. G.S.
Enniskillen, Earl of, F.G.S.
Evans, John, Esq.
Ewing, W. C., Esq.

Fischer de Waldheim, M.G., For. Mem. G.S.
Fitton, W. H., M.D., V.P.G.S.
Forbes, E., Prof.
Forchhammer, Dr. George, For. Mem. G.S.
Franklin, Sir J., F.G.S.
Freyberg, Council of Mines of.

Gardner, Mr. J.
Gawler, Lieut.-Col.
Geneva, Natural History Society of.
Geological Society of France.
Gibson, W. S., Esq., F.G.S.
Godeffroy, M. Ch.
Gorst, Gilpin, Esq., F.G.S.
Grantham, R. B., Esq., F.G.S.
Grateloup, Dr.
Gray, J., Esq.
Gray, J. E., Esq., F.G.S.
Graves, Capt. R.N.
Green, Charles, Esq.
Greenock, Lieut.-Gen. Lord, F.G.S.
Guise, W. V. Esq., F.G.S.

Hall, J., Esq.
Hamilton, W. J., Esq., M.P., Sec. G.S.
Hausmann, Prof. J. F. L., For. Mem. G.S.
Henwood, W. J., Esq., F.G.S.
Hopkins, W., Esq., F.G.S.
Hore, Rev. W. S., F.G.S.
Horticultural Society.
Hoskins, S. E., M.D.
Hunt, Robert, Esq.
Hutton, Robert, Esq., F.G.S.

Ireland, The Lord Lieut. of.

Jardin du Roi, Professeurs Administrateurs of the.
Johnston, Prof. J. F. W., F.G.S.
Jukes, J. B., Esq., F.G.S.

Krantz, A., Esq.

Lance, E. J., Esq.
Lea, Isaac, Esq.
Lewis, Rev. T.
Leymerie, M. Alexander.
Liebig, Professor Justus, M.D.
Linnean Society of London.
Literary Fund Society.
Literary and Philosophical Society of Newcastle-upon-Tyne.
Locke, J., Esq.
London Electrical Society.
London Library.
Lowe, Mrs.
Lubbock, Sir John.
Lyell, Charles, Esq., V.P.G.S.

Majendie, A., Esq., F.G.S.
Martins, Charles, M.D.
Michelotti, Sig. Giovanni.
Moore, C., Esq.
Morton, S. G., M.D.
Moscow, Imperial Society of.
Moxon, Charles, Esq.
Munster, Count, For. Mem. G.S.
Murchison, Roderick Impey, Esq., Pres. G.S.
Museum d'Histoire Naturelle de Paris.

Nattali, Mr. M. A.
Natural History Society of Northumberland.
Nelson, Capt. R.E.
Newbold, Lieut. T.
Newman, Edward, Esq.
Norman, G. W., Esq., F.G.S.
Nyst, M. H.

Ordnance, Master-General of the.
Ormerod, G. W., Esq., F.G.S.
Owen, Dr. Dale.

Parish, Sir W., K.C.H., F.G.S.
Parker, Joseph, Jun., Esq.
Phelps, J. D., Esq., F.G.S.
Portlock, Capt. R.E., F.G.S.
Pritchard, Andrew, Esq.

Quetelet, M. A.

Raulin, M.
Repertory of Patent Inventions, the Proprietor of.
Richardson, G. F., Esq., F.G.S.
Ritter, Herr C.
Royal Academy of Berlin.
Royal Academy of Brussels.
Royal Academy of Munich.
Royal Agricultural Society of England.
Royal Asiatic Society.
Royal Astronomical Society.
Royal College of Surgeons.
Royal Commission of Public Works of Bavaria.
Royal Geographical Society of London.
Royal Geological Society of Cornwall.
Royal Institute of British Architects.
Royal Institution of Cornwall.
Royal Polytechnic Society of Cornwall.
Royal Society of Copenhagen.
Royal Society of Edinburgh.
Royal Society of London.

Scarborough, Philosophical Society of.

Schomburgk, R. H., Esq.
Selkirk, Earl of, F.G.S.
Sharpe, Daniel, Esq., F.G.S.
Silliman, Prof., M.D., For. Mem. G.S.
Society of Arts.
Stevens, H., Esq., F.G.S.
Stock, Mr. Edward.
Stokes, Charles, Esq., F.G.S.
Sutherland, A. R., M.D., F.G.S.

Taylor, R. C., Esq., F.G.S.
Taylor, Richard, Esq., F.G.S.
Tennant, Mr. James, F.G.S.
Tenore, Sig.

Van Voorst, Mr. J.
Vetch, Capt. J., R.E., F.G.S.
Von Buch, Herr. Leopold, For. Mem. G.S.

Walton, W., Esq.
Washington, National Institution at.
Weaver, Thomas, Esq., F.G.S.
White, H. C., Esq., F.G.S.
Wiggins, John, Esq., F.G.S.
Wilme, B. P., Esq.
Wood, S. V., Esq., F.G.S.

Zoological Society of London.

List of PAPERS *read since the last Annual Meeting February* 18*th*, 1842.

February 23rd.—Report on the Missourium now exhibiting at the Egyptian Hall, with an inquiry into the claims of the Tetracaulodon to generic distinction, by Richard Owen, Esq., Hunterian Professor in the Royal College of Surgeons, F.G.S.

March 9th.—On the Salt Steppe south of Orenburg, and on a remarkable freezing Cavern, by R. I. Murchison, Esq., Pres. G.S.

——————— A Letter from Sir John Herschel to R. I. Murchison, Esq., in explanation of the Phænomena exhibited by the freezing Cavern.

——————— On some Phænomena observed on Glaciers, and on the internal temperature of large Masses of Ice or Snow, with some Remarks on modern Ice Caves which occur below the limit of perpetual Snow, by Sir John Herschel, Bart., F.G.S.

——————— On Rock-Basins in the Bed of the Toombuddra, in Southern India, between 15° and 16° of latitude, by Lieut. Newbold of the Madras Army.

——————— Notices on a great Cavern near the village of Cacaguamilpas; on the remains of an Elephant found near the Hacienda of Chapingo; and on six specimens of pumice and obsidian from a Well near Perote in Mexico, by J. Phillips, Esq. Communicated by J. Taylor, Esq., Treas. G.S.

March 23rd.—On the Coal-fields of Pennsylvania and Nova Scotia, by W. Logan, Esq., F.G.S.

——————— On the Tchornoi Zem, or Black Earth of the Central Regions of Russia, by R. I. Murchison, Esq., Pres. G.S.

April 6th.—Observations on the genus Tetracaulodon, by Mr. Koch. Communicated by the President.

——————— On the Central and Southern Regions of Russia, by R. I. Murchison, Esq., Pres. G.S., M. E. de Verneuil, and Count Keyserling.

May 4th.—Letter addressed to the President, by William Ick, Esq., of the Birmingham Philosophical Institution, on some superficial deposits near Birmingham.

——————— Postscript to the Memoir on the occurrence of the Bristol Bone-bed in the neighbourhood of Tewkesbury, by H. E. Strickland, Esq., F.G.S.

——————— On the High Temperature of Wells in the neighbourhood of Delhi, by the Rev. Robert Everest, F.G.S.

——————— On the Tertiary Formations and their connexion with the Chalk in Virginia and other parts of the United States, by Charles Lyell, Esq., V.P.G.S.

May 18th.—A Memoir on the Geological Structure of the Ural Mountains, by R. I. Murchison, Esq., Pres. G.S., and Count Keyserling.

June 1st.—Notice of some Experiments on the Electric Currents in Pennance Mine, near Falmouth, by R. Were Fox, Esq. Communicated by the President.

——————— On the Structure of the Lake District, by William Hopkins, Esq., F.G.S.

June 15th.—On the packing of Ice in the river St. Lawrence; the occurrence of Landslips in the modern deposits of its valley; and the existence of Marine Shells in them and on the mountain of Montreal, by W. E. Logan, Esq., F.G.S.

———————On the Structure and History of the Mastodontoid Animals of North America, by R. E. Grant, M.D., Professor of Comparative Anatomy and Zoology in University College, London, F.G.S.

June 29th.—Notices connected with the Geology of the Island of Rhodes, by T. A. B. Spratt, Esq., of H.M.S. Beacon. Communicated by Charles Stokes, Esq., F.G.S.

——————— On the minute Structure of the Tusks of extinct Mastodontoid Animals, by Alexander Nasmyth, Esq., F.G.S.

——————— On the Discovery of Insects in the Wealden of the Vale of Aylesbury, by the Rev. P. B. Brodie, F.G.S.

———————On the Geology of Egypt, by Lieut. Newbold, of the Madras Army. Communicated by the President.

——————— Letter addressed to the Secretaries, by C. Kaye, Esq., F.G.S., on the Discovery of Organic Remains near Pondicherry, Trichinopoly, and Verdachellum.

——————— On the Fossil foot-prints of Birds and Impressions of Rain-drops in the Valley of the Connecticut, by Charles Lyell, Esq., V.P.G.S.

——————— Note respecting the Ochil Hills, by Capt. Pringle, F.G.S.

November 2nd.—On the Geology of the Western States of North America, by Dr. Dale Owen. Communicated by the President.

November 16th.—On the Structure of the Delta of the Ganges, as exhibited by the boring operations in Fort William, by Lieut. R. B. Smith, Bengal Engineers.

November 16th.—On Pipes or Sand Galls in Chalk, by Joshua Trimmer, Esq., F.G.S.

——————— On some remarkable Concretions in the Tertiary Beds of the Isle of Man, by H. E. Strickland, Esq., F.G.S.

November 30th.—On the Bala Limestone, by Daniel Sharpe, Esq., F.G.S.

——————— On certain Impressions on the Surface of the Lias Bone-Bed in Gloucestershire, by H. E. Strickland, Esq., F.G.S.

——————— Notice on the discovery of the Remains of Insects in the Lias of Gloucestershire, by the Rev. P. B. Brodie, F.G.S.

Dec. 14th.—On the Ridges, Elevated Beaches, Inland Cliff, and Boulder Formations of the Canadian Lakes and Valley of St. Lawrence; with additional Remarks on the Recession of the Falls of Niagara, by Charles Lyell, Esq., V.P.G.S.

Jan. 4th, 1843.—Notice on a Suite of Specimens of Ornithoidicnites, or Foot-prints of Birds, on the New Red Sandstone of Connecticut, by G. A. Mantell, LL.D., F.G.S.

——————— Extract from a letter from W. C. Redfield, Esq., to Charles Lyell, Esq., on newly discovered Ichthyolites in the New Red Sandstone of New Jersey.

——————— Letter from Dr. Nicholson of Sydney, on Fossil Bones recently discovered at Moreton Bay.

——————— Extract from a letter from His Excellency George Gray, Esq., to Charles Lyell, Esq., on the Geology of the Country lying between the Eastern Shore of St Vincent's Gulf and Lake Alexandrina.

Jan. 18th.—On the Silurian Rocks of the South of Westmoreland and North of Lancashire, by Danial Sharpe, Esq., F.G.S.

——————— On the Stratified Rocks of Berwickshire, and their imbedded Organic Remains, by William Stevenson, Esq. Communicated by the President.

——————— Notice on the Fossilized Remains of the soft parts of Mollusca, by G. A. Mantell, LL.D., F.G.S.

——————— Description of three Fossil Fruits from the Chalk formation of the S.E. of England, by G. A. Mantell, LL.D., F.G.S.

Feb. 1st.—On the Tertiary Strata of the Island of Martha's Vineyard in Massachusetts, by Charles Lyell, Esq., V.P.G.S.

——————— Letter from J. Hamilton Couper, Esq., to Charles Lyell, Esq., on Fossil bones found in digging the New Brunswick Canal in Georgia.

——————— On the Geological position of the *Mastodon giganteum*, and associated fossil remains at Big-Bone Lick, Kentucky, by Charles Lyell, Esq., V.P.G.S.

Sums actually Received and Expended

Receipts.

	£.	s.	d.	£.	s.	d.	£.	s.	d.
Banker, including 34*l.* 10*s.* Wollaston Fund and 12*l.* 2*s.* Map Account..				126	10	11			
Accountant to meet current expenses .				40	0	0			
							166	10	11
Arrears :				£.	s.	d.			
Admission Fees				27	6	0			
Annual Contributions				129	3	0			
Transactions				2	10	0			
							158	19	0
Ordinary Income :				£.	s.	d.			
Annual Contributions...............				699	6	0			
Admission Fees :	£.	s.	d.						
Residents (8)	50	8	0						
Non-Residents (18)..	189	0	0						
				239	8	0			
							938	14	0
Compositions :									
Three at 31*l.* 10*s.* each							94	10	0
				£.	s.	d.			
Transactions (sold)				282	18	0			
Proceedings (sold).................				10	2	0			
							293	0	0
Geological Map..............................							34	10	0
Wollaston Donation Fund, 12 months' Interest on 1084*l.* 1*s.* 1*d.* Reduced 3 per cents..............							32	0	11
Dividends :				£.	s.	d.			
Six months on 2565*l.* 11*s.* 8*d.* Consols				38	9	8			
Ditto, 2706*l.* 19*s.* 1*d.* Consols				39	8	5			
							77	18	1
							£1796	2	11

We have compared the Books and Vouchers presented to us with these Statements, and find them to be correct.

Signed, R. HUTTON, A. AIKIN, WILLIAM TITE, } Auditors.

Feb. 8, 1843.

during the year ending December 31, 1842.

PAYMENTS.

	£.	s.	d.	£.	s.	d.
Bills outstanding:						
Scientific Expenditure	3	16	6			
House Expenditure	2	0	6			
Legal Expenses	24	1	0			
				29	18	0
General Expenditure:	£.	s.	d.			
Repairs of House	9	9	2			
House Expenses	158	5	1			
Taxes, Assessed	29	7	8			
Poor's Rates	25	12	4			
Parochial Rates	8	16	8			
Household Furniture	4	14	10			
				236	5	9
Insurance				9	0	0
Salaries and Wages:	£.	s.	d.			
Curator	148	11	0			
Sub-Curator	100	0	0			
Clerk	84	0	0			
Porter and Housekeeper	80	0	0			
Servant	33	4	0			
Collector's Poundage	32	3	9			
				477	18	9
Scientific Expenditure				76	3	3
Stationery and Miscellaneous Printing				49	4	11
Tea for Meetings				48	18	7
Cost of Publications:	£.	s.	d.			
Transactions	169	11	2			
Proceedings	165	14	3			
				335	5	5
Map				11	15	6
Contribution repaid				3	3	0
Award of Wollaston Donation Fund:	£.	s.	d.			
M. L. von Buch, Gold Medal	10	10	0			
Mr. J. Morris	24	0	0			
				34	10	0
Balances in hand:	£.	s.	d.			
Banker, including *32l. 0s. 11d.* Wollaston Fund and *34l. 16s. 6d.* Map Account	443	19	9			
Accountant to meet current expenses	40	0	0			
				483	19	9
				£1796	2	11

VALUATION *of the Society's Property; 31st December* 1842.

PROPERTY.

	£.	s.	d.	£.	s.	d.
Balances in hand, including *32l. 0s. 11d.* Wollaston Fund and *34l. 16s. 6d.* Geological Map				483	19	9
Arrears due to the Society:						
Admission Fees	58	16	0			
Annual Contributions	244	13	0			
Transactions	4	18	6			
				308	7	6
Estimated value of unsold Transactions				1214	8	6
Estimated value of unsold Proceedings				40	0	0
Value of Funded Property, *2706l. 19s. 1d.* Consols at 94				2544	0	0
				£4590	15	9

DEBTS.

	£.	s.	d.	£.	s.	d.
Bills outstanding:						
Scientific Expenditure	10	0	0			
House Expenditure	5	0	0			
Collector's poundage	5	7	1			
Sewers' Rate	2	13	0			
Transactions	558	4	0			
Proceedings	12	0	0			
				593	4	1
Cash belonging to the "Wollaston Fund"				32	0	11
Cash belonging to Map Account				34	16	6
Arrears not likely to be received				120	0	0
				780	1	6
Balance in favour of the Society				3810	14	3
				£4590	15	9

[*N.B. The value of the Collections, Library and Furniture is not here included: nor is the "Donation Fund," instituted by the late Dr. Wollaston, amounting at present to* 1084*l.* 1*s.* 1*d. in the Reduced* 3 *per cent. Annuities; the dividends thereof being appropriated to the purposes of the Founder.*]

Signed, JOHN TAYLOR, TREASURER.

Feb. 8, 1843.

Estimates *for the ensuing year* 1843.

INCOME EXPECTED.

	£.	s.	d.	£.	s.	d.
Arrears due to the Society, Dec. 31st, 1842. (See Valuation-sheet)				308	7	6
Ordinary Income for 1843 estimated:						
Annual Contributions (210 Fellows)				661	10	0
Admission Fees:						
Residents (15)	94	10	0			
Non-residents (15)	157	10	0			
				252	0	0
Compositions (2)				63	0	0
Sale of Transactions	200	0	0			
—— Proceedings	10	0	0			
				210	0	0
Dividends on "Wollaston Donation Fund"				31	11	6
Ditto on 12 months Consols, 2706*l.* 19*s.* 1*d.*				78	16	10
				1605	5	10
Balance against the Society				622	3	2
				£2227	9	0

Signed, JOHN TAYLOR, Treasurer.

Feb. 8, 1843.

EXPENDITURE ESTIMATED.

	£.	s.	d.	£.	s.	d.
Debts outstanding. (See Valuation-sheet)				593	4	1
General Expenditure:						
Repairs of House	15	0	0			
Taxes	66	0	0			
Insurance	9	0	0			
House Expenses	190	0	0			
Household Furniture and Linen	20	0	0			
				300	0	0
Salaries and Wages:						
Curator	150	0	0			
Sub-Curator	100	0	0			
Clerk	84	0	0			
Porter and Housekeeper	80	0	0			
Servant	33	4	0			
Collector's Poundage	20	0	0			
				467	4	0
Scientific Expenditure				60	0	0
Stationery and Miscellaneous Printing				60	0	0
Tea for Meetings				55	0	0
Cost of Publications:						
Transactions	400	0	0			
Proceedings	140	0	0			
				540	0	0
Arrears not likely to be received				120	0	0
Employment of the "Wollaston Fund"				32	0	11
				£2227	9	0

After the Reports had been read, it was resolved,—

That they be received and entered on the Minutes of the Meeting; and that such parts of them as the Council may think fit, be printed and distributed among the Fellows.

Gentlemen,

The Report of the Council having acquainted you that the Wollaston Medals have this year been adjudicated to MM. Dufrénoy and Elie de Beaumont, I beg to preface their delivery by a very few observations.

With liberal and enlightened views, Dr. Wollaston left the Council of this Society perfectly unfettered in the selection of persons qualified to receive the proceeds of a fund, which he bequeathed to us for the purpose of encouraging geological researches, or of rewarding those who may successfully complete them. In founding a medal which bears on it the likeness of that great philosopher, we recognised the principle of reward for eminence in geological labours, whilst the surplus interest of the fund was to be annually bestowed on some man of science employed in the accumulation of facts. In the course of the Address which I am about to read, the useful application of one of these donations will be pointed out, and in the mean time I will briefly advert to the destination of the two Gold Medals, which have been voted to M. Dufrénoy and M. Elie de Beaumont, for their Geological Map of the kingdom of France.

Of the peculiar excellences of this splendid work, as creditable to the French Government who fostered it as to the geologists who executed it, I expressed unqualified approbation in my Discourse of last year, soon after the map was sent to us; and I dwelt with great satisfaction on the assurance of its authors, that they had pleasure in offering it to us, as, in our own islands, when young geologists, they first acquired that knowledge of the classification of sedimentary deposits which led them to embark in their great national enterprise.

To treat of all the merits of our distinguished Foreign Associates, would be to enter, not only upon the geology of France, but also on the structure of other tracts of the surface of the globe on which their labours have shed so much light. I will therefore simply express my sincere belief, that the Council of this Society never made an award more creditable to its just appreciation of high geological merit.

In heartily congratulating you, Gentlemen, in having done honour to yourselves by adding the names of Dufrénoy and de Beaumont to the list of those foreign philosophers who have won the meed of your applause, you have, I am convinced, raised the value of our medals in the estimation of all cultivators of geology; and in handing them to our Foreign Secretary, for transmission to our French Associates, I beg he will express to them, that in this award we view them, not as foreigners, but as friends and leaders, from whose writings we have received both instruction and delight, and whose successful career we have thus endeavoured to honour by the choicest gift we have it in our power to bestow.

In presenting the Medals to Sir H. De la Beche, Mr. Murchison rose and said,—

Sir Henry, I have to request you to make known to our eminent French Associates, how highly we prize their services; a task which may indeed be well confided to you, as, by your long-continued and active labours in the same departments of our science, you are better qualified than any member of this Society to appreciate the high order of merit of the Geological Map of France.

Sir Henry De la Beche, in reply, expressed the sincere gratification it afforded him to receive the Medals on behalf of his friends MM. Dufrénoy and Elie de Beaumont. It would be superfluous, he said, in any assembly of geologists to advert to the labours of such men; they were known and fully appreciated by the world, and the Geological Map of France spoke for itself. MM. Dufrénoy and Elie de Beaumont had desired him to express to the Society the high estimate they entertained of the honour conferred upon them; and he felt assured that the Society could not but experience great gratification in thus endeavouring to show its deep sense of the important benefits which, in common with the geologists of all nations, it had derived from the works of these distinguished men.

The President then handed the balance of the Wollaston Fund to the Secretary, Mr. W. J. Hamilton, to promote the publication of Mr. Morris's tabular work, the merits of which were adverted to last year.

It was resolved :—

1. That the thanks of this Society be given to Roderick Impey Murchison, Esq., retiring from the office of President.

2. That the thanks of this Society be given to Prof. Daubeny, Dr. Fitton, and Charles Lyell, Esq. retiring from the office of Vice-President.

3. That the thanks of this Society be given to John Taylor, Esq., retiring from the office of Treasurer.

4. That the thanks of this Society be given to E. H. Bunbury, Esq., retiring from the office of Secretary.

5. That the thanks of the Society be given to Arthur Aikin, Esq., Sir W. J. Hooker, Joseph Prestwich, Esq., the Earl of Selkirk, and Prof. Daubeny, retiring from the Council.

6. That the special thanks of this Annual Meeting be given to Mr. Lonsdale, our late Curator and Librarian, for the unremitting zeal, talent, and efficiency with which he discharged the duties of those offices during a period of nearly fourteen years. That he be assured that the Society regards his exertions as having been advantageous in the highest degree, not only to our Institution, but to the advancement of Geological Science; and that he takes with him on his retirement, the respect of all our members, and their earnest wishes for his welfare and amended health.

After the Balloting Glasses had been duly closed, and the lists examined by the Scrutineers, the following gentlemen were declared to have been duly elected the Officers and Council for the ensuing year :—

OFFICERS.

PRESIDENT.

Henry Warburton, Esq., M.A., F.R.S. and H.S.

VICE-PRESIDENTS.

Rev. W. Buckland, D.D., F.R.S. and L.S. Professor of Geology and Mineralogy in the University of Oxford.
Charles Darwin, Esq. F.R.S.
G. B. Greenough, Esq. F.R.S. and L.S.
John Taylor, Esq. F.R.S.

SECRETARIES.

Robert A. C. Austen, Esq.
William John Hamilton, Esq. M.P.

FOREIGN SECRETARY.

Sir H. T. De la Beche, F.R.S. and L.S.

TREASURER.

John Lewis Prevost, Esq.

COUNCIL.

Thomas Bell, Esq. F.R.S. & L.S.
Edward Herbert Bunbury, Esq. M.A.
Sir P. Grey Egerton, Bart. M.P. F.R.S.
W. H. Fitton, M.D. F.R.S. and L.S.
Leonard Horner, Esq. F.R.S. L.S.
Robert Hutton, Esq. M.R.I.A.
Charles Lyell, jun. Esq. F.R.S. L.S.
Gideon A. Mantell, LL.D. F.R.S.
R. I. Murchison, Esq. F.R.S. L.S.
Samuel Peace Pratt, Esq. F.R.S. L.S.
J. Forbes Royle, M.D. F.R.S. L.S.
Rev. Adam Sedgwick, F.R.S. L.S. Woodwardian Prof. in the University of Cambridge.
Daniel Sharpe, Esq. F.L.S.
H. E. Strickland, Esq. M.A.

CURATOR.

Edward Forbes, Esq.

Anniversary Address of the President,

R. I. Murchison, Esq. F.R.S.

Gentlemen,

The past year has been favourable to the duration of the life of geologists, for we have lost no one working member. Some, however, of our Associates have passed from this stage of existence, and I will briefly allude to three, whose position and literary talents, or connexion with our pursuits, seem to me to claim notice.

In the first place, I have to pay a tribute to the late President of the Royal Asiatic Society, the Earl of Munster, the companion of my boyhood and the friend of maturer years. Educated at the Royal Military College, and with no other advantages than those which fall to the lot of other young soldiers, George Fitzclarence early shared in the bitter hardships and final triumph of the Corunna campaign; and, taking an active part in the Peninsular war which followed, he was repeatedly wounded and once taken prisoner, owing to the gallant exposure of his person. The esteem of his great commander, thus won in the field, attended Lord Munster to the close of his life. Without tracing the career of my friend in India, where he served on the staff of the Governor-General, or following him through his travels in Egypt, where he explored the pyramids with Salt and Belzoni, I may say that with his acute and observant mind, he there imbibed a taste for Eastern art and story; and, taking a comprehensive view of those countries and their people, he laid the foundation of that acquaintance with Oriental subjects which formed the chief object of his subsequent researches. The military annals of the nations of the East naturally attracted so enthusiastic a soldier, and fifteen years have now elapsed since he first conceived the plan of a history of Oriental Castrametation or the science of encampments from the earliest ages. With the progress of his inquiries, however, and with fresh materials, his views enlarged; and another work on a gigantic scale was commenced, which was designed to embrace the tactics and warfare of all Oriental nations, interspersed with ethnical notices from the earliest records down to the wars of British India. Some idea may be formed of the vastness of this undertaking, unhappily arrested by the death of its projector, from the fact, that the materials he had already collected with unwearied industry, and sometimes at great expense, in the libraries and archives of Europe and Asia, fill 2000 quires of folio paper; exclusive of a vast store of rare plates and detached memoranda bearing on his subject. Let us hope that the accomplished young scholar, Dr. Sprenger, whom his Lordship selected to translate many of these documents from the Arabic and other Eastern languages, or some fitting member of the Asiatic Society, may be found to prepare for publication the most important of the results at which he had arrived. So widely were his correspondents distributed, that they extended to Orenburg and Astrachan, the remotest limits of the Russian empire; and in the University of Kasan, where, I would observe, more knowledge of the East is to be obtained, both in historical and in numismatic lore, than perhaps in any other city of Europe, it was truly gratifying to me to find the name of my friend occupying a high place in the estimation of learned Oriental Professors.

As a member of this Society, Lord Munster took a warm interest in our progress. So persuaded was he of the practical value of geology, and so desirous of communicating a knowledge of it to his children, who were his constant companions, that he ingeniously devised a model of the crust of the globe, which served to convey a good elementary notion of the succession of the principal strata, and the derangements to which they have been subjected by the eruption of intrusive rocks. This anecdote will, I trust, not be considered irrelevant in addressing associates who can discern the merits of the man in his domestic relations; and in these Lord Munster was most exemplary. I cannot better terminate this brief sketch of one whom I loved, than by referring you to the eloquent panegyrics which have been paid to his memory, both by the Royal Asiatic Society, over which he presided, and by a gallant brother-soldier and respected Fellow of this Society, who, like myself, had been through life the attached friend of the Earl of Munster*.

The blank which has been left in the world of letters by the death of Dr. Arnold has been deeply felt, and the loss of a man of such profound erudition and high moral excellence is justly bemoaned by an eminent contemporary as a national calamity†. It is not for the President of this Society to attempt even a sketch of the broad lights in the character of this fervid lover of truth, nor to follow him in his useful career during the thirteen years in which he was the chief master of the great school at Rugby; but, admiring the vigour and independence of his mind, and reverencing his strenuous efforts to enlarge the bounds of education, I cannot omit to place on record, that the enrolment in our ranks of Dr. Arnold is a testimony borne by a good man, and an eminent scholar, to the usefulness and importance of geological inquiry, in the advancement of which, at the University of Oxford, under his friend Dr. Buckland, he cordially rejoiced. Though not a practical geologist, he held the pursuit in high honour, and more especially estimated its value as the true basis of physical geography.

Mr. Thomas Botfield of Hopton Court, a much-respected and very old member of this Society, came among us when geology was held at a low public estimate, and when its importance was ill understood, even by cultivators of other branches of physical science. Endowed with a very sagacious mind, he not only took an interest in our speculations and theories, but was strongly impressed with the practical beneficial results to be obtained from a cultivation of the positive departments of our science; and of this he gave the strongest proof, by selecting the Titterstone Clee Hill in Shropshire

* See Trans. Royal Asiatic Society, Anniversary 1842; and a short eulogium in the United Service Journal, 1842, vol. i. p. 565, written by Major Shadwell Clerke.

† Edinburgh Review, No. 154.

as the seat of his mining operations. Aware that this little elevated and detached coal-field was surrounded by older rocks, and that no similar mass was to be found between it and the heart of the adjacent country of Wales, he saw that by piercing the basalt by which it was covered, and by opening out the mountain in a scientific manner, he would render himself, to a great extent, the supplier of fuel to a large region. By this successful enterprise he amassed a considerable fortune, which he employed in hospitality and benevolence during a long and well-spent life.

OFFICIAL CHANGES.

The official change occasioned by the retirement of Mr. Lonsdale having been adverted to in the Report of the Council, and the warmest thanks of this Meeting having been voted to him, I would now express my own sense of the meritorious services of that officer.

Fourteen years, Gentlemen, have elapsed since his appointment was made; during which time your collections and your volumes attest the arduous and successful labours of your Curator and Librarian. Reorganizing our Museum, and naming a multitude of species after most elaborate comparisons with foreign and British types, he, at the same time, undertook and performed nearly the whole of the scientific duties which were formerly discharged in great measure by our honorary secretaries; and this too at a period when currents of fresh knowledge were rapidly setting in, and when our literary machinery had been rendered much more complex than in the early days of our body, through the addition of long and well-digested Proceedings, which were chiefly prepared by him.

All these duties were executed with a fidelity and singleness of purpose, an ability, and a consummate knowledge of the whole subject confided to him, which entitle him to our deepest gratitude, and fully justify me in saying that our Transactions, Proceedings, and Collections of the last fourteen years are the real monuments of Mr. Lonsdale's labours. Alas! such efforts are more than one man can continuously sustain; and the loss of health which ensued, compelled our Curator to sever those ties by which he had been connected with us.

It is not, however, to official duties only that I must now advert; for the various works of Mr. Lonsdale, also published during the same period, prove clearly how much science might have received at his hands, had they not been bound by the trammels of official duty. His new arrangement of certain strata in the Oolitic series,—his important and original suggestion of the existence of an intermediary type of Palæozoic fossils, since called Devonian,—and his masterly description of the Silurian Corals, are alone sufficient proofs of the vigour and accuracy of his researches. Placing in him the most entire confidence, and committing to his use, for a season, the proceeds of the Wollaston fund, this Society was amply repaid by the elaborate survey of a long range of the oolitic escarpments from the south-western country, with which he had long been familiar, to the Humber—a survey, from which, I venture to say, Sir Henry

De la Beche will derive the greatest advantage, when he turns his attention to these districts, in a large portion of which the boundaries of the different oolitic formations were laid down upon the Ordnance Map by Mr. Lonsdale.

The enumeration of all these duties and labours—many of them of most difficult execution—still leaves unrecorded, what every working Member of this Society must feel, that in the secession of Mr. Lonsdale we have also lost our wise and friendly adviser on every obscure and difficult point. Who among the active promoters of our science has not derived from him willing and devoted assistance? How often, when balancing difficulties inseparable from our subject, have we not benefited by his sound opinions! And with what disinterestedness and real kindness were they not offered! Where is the memoir in our Transactions, or the separate works recently published by our Members, which has not been materially improved by his suggestions? In short, I am certain I speak the sentiments of all when I say, that, from the moment of his appointment to the day of his retirement, Mr. Lonsdale infused a truly generous and highly philosophic spirit into every act and every proceeding with which he was connected. No expression, therefore, of our gratitude can be too strong when we record his labours as a geologist, the value we entertain of his official services, and the pang of deep regret we experience in his retirement from this Society.

For a while the vacancy occasioned by the retirement of Mr. Lonsdale was not filled up; but the value which was attached to the office was attested by the fact, that nine candidates claimed our suffrage. The selection of Professor E. FORBES leads me naturally to report to you the principal geological results at which our new Curator has arrived during his recent researches in the Mediterranean seas, as they are distinctly connected with the award of the Wollaston fund during a former year, to assist him in prosecuting his inquiries in the Mediterranean or Red Seas.

Mr. Forbes observed marine tertiary strata abounding in shells at an elevation of 4000 feet in the Lycian Taurus, and he fixed the age of two distinct tertiary groups in the Greek islands. He also determined that the freshwater deposits of Asia Minor and the Sporades belong to two separate groups, the relations of which with the marine tertiary strata prove that there were two eras of submergence and elevation, in that region, during the Tertiary period. He instituted a careful comparison between the organic remains of these beds and the living inhabitants of the adjacent sea, noticing the conditions under which each are found, and thus learnt that in the newest of these tertiaries (Newer Pliocene), the remains of such species as have ceased to exist in the Mediterranean are, for the most part, at present living in the Red Sea and Indian Ocean; and hence he very logically infers, that the former conditions of the Newer Pliocene period, which imply a similar and continuous submarine area, were interrupted by that elevation of land which separated the Egean and adjacent portions of the Mediterranean from the Red Sea, the faunas of which are materially distinct from each other.

Mr. Forbes explored a submarine tract of 300 miles in width, dredging in all depths between 1 and 230 fathoms. At more than 100 fathoms, the bottom often consisted of white chalky sediment, which extended throughout the Egean, and was invariably inhabited by the same species of Foraminifera. At a depth of 200 fathoms Mollusca only, of the genera Tellina, Corbula, Arca, and Dentalium were found, but associated with Annelides, Star-fishes, Crustaceans, and Zoophytes. Lastly, he ascertained the range and characters of 500 species of existing Mollusca and of numerous associated Radiata. Among the former were species which live indifferently at all depths between 10 and 150 fathoms, and several of them (including *Buccinum semistriatum*, *Dentalium quadrangulare*, and *Pleurotoma crispata*) which had hitherto been known only in a fossil state. By this examination he also arrived at the important fact, that such species as are abundant in a fossil are extremely rare in a living state, and *vice versâ*; and thus he lays before us the last remnants of a former state of the surface of whose existence we were ignorant, accompanied by the descendants of animals, which, first appearing in small numbers in a pre-existing period, are now attaining their maximum of numerical development.

Such discoveries, Gentlemen, are most important to the progress of true induction; and when these researches of Mr. Forbes are presented to you *in extenso*, as is his intention, each of us will, I doubt not, find in them some illustration of the stony deposits with which we are more familiar.

I may well, therefore, congratulate the Society on having obtained the services of such a naturalist as Mr. Forbes, of whom it has been said by a distinguished foreign contemporary, that "his anatomical knowledge, the accuracy of his thought, and the vigorous precision with which he can estimate the minute differences on which the distinction of species depends, render him a worthy successor of Mr. Lonsdale, and ensure to us that he will render important services to the advancement of Geological Science*".

Having spoken of those changes in the Society which have taken place through the demise of Members and through official changes, I now proceed to consider the progress of our Science, not merely within the British Isles, but also, as far as I am able, in other parts of the world to which geological researches have been extended. In so doing I shall follow the arrangement of last year, and treat of the rocks of each country in the order of their antiquity, commencing with the most ancient. First dwelling upon the British Isles, I will next advert to Russia, the Caucasus, Asia Minor, Turkey and the Alps, and then in succession to works upon America, the East Indies and Egypt; and after an analysis of the recent progress in Palæontology, I will take leave of you with a brief *résumé* of the principal geological results.

* Professor Agassiz, Letter to Mr. Murchison.

PALÆOZOIC ROCKS OF THE BRITISH ISLES.

Silurian Rocks.—In the Address of last year I plainly expressed my belief, founded not merely on researches in the British Isles, but also on examinations of large portions of the Continent, that the Lower Silurian group contained the most ancient fossiliferous type. This view now rests upon still firmer support, established by the labours of our geologists at home, and the doubts respecting the true zoological base of the Palæozoic rocks have been entirely dispelled. In South Wales this point has been worked out with extraordinary fidelity of research, founded both on geometrical measurements and a close search after fossils; and to these investigations I will presently advert, when speaking of the labours of Sir Henry de la Beche and his assistants of the Ordnance Geological Survey.

In illustration of the structure of the Lake Country of the North of England, Professor Sedgwick has recently given a short sketch in three letters addressed to Mr. Wordsworth; and I beg you to consult this little work, which is embodied in a Guide to the Lakes published by his friend the celebrated poet, both as a specimen of the author's vigorous style of communicating popular geological knowledge, and to obtain from it a clear general perception of the configuration of that remarkable region, and of the changes it has undergone. In regard to the older Palæozoic rocks, referring to a memoir which he read before this Society in 1832, he still adheres to the threefold division of the slate-rocks of Cumberland proposed by Mr. Jonathan Otley. With the two lowest of these, the Skiddaw slate and the green slate and its associated porphyry, we need not now concern ourselves, for they contain no organic remains. The third division, or the Upper Slaty rocks, is considered by Professor Sedgwick to represent the Silurian series. He separates it into three groups, the uppermost of which he compares with the Ludlow rocks, the second is an ill-defined hard siliceous mass, with no good fossils, and the lowest consisting of the Ireleth slate and limestone, including the Coniston, is proved by its fossils to be of the age of the Lower Silurian rocks. This view is, in short, that which has been for some time entertained by Professor Sedgwick*, and is essentially the same as that taken by Mr. James Marshall.

During the preceding year our attention was also attracted to the district by the labours of Mr. Daniel Sharpe, who had commenced a more detailed inquiry into the subdivisions of this series. He has since presented us with the results of additional researches made during the last summer, which have led to some corrections of the Map formerly prepared, and to some changes in lines of fault as well as in the order and subdivision of the stratified masses. Describing the formations in ascending order, he enumerates several additional Lower Silurian fossils as occupying the Lower Coniston limestone with its overlying series of shale, slate and flagstone; and he amends the arrangement which he proposed last year, by also including in the Lower Silurian division certain grey slaty greywacke grits which he had left in the undefined group called by him "Winder-

* See Proceedings Geol. Society. Vol. iii. p. 545 *et seq.*

mere Rocks." Another bed of limestone, that of Blawith, which Mr. Marshall had also shown to contain organic remains of the Lower Silurian type, is stated by Mr. Sharpe to underlie the Ireleth flags and slates; and he considers all this series, from the Coniston Lower limestone upwards, to form the representative of the Lower Silurian rocks, in which the Kirkby Ireleth slates are included; not from any fossils they contain (none having been found in them), but because they are strongly affected by a slaty cleavage, and though invariably conformable to the other Lower Silurian beds, are not equally conformable to those above them. After tracing the demarcation of these slates, Mr. Sharpe then adverts to the fine development of the Lower Silurian rocks in High Furness (Lancashire), where the formation has a north-easterly and south-westerly strike, in perfect parallelism with the ridges and valleys, which direction is strongly contrasted with the outline of the same rocks in Westmoreland and among the lakes, where the valleys are in the line of extensive faults, transverse to the strike; and it is in this region of greater disturbance that the rocks are in the most crystalline state (slaty cleavage, &c.). The Windermere rocks having been deprived, as above stated, of their lower member, by the admission of our author, and having been found to contain a species of Orthoceratite unknown in the Lower Silurian rocks, it is I think now more than ever probable* that they represent the Wenlock shale of the Silurian region; the more so as, resting on a great thickness of admitted Lower Silurian rocks, they are surmounted by unequivocal Lower Ludlow rock. In working out the exact relations of the Ludlow rocks of Westmoreland to those of Shropshire and Siluria, Mr. Sharpe has very considerably added to his memoir of last year, both by the addition of many species, and by distinguishing the Upper from the Lower Ludlow rock by fossils peculiar to each; and from what I know of the value of the *Terebratula navicula* as a guide, I completely approve of the arrangement, by which all the strata containing that shell are considered to be Lower Ludlow rocks.

It is indeed very remarkable, that a tract containing so little calcareous matter as the neighbourhood of Kendal, where the Lower and Upper Ludlow rocks, including in the latter the red tilestones, are strikingly displayed, should have afforded so many as eighty species of fossils which are identical with those published from the same formations in the Silurian region. Having myself visited this tract for the second time, and since Mr. Sharpe completed his last survey, I am sure he will unite with me in expressing the great obligations of all southern geologists like ourselves to the indefatigable industry and quick eye of Mr. John Ruthven of Kendal, who is the great purveyor of fossils both from the Silurian and Carboniferous rocks of the neighbourhood of his native place, and who, contributing largely to the Museum of Kendal, so ably directed by two gentlemen of that town †, is acquiring for himself a reputation in the North scarcely inferior to that which has been assigned to Miss

* See Discourse of last year.

† Mr. Gough and Mr. Danby.

Mary Anning in the South. The general conclusion of an independent and close observer like Mr. Sharpe cannot but be very gratifying to myself; for in stating that in mineral characters these Northern rocks differ most materially from those of Siluria, he points out that in each district the principal divisions of the Silurian system are distinctly maintained.

Transferring our view from the Lake Region to North Wales, we there find Mr. Sharpe applying the knowledge he had acquired in the Northern districts. In his memoir on the Bala limestone he shows, that, since that rock and its associated strata contain the same fossils as the Coniston limestone, it is of the Lower Silurian age and not Upper Cambrian, as it was formerly named. He is not however content with merely instancing a similarity of fossils and lithological succession in the Bala rocks, as compared with other well-known Lower Silurian strata, but he also proves by a transverse section, that they occupy a trough, supported on one side by older nonfossiliferous schists (part of the Berwyns) and on the other by igneous rocks (Arran Mowddy).

I am not prepared to oppose the accuracy of Mr. Sharpe's section; but when he quotes me as having stated that the Bala limestone dips under the chief mass of the Berwyn mountains, I must be allowed to state, that I visited the locality but on one occasion, with Professor Sedgwick, and the limestone beds which I then saw seemed to me to be overlapped by the Berwyn rocks upon the east. Mr. Sharpe has no doubt accurately examined the whole territory around Bala, for he states that the limestone, of which there are two bands, is on the whole thrown off from the Berwyns with a westerly dip*, and is again brought up on the edges of Arran Mowddy with an easterly and south-easterly inclination. In another section, from the head of the lake of Bala to Dinas Mowddy and Mallwyd, he proves that these Lower Silurian rocks, folding over to the east and south, are surmounted by Upper Silurian strata. The whole descending series beneath certain dark blue slates, referred to the lowest part of the Upper Silurian beds, consists of an upper limestone, rotten schist, a second Bala limestone, grey slaty grits, rotten grey clay-slate, and dark blue slate. In all these beds, with the exception of the two lowest, Mr. Sharpe has discovered fossils; and in addition to well-known British Silurian forms, including the Trinuclei, so characteristic of the Lower Silurian rocks, he has discovered the *Illænus crassicauda*, a Trilobite, eminently characteristic, I would observe, of the inferior strata of the same age in Scandinavia and Russia. The beds of this group are stated to rest against an unconformable mass of clay-slate forming a portion of the Berwyn chain; and to this rock, which is void of fossils, and all that lie beneath it, our author would restrain the application of the word "Cambrian."

This reasoning is clear, but the author must excuse me if I re-

* Professor Sedgwick still contends that the chief band of Bala limestone dips to the east.

mind him that no definite base-line of the Palæozoic rocks can be established by one transverse section only, which terminates in the centre of a very complicated region. He must know, that deposits which have no existence in a given territory set on and expand in adjacent tracts. Although, then, the structure of the Lake Country naturally gives him confidence in defining the base of the Silurian system by the comparison of the Bala rocks with those of Coniston, still it remains to be proved, whether the north-western tracts of North Wales do not contain other fossiliferous bands inferior to those of Bala. As Mr. Sharpe has not examined this part of the country, the question must be answered by others; and I rejoice to say that the reply is about to be made by the geologist, who, above all others, is most conversant with that region.

You are aware, Gentlemen, that this is the very tract in which Professor Sedgwick has so long worked, and from surveys of which he gained that intimate knowledge of slaty structure, which is now considered, thanks to his masterly memoir, an essential element in practical geology. I dwell upon this point with peculiar pleasure, because I well recollect the day when the truth of those lessons, which I first learnt from my friend, were opposed by many and accepted by few, though they now form part of the text-book of the field surveyor. To a re-examination of this country, then, Professor Sedgwick has devoted portions of the two last summers, with the distinct object of ascertaining, first, whether he was correct in his original opinion, on which I steadily relied, that great masses of the slaty rocks of North Wales, sometimes containing fossils, dipped under the Silurian rocks described by myself; and if so, secondly, what zoological distinction could be established between such rocks and those described as Lower Silurian. We were both aware, and the point was fully commented upon in my own work, that the Bala limestone fossils agreed with the Lower Silurian *; but depending upon his conviction that there were other and inferior masses also fossiliferous, we both clung to the hope that such strata, when thoroughly explored, would offer a sufficiency of new forms to characterize an inferior system. The results of Professor Sedgwick's recent researches would have been communicated to the Society before this Anniversary, had not his other avocations prevented his visiting London; and as the memoir will shortly be read before you, I will now so far allude to it only as to enable us to draw conclusions respecting the base of the fossiliferous slaty rocks of North Wales.

Professor Sedgwick has reassured himself that there are fossiliferous slaty masses, of great vertical thickness, which rise out from beneath the lowest Silurian rocks of North Wales hitherto described, and occupying the region of Merionethshire and Snowdonia, ultimately rest upon chloritic and micaceous schists (Menai Straits), into which they do not pass. The lowest of these fossil bands,

* See Silurian System, p. 308.

forming the summits and flanks of Moel Hebog and Snowdonia, are, he conceives, several thousand feet below the Bala limestone.

The hope, however, which was entertained by my friend, of finding these vastly expanded and lower members characterized by peculiar groups of fossils has been frustrated, and whatever may be the thickness of this lowest palæozoic division, in which he has collected a great number of species, he now fully admits, that zoologically it is from top to bottom a Lower Silurian series*. Charged as it is with characteristic Orthidæ and Trilobites, including the *Asaphus tyrannus*, so characteristic of the lowest Silurian rock, there are, as might be expected, a few new and undescribed species; and, among these, an Ophiura (an animal whose remains had not previously been found in strata of higher antiquity than the Lias) will not appear the least extraordinary.

The base of the palæozoic deposits, as founded on the distinction of organic remains, may now therefore be considered to be firmly established; for the Lower Silurian type is thus shown by Professor Sedgwick himself to be the oldest which can be detected in North Wales, the country of all others in Europe in which there is a great development of the inferior strata. But if classification is settled, there still remains much to be done before North Wales can be as accurately laid down upon a map as the parts of South Wales to which I will presently allude; though when the operations of the Ordnance surveyors are extended to this complicated region, we shall learn, by distinct geometrical admeasurement, the exact thickness of these subcrystalline rocks on the flanks of Snowdon.

In reference to the terms Caradoc Sandstone and Llandeilo Flags, as occasionally applied to the divisions of the Lower Silurian rocks, I must express my dissent from a proposal made by Mr. Sharpe to strike out one of these names from British nomenclature. He believes from what he has seen, that on the whole the type is the same throughout all these lower rocks; but I think Mr. Sharpe would not have offered this suggestion had he surveyed the whole of the Silurian region. If, for example, he had commenced his researches where Sir Henry De la Beche has been accurately fixing the limits of each formation, he would at all events have admitted the value of the term of Llandeilo flags, which the Director of the Ordnance Survey has informed me he considers to be a remarkably clear and well-defined formation, having a thickness of between 2000 and 3000 feet, and to be plainly separated from the Caradoc sandstone. If Mr. Sharpe supposes that by such a term as Llandeilo flags, I intended to restrict this or any other formation to a mass having one mineral character only, he has misapprehended my meaning, and I refer him to a description of the strata, as seen between Llandeilo and Llandovery, where sandstone, schist and limestone, occurring in repeated alternation, form the "Llandeilo flags." In the first years of my researches in the Silurian region, I

* See an expression of the same opinions, Geol. Proc. vol. iii. p. 5. p. 549.

was for a moment induced to think, that it would be better to merge the two lower formations under one local name; but the clear sections of South Wales, and those on the eastern flanks of the Berwyns, where the slaty calcareous rocks with large Asaphi are seen to dip under great masses of Caradoc sandstone, confirmed me in the resolution to adhere to the two local names. I trusted that as detailed surveys were made, the truth of their relations would be confirmed (under those limitations which are common to all deposits): whilst in the tracts where the calcareous matter thins out, and no clear lithological or physical differences exist, I urged that the whole of the inferior type should be distinguished from the Superior by the name of Lower Silurian. I have myself, therefore, provided for the cases when the local types are merged; but I am glad they were proposed, because they have already served as useful horizons for the labours of the Ordnance Geological Survey, to which I now call your attention.

Ordnance Geological Survey of England.—The progress which was confidently expected at the hands of the Ordnance Geological Survey, directed by Sir Henry De la Beche, has recently been so effectively extended to a country with great part of which I am well acquainted, that, whilst we are considering the subject of the Palæozoic Rocks, I take the opportunity to add my tribute to the large share of public approbation which such labours must earn for their authors. If my few comments on this subject involve reference to my own work, I trust the Society will believe that such allusions are made solely to explain the subsequent progress of other geologists.

In my last Address I alluded to the valuable researches of the Ordnance Geological Survey in South Wales, particularly in the great coal-basin; and I have now to speak of them amid the older rocks of Pembrokeshire and Caermarthenshire, forming the south-western tracts of the country termed the Silurian region. In the survey of that region, my chief object, as you know, Gentlemen, was simply to ascertain the general classification and right order of certain fossiliferous strata beneath the Old Red Sandstone. Having worked out the succession in typical districts in Shropshire, Herefordshire, Radnor and Montgomeryshire, I afterwards traced them to the south-west, until I equally determined their relations to the superior deposits in the coast-sections of South Wales. Although the labours in the latter country were thus auxiliary only to those of the arena on which the classification was established, I have had great satisfaction in finding, that my chief boundary lines of Old Red Sandstone and Upper and Lower Silurian Rocks are pretty nearly those which have resulted from the very systematic Ordnance Survey, the first corrected field-sheets of which Sir H. De la Beche has allowed me to view. This observation has reference only, however, to the development of what may be called one zone of Silurian rocks, or that to which, as contiguous to the Old Red Sandstone, I gave my chief attention. Of the existence of true Silurian rocks to the west and north of a certain line which was set up as a descending limit in South Wales, I was, I confess, entirely ignorant.

Finding no fossils in the few visits which I made to the west of that barrier in Caermarthenshire, which was provisionally agreed upon, and to the north and west of which all the country was ultimately to be explored by my friend Professor Sedgwick, we both of us believed, that such tracts, for the most part without fossils, were of higher antiquity than the Silurian districts, and that, rising up from beneath, they might hereafter be found to contain other and distinct forms of animal life.

The inquiry of Sir H. De la Beche has dispelled our ignorance. Instructing a number of intelligent young surveyors how to apply trigonometrical mensuration to stratified rocks, and patiently following up each mineral mass through its change of conditions upon its strike and throughout every contortion, the Director of the Survey has now clearly ascertained that the rocks to the north and west of the Towey in Caermarthenshire, as well as those to the north of Haverfordwest in Pembrokeshire*, instead of being an undefined assemblage, to which the term Cambrian had been applied, are in truth nothing but the very same Lower Silurian rocks which had been pointed out on the east and south, and which (the Llandeilo flags being much more important than the Caradoc sandstone) are repeated in great folds and undulations to the north and west. Often parting with their calcareous matter, these strata, often assuming a crystalline slaty cleavage, are in some tracts highly altered by the intermixture of trappean rocks, both of contemporaneous origin and subsequent intrusion. But in these altered rocks the Ordnance surveyors have detected true Lower Silurian fossils, and have thus, by zoological evidence as well as by geometrical admeasurements, convinced themselves that the rocks so very different in aspect, are nothing more than repetitions of the same fossiliferous strata which have been described upon the south and east. Such results, obtained amid strata so obscured by change, is one of the very highest triumphs of geological field-work; and I therefore wish to be foremost in recognising the deserts of the labourers who have obtained them, among whom the Director particularly cites Mr. Ramsay, already so favourably known to us by his geological map and model of the Isle of Arran.

In looking at the Ordnance Maps of North Pembroke, which have recently been coloured, and will shortly be issued to the public, it is surprising to see how symmetrical order has been obtained out of such a labyrinth, and how the fragments and pieces of such a patch-work are brought together. I have the authority of Sir H. De la Beche to state, that in some districts the convolutions are so rapid as to reproduce the same band of contemporaneous trap, in perfectly parallel lines, no less than ten or twelve times in the width of a mile, whilst bosses of eruptive trap are so numerous as to defy analytical research. Although I only passed quickly over the tract of North Pembroke, and ought therefore, never to have added it to those portions of my work which were more care-

* See Observations in Address of last year on Mr. M'Lauchlan's researches.

fully executed, I have still sufficient recollection of it to admire the beauty of the new delineations. If I may be allowed to suggest a parallel between it and districts which I have more minutely described, I am greatly mistaken if North Pembroke does not present phænomena almost completely analogous to those of the mineralized Lower Silurian rocks north of Builth in Radnorshire, and at Cornden and Shelve in Shropshire, where numerous lines of contemporaneous trap alternate with Llandeilo flags and Caradoc sandstone, and where the strata on the flanks of eruptive rocks are the seats of lead and copper ores, the sandstones being often converted into quartz rocks (Caradoc, Stiper Stones, Wrekin, &c. &c.). Combining the evidence of these tracts with those laid open by the extensive transverse sections which I formerly made in Montgomeryshire, in the north-western parts of the Silurian region, where the masses have been shown to roll over in great undulations from S.E. to N.W., I am fully prepared to admit the existence of a similar configuration in North Pembroke, West Caermarthenshire and Cardiganshire, districts with which I was very imperfectly acquainted, and where the aspect of rocks is at first sight, it must be admitted, very forbidding to those who search after fossil evidences. The greater, however, the difficulty, the greater is the merit of those who have solved the problem, and have thus established in parts of South Wales the precise relations of what were previously considered to be anomalous masses. The result of this Survey, up to the present moment, is, that in one small part only of North Pembroke is there any development of rock older than the strata containing Lower Silurian fossils, and this occurs in the promontory of St. David's, with which I am familiar: this rock, I can confidently say, is mineralogically undistinguishable from the close-grained purple greywacke of the Longmynd and Haughmond Hill in Shropshire; and in both these localities it has hitherto been found as void of fossils as in the similar rocks of the Lammermuir Hills in the South of Scotland.

In the south-eastern parts of the Silurian region, to which the Ordnance Geological Survey has also extended its labours, the accuracy of the chief lines which had been laid down, whether in May Hill, Usk, Woolhope, and the Malvern Hills, has been confirmed; and, under the vigilant eye of Mr. Phillips, some new species have been added to the former lists, both in the Lower and in the Upper Silurian rocks. Among the latter the *Pentamerus Knightii* has been found in a new locality, in the southern prolongation of the axis of Woolhope, thus showing how persistently the place of the Aymestry limestone is maintained; whilst a species of that remarkable shell, the Pleurorhynchus, has been detected in true Wenlock limestone.

In relation to the west flank of the Malvern Hills, Mr. Phillips has, by very close researches, come to an important conclusion. Certain specimens of a peculiar conglomerate or breccia having been found by his sister Miss Phillips, in which the *Pentamerus lævis* and other Caradoc fossils are associated with fragments of syenite, a further search was instituted, and a small boss of this rock was laid bare on the very edge of the syenite and in a vertical position, like most of the beds of the same formation along the north-western prolongation of these hills. The conclusion drawn by Mr. Phillips is, that a portion at least of the crystalline Malvern chain was in existence when the Caradoc sandstone was formed, an inference which is strengthened by the finer-grained adjacent and regularly bedded varieties of the sandstone containing similar minutely triturated, igneous materials. At the same time it is certain, that the great upheavals of the syenite and trappean rocks took place long after the deposition of the Silurian strata, and even after that of the old red sandstone and coal-measures, which at various points along this ridge, and particularly at the Abberley Hills, have been violently dislocated in contact with such intrusive rocks. The discovery on the west of the Malverns is, however, analogous to what has been observed along the flanks of the granitic axes in the Highlands of Scotland (Ord of Caithness, &c.), where fragments of rocks derived from them are imbedded in the old red sandstone conglomerates, thus showing an original crystalline nucleus, followed by other granitic eruptions. The Isle of Arran offers proof of such a period of activity, which it has been inferred, was posterior to the contiguous red conglomerate, in which no granitic fragments are imbedded.

When he pursues his researches to the northern parts of the Silurian region, Mr. Phillips will then see, on the flanks of the Breidden Hills, evidences nearly analogous to those which he has so well described in the Malvern Hills, and where it has been shown, that along a very ancient fissure of eruption, molten matter was consolidated before the existence of the Silurian rocks; that other eruptions followed, and were in continuous activity during the formation of the Lower Silurian strata; that again other upheavals took place by the rise of intrusive trap, which threw the previously formed contemporaneous plutonic deposits upon their edges; that the coal-measures deposited unconformably on such uplifted strata were afterwards deranged; and finally, that along the very same line of eruption, igneous matter, undistinguishable in mineral composition from that which had affected the ancient rocks, has cut its way in irregular dykes through the new red sandstone, and, from the isolation of a deposit of lias, was probably ejected subsequent to the accumulation of that deposit*.

Such facts are, it seems to me, miniature counterparts of the upraising at successive periods of mountain chains; and the grand phænomena of the Caucasus, the Alps, and the Pyrenees may nearly all be studied in our small English ridges, and some of them peculiarly well upon the flanks of the Malverns, and their continuation the Abberley Hills.

In the sequel I shall have occasion to speak of other important researches of Mr. Phillips. For the present, then, I take leave of

* See Silurian System, p. 294.

the Ordnance Geological Survey, assuring this Society, that having during the past year, for the first time, seen the practical application of the admirable method of field-survey which has been instituted by Sir Henry De la Beche, I am convinced that it will not only act directly as a great national benefit, in making more correctly known the structure of the subsoil, in a manner beyond the reach of private enterprise, but that it will materially tend to elevate Geology, by connecting it in a permanent manner with Physical Science.

Rocks of the Scottish Border.—A memoir by Mr. W. Stevenson on the Geology of Berwickshire appears to me to be worthy of commendation, from the perspicuity with which he treats a difficult subject in this his first production. In consequence of a notice in the work of Mr. Hugh Miller on the Scottish Old Red Sandstone, that Mr. Stevenson had discovered ichthyolites in that rock near his native town of Dunse, I made an excursion thither during the last summer, from the east coast of Berwickshire, which I was examining in company with my friend Count Keyserling. Having visited the localities of the Old Red fossils, and made the acquaintance of Mr. Stevenson, I perceived that he had clearly worked out the leading phænomena of the border country, and I therefore urged him to prepare the paper which has been read before you.

Notwithstanding the memoirs of Mr. Winch, Mr. N. Wood, and Mr. Witham, on the Carboniferous rocks of Northumberland and the borders, and of the excellent work of Mr. D. Milne on Berwickshire, no portion of the British Isles more required surveying, than the tract on both sides of the river Tweed, from its mouth upwards. The very clear section laid open by lowering the high road in its descent from Belford to the town of Berwick, had, it is true, completely satisfied every one who had seen it, that of the Berwickshire coal-seams (seven of which are worked), some are subordinate to the lowest beds of the mountain limestone series, and that others are far below it. Having confirmed the views of Mr. Witham, my fellow-traveller and myself worked out this point further, by following the coast from Berwick northwards to Bourne Mouth, and by ascertaining that the coal-beds beneath the Lamberton Cliffs (and others are still lower) are at considerable depths under the lowest band of limestone, containing Producti and shells of the carboniferous limestone; in short, that they form part of a red sandstone group, in which the plants of the Carboniferous system prevailed. Unluckily, the regular descending sequence from these lowest *red* coal-fields into the deposits of old red sandstone, properly so called, has not yet been noticed on the sea-coast, nor is it probable that such passage can there be detected, owing to a great dislocation which has thrown the lower carboniferous strata into a vertical position against metamorphic greywacke and trappean rocks.

Unacquainted with these coast-sections, Mr. Stevenson has, however, made out in the interior, and from comparatively obscure data, a natural ascending succession from the nonfossiliferous slaty rocks of the Lammermuir Hills, through the old red sandstone, to the base of the productive coal-field above alluded to. The old red sandstone which reposes on the Lammermuir rocks, and is frequently a coarse conglomerate, contains the scales of Holoptychius; and at a little distance in the direction of the dip, other and newer beds are loaded with impressions of plants, probably marine. Red and greenish-white sandstone and argillaceous red strata are followed by impure concretionary limestone, termed corn-stones by our author, and these pass upwards into sandstones and shale, enclosing plants peculiar to the Carboniferous system. Occupying a great breadth in the county of Berwick, and for the most part unproductive in coal, some of these bands being of red colours, and containing gypsum, were formerly mistaken for the new red sandstone. So long as a too strict adherence to lithological characters, as decisive of the age of formations, prevailed, doubts were thrown upon the age of the Berwickshire coal-field; for notwithstanding the memoir of Mr. Witham, which distinctly showed that a part of this great red coal-field lay beneath the mountain limestone, and contained many species of true carboniferous plants, the influence of the red and gypseous characters of this deposit was all-powerful. The correct view, however, has been maintained for some years by Professor Sedgwick and several other geologists.

Taking our earlier views chiefly from the English southern coal-tracts, and not sufficiently attending to their far greater development in the northern counties, we have been apt to force the larger into too strict accordance with the smaller type. Geologists, therefore, who are well acquainted only with the carboniferous succession of Bristol and South Wales, must now learn, that the lower limestone shale of these tracts (oftentimes indeed a sandstone) is the miniature representative of the enormously thick and varied carbonaceous deposits of the South of Scotland. I may say of Scotland, for it is quite evident, that some of the most productive of the coal and iron-stone fields (many of them associated with much red sandstone) in the centre of that country, occupy precisely the same horizon; their upper masses being interlaced with thin calcareous courses in which mountain limestone fossils prevail. I shall revert to this subject in alluding to a recent work of Mr. Griffith on the Geology of Ireland, where the lower part of the carboniferous system is enormously developed.

In reference to Mr. Stevenson's effort to class the fossil beds of the Old Red Sandstone near Dunse, I would observe, that we can scarcely hope to separate this formation into all its true divisions, by the aid of a very few scales of one or two species of fossil fishes only. In Russia, for example, the very highest beds of the system —beds absolutely in contact with overlying carboniferous strata, are loaded with the *Holoptychius nobilissimus*; whilst in the same region, strata, infinitely lower in the series, are charged with the *Dendrodus strigatus* and other forms which are associated with the *Holoptychius nobilissimus* in the very same stratum at Scat's Craig, near Elgin.

Describing the dislocations around Dunse, Mr. Stevenson connects them with trappean dykes, and sustains the original view of Mr. D. Milne, that the Lammermuir chain has undergone two distinct upheavals; one marked by the felspathic nature of the igneous masses affecting the older greywacke; the other by the augitic nature of the trap which has pierced the old red sandstone and coal-fields, and thrown them into discordant positions. Thus, whilst he indicates faults which traverse the whole series, he also demonstrates, that the masses of granite which intrude upon the older felspathic trap, have produced no alteration in the overlying red sandstone; the latter in fact having been deposited upon those rocks of earlier disturbance, fragments and pebbles of which are included in the red sandstone matrix, and even in the basaltic matter which has been the cause of the second great elevation of the tract.

This reminds me of an old observation of Professor Sedgwick on the flanks of the Cheviots, where he discovered that the old conglomerates at the base of the lowest carboniferous strata of Northumberland are almost made up of Cheviot porphyry; and that where the coal strata north of Berwick are set on edge, and in one place inverted, there are dykes and masses of a newer augitic trap.

Irish Ordnance Geological Survey—Tabular List of Irish fossils.—A compendious volume, entitled 'A Report on the Geology of Londonderry, and parts of Tyrone and Fermanagh,' has just been published by our associate Captain Portlock, R.E., employed in the Irish Trigonometrical Survey. Illustrated by a geological map, numerous coloured sections, and plates of organic remains, this closely packed volume, of nearly 800 pages, is a sample of how great a mass of matter may be derived from a small district. Not having had sufficient time to study the details of this work, I must crave the author's indulgence if I refer only to such parts of it as have arrested my attention. Captain Portlock, having some time ago discovered a small patch of Silurian rocks in the region of his official labours, commenced a careful and systematic inquiry into the nature of the Trilobites with which it seemed to abound, and he now presents us with some very valuable results. In a preliminary discourse he offers many important remarks upon the affinities and anatomy of this group of animals, and after a very elaborate comparison of all the forms which he could detect in his district with those published by British and foreign authors, citing among the latter several works very little known to us, he arrives at the conclusion, that of sixty species in this palæozoic tract, fifty-two belong to true Silurian strata (for the greater part Lower Silurian), and eight only to the enormously developed carboniferous limestone of the North of Ireland. This fact is quite in accordance with what has long been my belief, that the Silurian or oldest palæozoic group is the great centre of Trilobitic life. Describing many new forms, which are figured, he establishes several new genera, among which the Rhemopleurides, obtained from the Lower Silurian rocks, is a very curious and apparently quite distinct trilobite. There are but small traces of Upper Silurian or Devonian deposits in this district, the greater part of it being covered by a carboniferous series, consisting, as the mountain limestone of Ireland is known to do, of much sandstone and slate as well as limestone. Finding in it several shells which are eminently characteristic of the lower as well as of the upper beds of that great formation, he infers, and I think with perfect justice, that the mountain limestone of the North of Ireland must be compared with the whole and not with the upper part only of that formation in the North of England; an opinion I am prepared to support, by having found last summer several shells (notably the *Sanguinolaria undata*), which are published by Captain Portlock from the north of Ireland, in the very bottom beds of the limestone of Berwickshire and Northumberland. Confining myself to the researches of this author in the palæozoic rocks, on which he has shown so much skill, I must also request my hearers to consult this volume of the Irish Geological Survey, for much information respecting the overlying strata, among which some new features of the Keuper formation are sketched with the author's usual fidelity.

From the researches of Captain Portlock I turn to those of Mr. Griffith, who spent many years in preparing the Geological Map of Ireland, and for which he has deservedly received much praise. In a very elaborate comparative table of the fossils of the mountain limestone series of Ireland, presented to the Manchester Meeting of the British Association, Mr. Griffith divides that series into five subformations, which in ascending order are the Yellow Sandstone, Carboniferous Slates, Lower Limestone, Calp, and Upper Limestone. He also shows that the two lower of these subdivisions must, from their fossils, many of which ascend into the overlying strata, be classed with the mountain limestone series, and not with the Devonian rocks; in which case, I would observe, that they must also be classed with the sandstone, limestones and shale of Berwickshire, to which allusion has already been made. I am the more induced to believe in the accuracy of this comparison, because Count Keyserling and myself have this year confirmed the observation of Professor Sedgwick, made in 1828*, viz. that Posidoniæ, similar to those in the culm limestones of North Devon, exist in the middle of the mountain limestone series of Northumberland. As Mr. Griffith has shown that the Irish Calp, which also occupies the middle place in the limestone of Ireland, contains the same peculiar fossils, the parallel may now be considered as very well established, between this central mass of the mountain limestone in these distant localities.

Drawn up as this table has been under the directions of Mr. Griffith, by a diligent young naturalist of good promise, Mr. F. M'Coy, there can be no doubt that it is entitled to much consideration, and that its publication will be very useful. In reference to the comparison instituted by Mr. Griffith between the strata of North and South Devon and those of Ireland, I may observe that it is of infinite importance to the establishment of a true series of equivalents, that large adjacent tracts of country should be surveyed, and their fossils compared by the same observers, for the want of which identical species may sometimes obtain

* See Professor Sedgwick and Mr. Murchison, Geol. Trans. vol. iii. p. 693.

different specific names; thus considerably interfering with a nice discrimination of the groups.

Palæozoic Fossils.—Before I quit the subject of the older British rocks, it is my duty specially to call your notice to a memoir just published in your Transactions, because, although inserted by order of the Council, and throwing great light on British palæozoic remains, it has not yet been sufficiently alluded to from this Chair. It is the work of MM. de Verneuil, and D'Archiac on the Fauna of the Palæozoic Rocks. In the first instance this memoir was designed to consist simply of a description, by M. E. de Verneuil, of the organic remains of the Rhenish provinces explored by Professor Sedgwick and myself, and of which you have now our published views. M. De Verneuil, who combines the attainments of a good conchologist with those of a geologist, had accompanied us during a part of our survey of that region, and approving the general classification, had kindly offered to illustrate our views by the use of the very fine fossils from the Rhine and the Eifel which his cabinet contained. While instituting the comparisons necessary to prove, by evidences independent of those in England, that the Devonian is a true intermediary type, the subject became enlarged in his hands, and he was so fortunate as to procure the assistance of his friend the Vicomte D'Archiac. By combining researches and making a variety of comparisons, their work soon acquired great value, not merely as regards an accurate description of beautiful organic remains, admirably lithographed, but as containing also a general tabular list of the fossils of the Devonian system in Europe, as compared with the species of the Silurian and Carboniferous deposits in the Rhenish provinces.

This table, enriched as it has been up to the moment of publication by additions drawn from recent researches in Russia, must be considered a standard acquisition, the intrinsic merit of which can only be estimated by those who are aware of the labour and range of study which its preparation required. Nor are the general views of the authors, which are embodied in their preface, less worthy of consideration, for they exhibit an intimate acquaintance with fossil zoology and its relations to each great system of the palæozoic rocks; whilst it must be satisfactory to British geologists, that the inductions of these foreign naturalists are in harmony with those of Mr. Phillips, drawn from his own observations upon the fossils of Devon and Cornwall. As this is the first occasion on which French geologists have presented to us a memoir illustrating the writings of our own countrymen, I am confident you will unite with me in thanking them most cordially for their liberal and enlightened assistance. Whilst considering the palæozoic classification established in Great Britain, I have, therefore, thought it not irrelevant thus to allude to the labours of foreign geologists which support it; and I have the pleasure of acquainting you, that in addition to their claims upon us, MM. D'Archiac and de Verneuil have, during the last summer, explored parts of Normandy and Brittany, where they have clearly recognised in that obscure tract, the same palæozoic divisions as exist in the Rhenish provinces and the British Isles.

I cannot take leave of the palæozoic rocks of our own islands without communicating to the Society a fact, which, minute as it may seem to be, is of interest in regulating our views respecting the development of animal life. The Rev. P. B. Brodie, to whose researches in the secondary rocks I shall presently allude, informs me, that he lately discovered in the Silurian limestone on the west flank of May Hill, Gloucestershire, two palates of fishes. Now as the rock in question is of the age of the Wenlock limestone, we learn that fishes existed in the inferior as well as in the superior member of the Upper Silurian rocks, in which they had previously been noticed. No trace, however, of Vertebrata has yet been discovered in the widely extended and enormously thick Lower Silurian deposits.

Igneous Rocks of South Staffordshire.—As connected with the older depositary rocks of the central counties of England, I will now direct your attention to some recent observations on the changes to which they have been subjected by igneous agency. Besides forming a most instructive museum, singularly rich in Silurian and Carboniferous species (including many unpublished), the Geological Society of Dudley, to the establishment of which I last year alluded, has produced a report 'On the Igneous Rocks of the South Staffordshire Coal-field*,' not yet printed, with the results of which I am convinced you will thank me for making you acquainted. In the southern portion of this coal-field there are centres of eruption where the basaltic and trappean matter, rising from the bowels of the earth, completely cuts through the surrounding carboniferous strata, dislocating and altering them in the manner which has been pointed out by Mr. Keir, Mr. Arthur Aikin, and other observers, including myself. In regard to the lateral injections of the igneous matter among the coal strata, Mr. Blackwell, by comparing the shaft-sections of contiguous collieries, has shown, that however a single vertical section might seem to afford grounds for belief, that such igneous matter had been formed as a bed, yet that in reality it traverses various depositary strata in a slightly oblique direction, and often thins out in the form of a wedge. From such apparently horizontal masses, vertical dykes, with occasional lateral veins of white felspathic rock, varying in thickness from a few inches to three or four yards, are seen to rise up and traverse the coal-beds in the most irregular manner, though such dykes are not found to produce any derangement in the regular measures. Another good fact observed in relation to a supposed horizontal sheet of basalt in the midst of the sedimentary strata, is, that the beds on which it rests are less subject to faults and dislocations than those which lie above it; the intruded mass, indeed, sometimes rising up to the surface and forming a knoll, occasionally bare, and at other places covered by the coal strata, which mantle round it.

The report also proves, that some of the chief faults which radiate

* The Report to which allusion is here made, including the Sections, was drawn up by Mr. J. H. Blackwell of Dudley, assisted by Mr. W. Spencer.

from one of the great centres of eruption (Barrow Hill), were produced contemporaneously with its elevation; since the basaltic matter which flows laterally in apparent beds, follows the line of fault, bending and leaping up, as it were, without a break from lower to higher levels. From this fact Mr. Blackwell infers, that the basaltic matter must have been in fusion when it was extruded laterally along the surfaces of certain strata, but that the subsequent dislocation by which these beds were moved to different levels, took place before the igneous matter had cooled and when it was still plastic. This very remarkable phænomenon, which is indeed similar to examples cited by Dr. Mac Culloch, is an exception to the cases in other parts of the district (Wolverhampton), where the beds of basalt are broken off and change their relative places with the coal strata; and thus we learn that in the same district the faults were not all produced at one period.

Near Wolverhampton, the underground trap, which is spread over an area of five miles by two, is to a great extent perfectly conformable to the coal-measures above and below it; but when traced for upwards of three miles, its nonconformity to the coal-beds becomes apparent, and this is further confirmed by the giving off of white vertical felspathic dykes, similar to those before alluded to. It is, however, worthy of record, that no centre of eruption has yet been discovered in this part of the district whence the flow of basaltic matter could have been derived, though it is believed that it may have proceeded from the distant Rowley Hills.

After minutely elucidating the distinctions and the variations of structure and form in the various trappean rocks of this district, the report proceeds to point out the changes which have been produced in the coal-measures by their intrusion. The same beds of coal, which in parts of the field exempt from basalt are highly bituminous, are, when in contact or in the vicinity of that rock, either converted into anthracite or charred into cinders. In the Wolverhampton tract the upper portion of the coal beneath the greenstone is entirely cut out, whilst the lower part is converted into anthracite, and often fissured by vertical joints, accompanied by veins of calcareous spar; as if, in driving off the bituminous matter of the coal, the extreme heat had also occasioned a contraction of the carbonaceous mass. Besides these alterations of the coal, the beds of ironstone are equally affected, the clay being rendered porcellaneous, and the sandstones, usually much hardened, are in some cases even vitrified.

In addition to these changes, which are analogous to effects observed in other countries, and are such as a high degree of temperature will readily explain, other alterations are cited, with some of which, indeed, Mr. W. Matthews acquainted me when I examined the tract, and the solution of which is not so easy; viz. that beds slightly impregnated with iron at a distance from them, become gradually more charged with it as they approach the igneous rocks, and are of very superior quality in their immediate vicinity. This fact, indeed, is perfectly in accordance with what I have lately observed in the Ural Mountains, where masses of iron ore are crystalline and even highly magnetic when in contact with eruptive rocks.

Another point dwelt upon, perhaps still more curious, and which also requires the consideration of the chemist, is, that wherever igneous rock is present in the neighbourhood of beds of coal, and yet separated from them by an intervening substance, which has prevented their being injured by intensity of heat, the coal is frequently what is called "brighter and more bituminous!"

With such facts before them, the authors of this report are aware, that other agencies than those of mere heat, are required to account for the production of iron concretions and the crystalline structure of coal; but whilst they think that electric and magnetic currents must also have operated in bringing about some of the results, they are convinced that the presence of igneous matter, often extended laterally in the form of vast beds, must have had a great share in the production of such phænomena. Having myself taken no little interest in the formation of the Dudley and Midland Geological Society*, I hail this report upon the physical condition of the subterranean masses of that tract as worthy of the approbation of men of science in all countries; for the history of Dudley is that of many regions of the earth, which have been penetrated by intrusive matter.

Secondary British Rocks.

New Red Sandstone.—Our knowledge of the structure and contents of the uppermost member of the New Red Sandstone has been considerably increased by the researches of Mr. Phillips and the Ordnance Surveyors. In our Memoir of parts of Gloucestershire, Worcestershire and Warwickshire, Mr. H. Strickland and myself pointed out the existence of a peculiar bed of sandstone subordinate to the marls underlying the Lias, and we were led, on account of the fishes and shells contained in it, as well as from the footmarks of peculiar saurians and its geological position, to refer this rock and the associated marls to the Keuper formation of Germany and France. The more detailed researches of Mr. Phillips confirm this view, and show that the sandstone is far more continuous than was believed; winding with remarkable sinuosities over large areas, and characterized by peculiar fishes and other fossils. With such clear types to guide them, the Ordnance surveyors will, I trust, be able, as they move northwards, to show the exact line of separation between this deposit of Keuper marl and sandstone, and the great masses of inferior red and yellow sandstone, which extending from Warwick northwards, occupy large portions of the central counties, and expand into the great formation on the banks of the Mersey, so strikingly characterized by the footmarks of the Cheirotherium. These lower sandstones must, I contend, be placed on the parallel of the *Bunter Sandstein* of the Continent, in which similar impressions occur, and can never be confounded with the upper marls and sandstone of the true Keuper†.

* See Address to the Dudley and Midland Counties Geological Society, 1841.

† Since this Address was read, I have been informed by my friend Dr.

Lias and Oolites.—When we consider the number of years during which the oolitic system and the lias have been submitted to the researches of geologists, it might be expected that few or no new fossils remained to be discovered in them, but such is not the case. Whenever fresh investigations are made, undescribed forms appear, and of this we have just had a striking example in the neighbourhood of Cheltenham, where one of our members, Mr. Buckman, has collected a vast number of new species characterizing each stratum in the Lias and Inferior Oolite, and has published a most instructive tabular view, illustrating much more completely than myself, the order which I formerly pointed out to this Society. He has in short detected many undescribed organic remains, throughout the series from the Lower Lias to the Stonesfield Slate inclusive, some of which will be figured in a new edition of the outline of the Geology of the neighbourhood of Cheltenham.

And here, whilst speaking of detailed sections of the same formation in distant localities, I request my countrymen, who have studied this portion of the series, and who may travel through Germany, not to omit to visit the noble sections of lias exposed at Banz in Upper Franconia, to which I called your attention nine years ago, and which have since been grouped and described by M. von Buch in his general work on the Jura formations. In mentioning this foreign locality, I specially recommend to your notice a detailed tabular view, by M. Theodori of Banz, of the strata between the Keuper and the Inferior Oolite. With one sandstone at its summit and another at its base, the great blue lias portion of the formation is separated into no less than forty-six bands, each of which is distinguished by either peculiar mineral or zoological characters, the upper portion being

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Buckland, that he has re-discovered among the mislaid treasures of his museum, certain saurian remains from Guy's Cliff to which much interest was attached, and that Professor Owen has pronounced them to belong to the species of *Cylindricodon* described by Jäger from the Keuper sandstone of Würtemburg. When Mr. Strickland and myself contended that the sandstone of Guy's Cliff and Warwick did not represent the Keuper, we did so from positive stratigraphical evidence, which proved that a thick formation of marl and sandstone was interpolated between the base of the Lias and the Warwick sandstone. We may, indeed, have been carried too far in saying that the discovery of the same species of saurian described by Jäger must determine the age of the rock; for we are not yet sufficiently acquainted with the distribution of the fossils of the *Trias*, to know whether some species may not be common to the whole of that group, and in England, where the muschelkalk is wanting, it is no easy matter to draw the line of zoological demarcation between the *Keuper* and *Bunter* sandstones. In the mean time it will be admitted, that Mr. Strickland and myself pointed out, for the first time, an upper stage in the series of the New Red Sandstone of England, which, containing peculiar organic remains, was proved to be distinct from the underlying masses of red sandstone (Warwick, &c.), and whatever may be the *names* attached to them, these two formations must henceforward be distinguished from each other in English geology.

chiefly characterized by bituminous slaty marl, alternating with *Posidonia* and *Monotis* limestone; the middle mass by consisting of slaty clay and alum-shale with a great profusion of our well-known lias fossils; and the lower part by Gryphite limestone with its underlying shale and sandstone.

I have alluded to this detailed section, not only because I know, from personal inspection of the spot, that the author is well acquainted with the position of the numerous fossils which he cites, but also to impress upon you, that differing, as this section does, in lithological features from our British types of Lias, the agreement between the fossils of the two countries is very remarkable, a great number of species being identical with our published forms, whilst others are new. It remains, therefore, for good conchologists to ascertain how many of our British unpublished species are similar to the additional German forms; or otherwise confusion may be introduced by employing two names for the same shells.

The Rev. P. B. Brodie, to the value of whose minute researches I last year bore testimony, has since discovered insects, of which even the wings are sometimes preserved. He states that they are extensively developed in the bottom beds of the Lias through the Vale of Gloucester, an observation which he has rendered still more important, by showing that these creatures are associated with fresh-water remains and terrestrial plants mixed up with marine shells, or such, at all events, as inhabit estuaries; thus indicating the tranquil transport of insects and plants from adjacent land, probably at that period, in the form of scattered islands.

In reference to one member of these deposits, the celebrated bone-bed at the base of the Lias, Mr. Strickland, in observing certain hitherto uninvestigated appearances on its surface, has employed the analogical reasoning of a naturalist accustomed to note the habits of the lower vertebrata. Some of these markings he has sought to explain by the action of fast-swimming fishes; others by mud-feeding fishes probing and turning up the surface, whilst narrow and angular grooves are referred to the movements of an acephalous mollusk, and fine tortuous tracks are supposed to have been caused by the crawling of small annelids. This latter point was previously adverted to by Mr. Atkinson*.

Wealden.—In enriching the fauna of the Wealden formation by a second discovery of a number of new species of insects in the Vale of Wardour, Mr. Brodie has again proved how much may be done by minute and careful researches, and has shown us how essentially our acquaintance with the former conditions of land and water depend on such information. He observes, that next to the Coleoptera, the most prevalent orders are the Homoptera and Trichoptera, the first of which now live on plants, similar to those found fossil in the Wealden, and the existing species of the latter hover over the surface of our present streams. From their broken condition

* Proceedings, vol. iii. p. 126.

he thinks it probable, that these insects were carried for some distance down rivers before they reached the estuary of the Wealden*.

Cretaceous System.—Passing from the Wealden, I must allude to two communications which this session has produced from Dr. Mantell, both relating to the Cretaceous system. In one of these he describes three species of fruit from the lower greensand and chalk of Kent and Sussex, thus offering the most important addition to the flora of that period since the publication of the compendious memoir of Dr. Fitton. The other memoir is upon certain small dark brown concretions from the lower greensand of Maidstone, and to which Dr. Mantell has given the name of Molluskite, in consequence of their being supposed to be the carbonized remains of the soft parts of Mollusca. This communication is the result of the researches of Mr. W. H. Bensted of Maidstone, who collected slabs full of these concretions, previously supposed to be of coprolitic origin, but he suggested that they might be the soft portions of testaceous Mollusca. When free, and where the peculiar substance had been formed in considerable quantity and in a pure state, it was inferred by Dr. Mantell that the soft parts had floated away from the shell after the death of the animals, as often occurs at present among living testacea. Chemical examination by the Rev. J. B. Reade and Mr. Rigg detected animal carbon in the substance of some of these bodies.

Tertiary Period.

The session has not added much to our knowledge of British Tertiary deposits. Mr. Trimmer, well known to us by his researches in detrital phænomena, has lately expressed his opinion that the peculiar eroded surface of the chalk, in which pipes filled with sand or gravel are of frequent occurrence, was produced by the action of the sea during a period which preceded the deposit of the London clay. There can be no objection to this view being applied to all those corroded surfaces of the chalk, which are surmounted by the Eocene deposits of plastic clay and sand and London clay, including, I would add from the recent observations of Count Keyserling and myself, the junction of the chalk and Lower Tertiary in Alum Bay. It would, however, be manifestly wrong to suppose, that such a corrosion of the surface of the chalk had not also been effected at other and subsequent periods; and as proofs of a still more recent corrosion, the observer has only to examine the shore and cliffs near Brighton, and see how similar cavities have been filled up by a breccia, in which the bones of elephants are imbedded.

Some remarkable concretions in the Tertiary beds of the Isle of Man (where the newer marine Pliocene strata were first described by Professor E. Forbes, and shown by him to occupy perhaps a larger area than in any one locality of the British Isles), have elicited from

* See observations on the Neocomian not being an equivalent of the Wealden, p. 67. I may here also state, that Mr. Robertson of Elgin has discovered some of the fresh water shells of the Wealden, intercalated in the oolitic strata of Brora. His memoir will soon be read.

Mr. H. Strickland the suggestion, that they were caused by currents of water, or by the action of wind during ebb-tide.

Among the terrestrial phænomena which have recently excited notice, is the discovery by Dr. Riley of a bone-cavern in the Mountain Limestone of Durdham Down near Bristol, the opening of which has been conducted by Mr. Stutchbury, who has described its contents. Distinguishing, as Dr. Buckland had formerly done, the cavities formed by fissures in the rock, into which bones had been washed with detritus of rocks and soil, or into which whole animals had fallen, from caverns inhabited by extinct species of canine animals, Mr. Stutchbury shows, that the facts observed in this case entirely favour the latter hypothesis, the bones (among which those of the hyæna vastly preponderate) being fractured into small bits without the admixture of any rolled or far-transported detritus. The most novel point connected with this cavern is, that several of the hardest bones and teeth have been split across, and their parts relatively moved, as if the detrital mass had been affected by faults posterior to its original deposit, which movements may, Mr. Stutchbury supposes, have been connected with the operations which closed the orifice of the aperture*.

Geological Dynamics.—Detrital Phænomena.—Raised Beaches and Shingle Terraces.—Marks of Ancient Levels of the Sea.—In previous years Mr. Hopkins led the way in applying mathematical and mechanical knowledge to geology, and in a memoir which will, I trust, soon appear in our Transactions, he shewed satisfactorily, that the transverse fissures through the ranges which bound elliptical areas, are the necessary mechanical effects of the upheaval of such districts. He now lays before us a memoir on the elevation and denudation of the lake districts of Cumberland and Westmoreland, in which, going further, he encounters some of the most difficult problems in geological dynamics. The first of these is to reconstruct exactly the former conditions of this district, and certain data being assumed, to deduce a series of geological events, the occurrence of which would explain the present position of the different rocks, as so many fragments of a former whole, which has been broken up at two distinct periods of eruptive agency. If all the premises which Mr. Hopkins assumes be granted, there can be little doubt, that with his profound mathematical and physical knowledge, his deductions will be accurate; but I confess that two of his postulates, viz. a perfectly smoothed down surface of the older rocks anterior to the deposition of the Mountain Limestone, and the former persistence of a continuous mantle of the latter rock over the transition, metamorphic and plutonic rocks, seem to me to be very difficult to understand.

On referring to the opinions which Professor Sedgwick has published on the structure of the Lake Country†, I perceive, that

* A similar case occurred in the gravel beds of Darmstadt, where the Dinotherium was found.

† Letters to Wordsworth in the New Guide to the Lakes.

whilst he agrees with Mr. Hopkins respecting the comparatively modern origin of the existing lakes and valleys, he does not believe with him that the whole of the valleys were formed posterior to the Mountain Limestone. On the contrary, he thinks that there are rudiments of diverging valleys of an older period. Professor Sedgwick must also I presume reject the hypothesis of the Mountain Limestone having at any period been deposited as a continuous calcareous sheet upon the older rocks, for he has expressed his belief that the limestone was accumulated as an external fringe like a vast coral reef around a cluster of more ancient rocks.

But whatever may be their differences on these points, I have reason to think that Professor Sedgwick entirely concurs with Mr. Hopkins, in the necessity of calling into play enormous aqueous currents (which followed elevations) to account for much of the coarse drift which has been poured off upon the flanks of this mountain chain. Unwilling to call in the assistance of icebergs, and opposing the hypothesis of a depression of temperature, Mr. Hopkins shows, that the propelling forces of water alone are fully adequate to produce the transport of all the blocks and gravel around the Cumbrian chain, and to spread them out in the great masses of drift which encumber the adjacent northern centres, accounting for the existence of diverging currents by a number of paroxysmal elevations. Assuming moderate upheavals of certain areas of land, to a height of 50 feet each, from beneath an ocean having a depth of 300 and 400 feet only, he informs us that a number of great divergent waves would be the consequence.

In describing the motion of such masses of water, he invokes the aid of those waves of "translation" whose properties have been reduced to laws by the ingenious and valuable researches of Mr. Scott Russell, and who, giving us measures of their relative velocity and power, has brought forward exact proofs of the transference by them of solid bodies immersed in water. Such waves have in fact been generated by the experiments of Mr. Scott Russell, exactly in the same way as Mr. Hopkins supposes waves to have originated on the great geological scale. These experiments prove, that a sudden elevation of a solid mass from beneath the water, causes a corresponding elevation of the surface of the fluid, which infallibly produces a wave of translation of the first order. Now this wave is termed one of *translation,* because it is found not to rise and fall like common waves, but wholly to rise and maintain itself above the level of the water. Arguing that this wave is propagated with a velocity which varies with the square root of the depth of the ocean, Mr. Russell determines the velocity of wave transmission; but what is of most importance to the geologist is, that the old idea of the agitation and power of waves extending a little way down only in the sea, is found to be not true as touching waves of translation; for Mr. Scott Russell has ascertained that when they are in action, the motion of the particles of the water is *nearly as great at the bottom as at the top.* He further shows, that the body moved at the bottom, is not rolled backwards and forwards as by a common surface-wave, but has a continuous forward motion during the whole transit of the wave's length. A complete transposition does therefore result from the wave-transit; and the wave of translation, says Mr. Scott Russell, may be regarded as a mechanical agent for the transmission of power as complete and perfect, as the lever or the inclined plane.

Arguing from these remarkable data of Mr. Scott Russell, and applying them to our geological phænomena, Mr. Hopkins states, that currents of twenty-five and thirty miles an hour may be easily accounted for, if repetitions of elevations of from 160 to 200 feet be granted; and with motive powers producing a repetition of such waves, our author has no difficulty in transporting to great distances masses of rock of larger dimensions than any boulders in the North of England.

In bringing his mathematical and mechanical knowledge to bear on this difficult question, Mr. Hopkins has rendered essential service to geologists, well convinced, as they must be, that no one cause could have been adequate to the formation of all the varieties of superficial detritus. He has in short arrived at numerical results, acquainting us with the exact influence of the moving power, under certain conditions*.

Admitting with Mr. Hopkins, that nearly all the great boulders at a distance from the mountains from whence they were derived, were accumulated upon the bottom of the sea, which bottom was subsequently elevated, I regret, that whilst he allows the possibility of floating ice having played a part in some cases in the transport of large blocks, he should doubt its agency in the country under consideration; for the North of England is full of examples of far-borne detritus, the position of which seems to me inexplicable by calling in the power of water *alone*. Many practical geologists must, I think, admit, that in the desiccation of the former bed of the ocean, and in its conversion into our present lands, the submarine outline of hill and dale has been, to a great extent, preserved; and if this be granted, no waves of translation nor any force of water can have hurled blocks across high ridges and deep valleys which are *transverse* to the direction which the erratics have taken, and of such relations England offers numerous examples. To a remarkable instance of this transport in our central counties I formerly adverted, contending that without the agency of floating icebergs the phænomenon seemed inexplicable†, and I now direct your notice to an excellent example of this nature which was communicated by Mr. Clay at the last meeting of the British Association, who shows that in the narrow valley of the Calder excavated in the carboniferous strata, there is a group of boulders of granite and other crystalline rocks, of which there are no traces in any part of the adjacent country. As these blocks are separated from the Cumbrian chain by the lofty region of Lancashire, and numerous deep, transversal or east and

* See Proc. Geol. Soc. vol. iii. p. 766. See also a hypothesis by the present Master of Trinity Coll. Cambridge, on this subject, Silurian System, p. 538.

† Silurian System, p. 535 *et seq.*

west valleys, it is quite manifest that no force of water could have hurled them to this position, their detached nature seeming singularly to favour the hypothesis, that they were carried thither by a large mass of floating ice, which, on melting, left them as an isolated group in this remote valley, then probably a bay or frith of an arctic sea.

Glacial Theories.—The glacial theory, as at first propounded, has now, I apprehend, very few supporters, but to any such I recommend the perusal of the theoretical investigation of Mr. Hopkins, 'On the Motion of Glaciers;' for he has shown, by clear mathematical analysis, that the locomotion of such bodies over large and flat continents is a theory founded in mechanical error, and involving conclusions irreconcilable with the deductions of collateral branches of physical science.

Having occupied so much of your time last year with observations on the theories respecting the action of ice under both terrestrial and marine conditions, and having then so fully expressed my opinions on the impracticability of explaining the transport of erratic blocks to great distances, except by the medium of *floating* ice, I shall no longer enter into the list of disputants upon a question which must be long studied, and viewed under various aspects, before good and firm conclusions can be separated from those which are loose and dangerous. I must, therefore, content myself with referring you to the additional communications of M. Agassiz to the Institute of France, and to the writings of Professor James Forbes*. The new views of the subject which are introduced by so profound a mathematician as Mr. Forbes, lie rather beyond the compass of the practical geologist, and lead into the domain of pure physics. As geologists, however, you must not omit to consult that excellent work on the Glaciers of the Alps, by our eminent foreign associate M. Charpentier, of the existence of which I very much regret to have been ignorant when I last addressed you; for to whatever extent we may be led to agree with or dissent from his theories, it is quite manifest that they are founded on patient and very long-continued observation of facts. Nor will you pass over the ingenious views of M. Hugi, long known as an Alpine geologist; and you will sift the value of the evidences on which he grounds his rejection of the views of Professor Agassiz. This subject is now, indeed, so extended, that without revisiting the Alps or some active centre of glacial action, it would be presumptuous to advance any further opinions of my own.

Ready as I have always been to admit the transport of blocks in ice from any former seat of congelation, and particularly in tracts where marine shells of arctic characters are associated with the surrounding drift, I am here, however, bound in candour to state, that in my desire to see established as a fundamental point of reasoning, "the submarine condition of by far the largest parts of the surface of Northern Europe when erratics were distributed," I have been

* Edinburgh Phil. Journal, 1842.

carried too far in my Discourse of last year, in the endeavour to limit the number of centres from which icebergs may have been detached. Whilst, therefore, I cannot bring my mind to advocate that extent of glacial action in which my friend Dr. Buckland believes, and have failed, in a recent excursion, to observe any proofs of the existence of "moraines" on the flanks of Snowdon, I allow that, looking to the sea-shells which lie around it at different altitudes, the summits of Snowdon may, like those of Spitzbergen, have constituted icy peaks in the midst of an ocean, others being at the same time in existence in the mountains of Cumberland. This is, I am persuaded, the full extent to which we can admit the application of the glacial theory in England, and it therefore appears to me to be futile to look for marks of terrestrial glaciers upon the surface of the rocks of Cornwall or on our southern and eastern counties, the coasts of which exhibit beds of marine gravel and shells at different altitudes upon the cliffs. This observation leads us away from Alpine theories little suited to our island, and carries our thoughts to other superficial phænomena, some of which we can much more satisfactorily explain by means of our own insular evidences *.

Raised Beaches, and proofs of ancient Levels of the Sea.—In a recent report to the French Institute, our foreign Associate, M. Elie de Beaumont, has given the substance of a most important memoir by M. Bravais, 'On the Lines of Ancient Sea-level in Finmark.' Informing us that this work proceeds from the pen of a naval officer attached to one of those numerous scientific enterprises conducted at the public cost, which do so much honour to the French government, M. de Beaumont embodies the labours of M. Bravais in a lucid analysis of many of the facts relating to the same subject, which have been accumulated in Norway, Sweden, and the British Isles.

Proofs of the elevation of the coasts of Norway have been brought before geologists by Von Buch, Brongniart and Keilhau, and have recently been extended by M. Eugene Robert to Spitzbergen. Mr. Lyell has made the British public familiar with the great oscillations which the land of Sweden has undergone since the existence of the present marine fauna; (for Scania has been depressed beneath the Baltic, whilst other parts of Sweden have been raised) and I may be permitted to add, that the extent to which elevations have affected the north-eastern corner of Europe has been recently pointed out in Russia by my companions and myself.

In the prelude to the report on the part which M. Bravais has performed in these labours, we are put in possession of the results of the valuable researches of Professor Keilhau, who, prior to the French expedition, had ascertained the levels of different accumulations, all supposed to be marine, from the sea-shores to altitudes of above 600 feet in the interior of Norway.

The greater number of geologists have for some time believed, that these phænomena could alone be satisfactorily explained by

* See letters addressed to Sir Charles Lemon, Bart. M.P., published in his last Discourse as President of the Royal Geological Society of Cornwall.

upheaval of the land, and M. Bravais has, by a new method of proof, arrived at the same conclusion.

Passing about a year in the environs of Hammerfert, he observed that terraces of gravel in some spots, and marks of erosion on the face of the cliffs at others, indicated at least two ancient lines of sea-level, which extended from the coast far into the interior along the sides of the sea-loch of Alten fiord. Availing himself of the water-mark left by the line of sea-weeds (*Fucus vesiculosus*), and estimating from that horizon an approximate mean level of the tide, he instituted a series of exact measurements of the altitude of both the lower and upper sea beaches, or ancient water-marks upon the rocks, at six different stations between the mouth of the fiord and its southern extremity, a distance of ten to eighteen leagues, and he arrived at the striking result, that the two terraces of Alten fiord, which at first sight, or seen only to a limited extent, seemed to be horizontal and parallel, are, when measured rigorously, found to rise from the levels of 46 and 92 feet (English) above the sea near the mouth of the firth to the heights of 90 feet and 22 feet at its further or inland extremity! In referring you to the Memoir for the ingenious and accurate methods employed by the author to obtain these results, and of which M. de Beaumont has given a very clear account, I will here simply direct your attention to some of the chief geological considerations with which they are involved.

As these lines of deposit rise towards the interior, so as to mark that they coincide nearly with the chief axis of elevation of the Norwegian chain, and as there is a want of parallelism in the two beaches, the relative altitudes of which vary much in short distances, so is it obviously impossible to account for the phænomena by any former condition of the tides; and the hypothesis of salt water lakes is, from the same causes, equally inadmissible.

Submarine currents dependent upon violent elevation of the chain will, the author contends, no better explain the phænomena, because the torrential debacles which would have accompanied such movements would have left confusedly assembled drifts, and not regularly arranged terraces. It therefore seems fair to admit that these are truly ancient sea-beaches. The measurements of M. Bravais show, in fact, that in proceeding from the coast into the interior these beds not only rise to higher levels, but that their elevation has been irregular, viz. that whilst the sea-ward inclination of the older or higher of the two terraces, taken from a station at the middle of the fiord, is very moderate, the rise of the same beds from that central point to the southern extremity of the fiord is at a greater angle, and therefore, that there has not only been a much more intense movement of elevation over one portion of this area than another, but that this notable change of dip indicates the greatest movements at the two extremities, the centre varying slightly from the horizontal. Now from these facts (independent of all the geological evidence) it is argued, as before observed, that no change of level of the sea will account for such an outline.

I will pass over those parts of the report which are connected with pure physics, not only on account of my own incompetency to do justice to them, but because I would suggest, that however certain geological phænomena may be eventually proved to be connected with the question of the density of the earth, it is obvious that unequal simultaneous elevations and depressions over so small an area as Scandinavia can scarcely be due to such a cause. After ably treating this subject, and showing that great terrestrial movements only can be admitted as explanatory of the facts observed, M. de Beaumont refers to the works of British geologists, and suggests, as indeed Mr. Phillips has done*, that the parallel roads of Glen Roy may, by accurate measurement, be proved not to be parallel; and he then goes on to show, that the lines of ancient sea-level of comparatively modern periods, have undergone broad undulations or great ascending and descending movements over extensive areas.

Let us see how these views are strictly applicable to our own country. The occurrence of ancient beaches containing marine shells of existing species at different levels above the sea has long been observed by geologists in the British Isles. Terraces of gravel have also been noted at various altitudes. In some instances they have been referred to the formation of lakes, but in others they have been compared to sea shingle; in many cases also they have been merged with diluvial deposits, and latterly an endeavour has been made to explain some of them by the action of glaciers which are supposed to have barred up former lakes. It may be that we should not endeavour to refer the whole of these phænomena to one common origin; though most persons must admit that the mass of recent evidence proves the greater number of the superficial deposits, to which allusion is now made, to have been formed beneath the sea. Wherever, indeed, these accumulations are found to contain marine shells so imbedded in the sand or gravel as to resemble sea bottoms, and no doubt can remain of their origin, the only question is, why do we find these shells at such different altitudes? why are the same marine remains (appealing to British examples) placed at the height of upwards of 1600 feet in North Wales, and a few feet only above the sea in Devonshire and Cornwall, and at heights varying from 200 to 400 in the central counties? Most geologists have been satisfied to reply (and I am myself of the number), that in these evidences they had distinct proofs, not that the sea had stood at an indefinite number of levels, thereby making a most broken and irregular outline *within the same period* (a supposition apparently absurd), but that the bottom of the sea had undergone irregular oscillations, some points having been raised to much greater heights than others. The examination of the mountains of North Wales and the adjacent plains of Shropshire, for example, could lead to no other inference; there being in tracts absolutely contiguous, a difference of not less than 1000 feet between the level at which the same species of marine shells are now lying: and as no other portion of England or South Wales offers a trace

* See Penny Cyclopædia, *Parallel roads*.

of testacea at the higher of these altitudes, it is demonstrable, that when the sea deposited the shells in Moel Tryfane it did not stand at that height above the whole of England, but that the local appearances resulted simply from unequal elevation of the sea's bottom.

All the analogous phænomena in the British Isles seem to lead to the same conclusion. Whilst the modern marine alluvia of the central counties are found to rise towards Snowdon as a great centre of elevation, the banks of gravel with similar shells ascend from the coasts of Lancashire towards the Penine chain in the interior. Again, in the south-west of England, the most distinct sea-beaches yet noticed, were ascertained to rise very perceptibly from a low level on the south coast of Devon and Cornwall, to heights of 120 feet above the sea in North Devon, where the elevation is more intense. The valley of the Severn afforded similar proofs; the beds of gravel with sea-shells, between Worcester and Gloucester, near its estuary, are slightly elevated above the sea, but in ascending to its source, the same gravel and shells occur at altitudes of 500 to 600 feet, until finally they are seen in the lofty cliffs of Moel Tryfane, before alluded to.

Whilst such may be justly received as absolute proofs (quite as clear as those of M. Bravais) of more intense elevation at some points than at others, the submarine forests along our coasts have been supposed to offer proofs of subsidence. These evidences, however, are not of the same satisfactory nature as those of elevation, for it may in some instances be contended, that the forests in question grew upon low deltas, and have been overwhelmed by irruptions of the sea, which broke down certain banks or natural barriers, that at one period protected them from inundation. But granting these submarine forests on the east coast of England to be really as good proofs of a depression of the land as any which exist on the shores of Scania, where a great subsidence has been established, it must also be borne in mind, that the rocky western coast of our island offers equal signs of depression, since Cornwall and Pembrokeshire, and even Cardigan, so near to the point of intense elevation, Snowdon, have each their submerged forests as well as Lincolnshire. Examined, then, as a whole, England offers many evidences which to me seem conclusive, that within a very recent period, the land has undergone great and unequal movements, both of elevation and depression, in relation to the level of the sea. Scotland and Ireland present like phænomena. In the latter country modern marine shells have been found in many localities at various altitudes. Scotland, so rich in superficial accumulations, also offers near her shores many testimonies of former sea-bottoms laden with numerous shells, but hitherto these remains have only been found at comparatively low altitudes. Another class of detritus, in which, in common with England, she is rich, consists of extensive irregular accumulations of clay, boulders and gravel, usually called "till," and which may be compared with the drift of the tract extending from Bedfordshire and the eastern side of Huntingdonshire, to the coasts of Norfolk, Suffolk and Essex.

A third class is composed of gravel and sand, often arranged in terraces, which in some cases occur at different levels, following the sinuosities of the bays and headlands of the seacoast; in others ramifying into the interior, along the sides of deep cavities occupied by freshwater lakes.

The well-known "parallel roads" of Lochaber offer the most striking example of terraces at different levels above a series of existing lakes, and their explanation has been long the subject of controversy. For many years it was the favourite hypothesis, based, however, upon the supposition of their *perfect parallelism*, that these lines of shingle were the shore lines of the lakes when they stood at higher levels, from which they have been successively let off by the breaking down or wearing away of their barriers. Though supported by several good observers, this view has always presented great difficulties as to the demand upon our belief in the wearing away and destruction of enormous barriers. Very recently, indeed, the expounders of a terrestrial glacial theory have at once obviated all difficulty, by constructing in their imagination enormous walls of ice 2000 feet high, by which such lakes were formerly supported, and by the sudden melting of which they have been let off.

Unable to screw my courage up to the belief in this glacial explanation, I will not now repeat the many objections which must be raised against it, but will simply join those who prefer to invoke the more rational, and, as it appears to me, perfectly satisfactory hypothesis, that all these terraces of gravel (including those of the parallel roads) are nothing more than ancient lines of beach, which are so many marks of the successive rise of the land. This view is, that, as you all know, which was so ably sustained by Mr. C. Darwin, who, in pointing out their analogy to raised beaches in other countries, has also shown, that as similar materials occur in the great chasm of the Caledonian Canal at still greater altitude (900 feet above the sea), it was impossible to refer them to any other cause than submarine elevation. I have too long entertained the same opinion respecting most of the great gravel accumulation of our isles, to doubt that this is the true explanation. I would add, however, that the southern shores of the Murray Frith, which are of course open to the wide ocean, offer to my eye still more convincing proofs of the accuracy of this view, than the patches of gravel along the Caledonian Canal. The terraces of gravel, sand and boulders which there occur at different levels, may, in fact, be traced from the slopes of the mountains of Morayshire and Elgin, to those heaps which lie in the great gorge of the centre of the Highlands; and therefore I maintain, that all these accumulations must have been once connected, and were all originally formed under the sea.

No one who has read M. de Beaumont's report on the memoir of M. Bravais, can fail to be struck with the strong, nay even direct analogy which the gravel and shingle beds of the marine bays and freshwater lochs of the Highlands of Scotland bear to the terraces of the Norwegian fiords; and as the latter author has now by patient observation brought the phænomena observed among the latter under the direct control of geometrical admeasurement, and has shown that such lines, when correctly examined, are neither horizontal nor parallel, so is it my duty, believing that many of the Scottish gravel terraces have been produced by similar agency, to incite my brother geologists to apply the rigorous method of examination of M. Bravais, and thus to render this branch of our inquiries more exact. I entertain, indeed, the most sanguine hope, that before another anniversary passes over, the Scottish phænomena will be tested in a similar manner with those of Norway; and, that as the beds of marine shells in England and parts of Scotland and Ireland so clearly bespeak great irregularities of movement in the land, so shall we be equally able to show that in the Highlands, lines of elevation acting from different centres and with different degrees of intensity, have raised former sea-bottoms to the different levels at which we now find them, whether along shores or in the deep lateral depressions by which Scotland is so fissured. Let the memoir of M. Bravais therefore, with the admirable commentary of M. Elie de Beaumont, be the stimulus to those who enter upon this inquiry, which should not be limited to the parallel roads of Glen Roy, but extended to the Western Islands and shores of the lochs of Western Ross, among which I have a recollection of numerous shingle terraces, including that so well described by Captain Vetch*; and eastwards, to the great accumulations adverted to on the southern shores of the Moray Frith, which in their turn should be connected with the elevated shelly beaches of Banffshire, first pointed out by Mr. Prestwich†.

In quitting the consideration of this very interesting topic, I cannot however occupy this Chair without saying, that albeit British geologists have not yet employed the rigorous test applied by M. Bravais, there is no department of our science on which their observations have thrown more light than that which embraces the phænomena of ancient sea-beaches. Reasoning backwards from existing causes and the facts of yesterday, Mr. Lyell has, by a well-digested set of observations, led us to contemplate the very period when the ocean was beating against our inland escarpments of chalk, and when our valleys and those of the opposite coasts of France may have been fiords like those of Norway‡.

I also know that my friend Mr. Lonsdale has long entertained similar views, derived from his intimate acquaintance with the escarpment of the oolitic strata; along some of which he has observed as perfect lines of dunes as those upon the sea-coast of France, whilst in others he has been struck with their resemblance to many great dislocations of marine undercliffs, whereby masses of the inferior oolite have been pitched into inclined positions at the bottom of the adjacent valleys; and as I know that this subject is one which now occupies his attention, I have strong hopes that by his present residence on the coast of Devonshire, he will be enabled

* Geol. Trans. vol. i. p. 416.

† M. de Beaumont makes full allusion to the British cases.

‡ Elements of Geology, vol. ii. pp. 3—8.

to add materially to the exact conclusions which have been already drawn in this class of researches.

Russia and the Ural Mountains.

Having occupied your attention during the past session with memoirs on the Geological Structure of so large a portion of the earth as the Russian empire, I must make a few allusions to a subject which has to a great extent engrossed my thoughts and those of my coadjutors, M. E. de Verneuil and Count A. Keyserling. Employed as we are in preparing a work explanatory of our views, in which we hope to do justice to all previous inquirers*, and to the Imperial Administration of Mines which supported us, I will not on this occasion venture to occupy more time than will be sufficient to touch upon some of the most striking geological features of that empire, which either sustain or enlarge our views of classification and comparison.

Silurian Rocks.—The Silurian, Devonian and Carboniferous deposits of Russia, are each characterized by distinct organic remains; and these rock systems are very clearly separated from each other over enormous spaces. Occupying (including the Baltic islands) a tract as large as the principality of Wales, the Silurian rocks, like those of Norway and Sweden, are unequivocally the oldest fossiliferous strata, since they are seen to repose upon the primary crystalline masses of Finland and Lapland. Little elevated above the Baltic Sea and the rivers of the northern watershed of Russia, these Silurian rocks constitute low plateaus only of limestone, clay and sandstone, often incoherent, and on the whole of very small thickness; thus exhibiting the most obvious contrast to their mountainous and frequently sub-crystalline equivalents in Western Europe and the British Isles. In their small vertical dimensions they present to us, indeed, a very instructive lesson, for in passing from Norway, Sweden and Gothland into Russia, the distinguishing strata thin out, and losing their divisionary lithological characters, part also with many of their characteristic shells. "When followed from one region to another, deposits of all ages exhibit like contractions and expansions, dependent on the forms of the ancient bays, the nature of the springs and currents, and the depth of the seas in which they were accumulated†."

Devonian Rocks.—If the horizontal range of the Silurian rocks of Russia be considered large as respects our terms of comparison, what will my associates say to the expanse over which the Devonian or next ascending group is spread, when I tell them that it is much larger than the whole of the British Isles? Reposing upon the low Silurian plateaus, this widely ranging deposit rises to heights of from 500 to

* During its preparation, our general map of the Russian empire has been much improved in its north-eastern extremity, the country beyond Archangel which we did not visit, in consequence of the observations of the distinguished botanist M. Ruprecht.

† Geological Researches in Russia (in the press) by Roderick Impey Murchison, E. de Verneuil, and Count A. von Keyserling, assisted by Lieut. Koksharof, p. 40.

900 feet above the sea; and it is very remarkable by being charged in many localities with ichthyolites, several species of which, hitherto considered peculiar to the Scottish Old Red Sandstone, are found associated with Mollusks, perfectly similar as a group, and often specifically the same, as those of the limestones of South Devon, the Boulonnais and the Eifel. The discovery of the intermixture of Scottish Old Red Sandstone fishes and true Devonian shells in the same strata, was, you may believe, one of the most gratifying results of the recent explorations in Russia, as being confirmatory of the views of Professor Sedgwick, Mr. Lonsdale and myself respecting the divisions and equivalents of that member of the Palæozoic Rocks. In some parts of Russia, the Devonian rocks are red sandstones and marls; but in an extensive central tract, where they rise into a dôme which separates the northern from the southern basin of the empire, they are composed of yellow sandy marls and limestones, which lithologically might be mistaken for the magnesian limestone beds of our northern counties:—so inapplicable are mineralogical terms as marks of geological epochs.

In the vastness of their undisturbed and nearly horizontal extent, these strata afford us most instructive proofs of the intimate connection between the stony condition of the rocks and the imbedded fossils; for, when the calcareous matter is present, various mollusks are associated with some fishes, whilst in those tracts where the limestones disappear and the beds have the characters of the Old Red Sandstone of Scotland, fishes only can be detected: thus presenting a remarkable analogy between the distribution of this very ancient fauna and that of existing nature; the present great receptacles of fishes being deep sandy bottoms, whilst shelly creatures congregate towards the shores where calcareous springs attract them. I shall elsewhere allude to the fishes of this deposit when speaking of the researches of Professor Agassiz.

Carboniferous Rocks.—The Carboniferous deposits, which succeed, cover an area as broad as that of the Devonian or Old Red rocks; and they are throughout clearly distinguished by a decidedly distinct type of animal life, presenting in some families an extraordinary number of species absolutely undistinguishable from those of our own country published in the works of Sowerby and Phillips. This system is eminently calcareous, and exhibits a vast marine succession, in which the fossils of the Mountain Limestone prevail, whilst in no part of the empire is there a trace of the overlying deposits, with which we are familiar under the term of "coal-measures." Coal, however, does occur at intervals, both underlying the carboniferous limestone, as in Berwickshire, and alternating with its central and upper members, as in Northumberland, and the carboniferous valleys of our lake country.

Of the latter, the extensive tracts in the south of Russia, occupying from 10,000 to 11,000 square miles, and usually known as the country of the Donetz, offer a very striking illustration; containing in one district as many as seven good seams of coal, subordinate to sandstone, shales and limestones, very analogous to those rocks which abound in the western dales of Yorkshire. These strata, based upon the crystalline rocks of the southern steppes, constitute a greatly disturbed region, and, owing to numberless convolutions, present the most remarkable contrast to the horizontal deposits of Central and Northern Russia. It is therefore difficult to observe the order of succession; but, owing to our previous acquaintance with the types in their normal condition, we were enabled to trace the sequence, from conglomerates and sandstones at the base of the carboniferous limestone, up to the equivalents of the Magnesian Limestone or Zechstein.

Whilst thus briefly alluding to this tract, I must pass, for a time, from my own labours, and those of my friends, of the value of which you must judge when our work is completed, in order to mention the recent appearance of the fourth volume of the splendid work of M. Anatole Demidoff, 'Voyage dans la Russie Méridionale,' which is entirely devoted to the description of the carboniferous region of the Donetz. M. Le Play, an eminent French engineer, happily selected by M. Demidoff to ascertain the true mineral wealth of the tract, and to describe its physical and geological structure, has produced a work so replete with well-digested details, collected, not only from observations of the natural features of the region and the mines which have already been commenced in it, but also by numerous borings carried on by himself or his assistants during a period of three years, that the Imperial Government will doubtless feel grateful to the accomplished patron who has so liberally fostered these inquiries.

In a large geological map, in which the demarcations of the carboniferous and crystalline rocks, and also of the overlying secondary and tertiary deposits are given, M. Le Play has grouped under darker colours such parts of the tract as are known to be productive of coal, to distinguish them from those in which the mineral has not yet been discovered. This method, doubtless, carries with it a certain amount of information, but is deficient in stratigraphical meaning, for some of the beds so marked are higher than others; in some the coal is interlaced with limestone, and in others it is almost entirely subordinate to sandstone and shale; in one tract anthracite exclusively prevails, in another bituminous coal. By reference, however, to the explanation, and to a series of tables, this defect is obviated. These tables are, in fact, perfect models for the practical mining engineer; they give at one view the direction, inclination, thickness and quality of the coals at each locality, also the characters of the associated strata, as well as the state of the works, and their produce at each mine or trial-spot. To these is added another set of tables, in which the chemical analysis of the coals from forty-three different places is given by M. Malivaud, another agent of M. Demidoff.

Into such details, valuable as they are, it was not our province to enter, and I will now, therefore, merely offer a few remarks explanatory of those points in which the geological conclusions of my friends and self either agree or are at variance with those of M. Le Play.

Certain fossils which he had brought to France, and which we inspected before our journeys to Russia (1840), first led us to believe, that these coal beds are subordinate to the carboniferous limestone. Of this, indeed, there could be no doubt, for the species were, to a great extent, the very same as those with which we were familiar in rocks of that age in western Europe. On interrogating M. Le Play, however, we could not ascertain that he had arrived at any defined idea of a succession of strata, derived either from the stratigraphical order of mineral masses, or from their imbedded organic remains. In fact, he then distinctly acquainted us with what has now appeared in his work, that, owing to the disturbed and convoluted condition of the strata, the want of persistency of mineral characters, and the apparent existence of similar species of shells throughout the series, it was impracticable to assign a base line to the deposits, or to trace their uppermost limits, still less a passage into any superior formations.

Now, as we have ventured to effect these objects, with what success we must leave others to decide, I will here briefly state why I conceive M. Le Play did not arrive at similar results; although he had in his own hands some means of proof, which, through the short time at our disposal, we never obtained.

No geologist, however practised, can, I venture to say, explain the structure of any complicated part of a distant country, unless he has made himself master of the clear succession of its normal formations. Long as I have been occupied in the study of the Palæozoic rocks, I am confident that, had my friends and myself been thrown suddenly into the chain of the Donetz, and had been desired at once to unravel its complexity, we should have reached no other geological result than that to which M. Le Play has attained, viz. of stating that the coal-seams are, as a whole, subordinate to the carboniferous or mountain limestone. We had, however, by two years of extensive comparative researches, obtained an intimate acquaintance, not only with the older Palæozoic rocks of Russia generally, but, in reference to the carboniferous system, had convinced ourselves, that, throughout the enormous area over which we had traced it, the upper or coal group of western Europe was absent; and that the calcareous or lower group, occupying the whole carboniferous horizon, was divisible into three stages, by help of certain fossils characteristic of each. Again, we had ascertained, by numerous sections on both flanks of the Ural Mountains, that, in becoming part of a mountain mass, this system, so uniform and so peculiar over a space as large as an ordinary European kingdom, put on many of the features which are so well known to those who have studied the carboniferous limestone only in the western parts of Europe.

We further learnt, that, in the absence of any deposits to represent our great coal-fields, the carboniferous system was succeeded, in ascending order, by a vast series of red and cupriferous deposits to which we have assigned the name of Permian. It will not, therefore, be arrogant on our part to say, that we entered upon the examination of the territory of the Donetz, in the possession of elements of comparison which no previous travellers had acquired.

Knowing, from the maps and instructions furnished to us by the Imperial Administration of Mines*, that the major axis of this tract and the main direction of the strata trend from west-north-west to east-south-east, we resolved, after terminating our researches in Southern Russia, to examine the chain of the Donetz in parallel lines transverse to its general strike; and, by carrying out this scheme, we arrived at the conclusion, that the oldest member of the series occupies its southern frontier, and that, after a multitude of flexures, the central strata dip under a limestone charged with Fusulinæ, fossils which we had invariably found in the uppermost bands of limestone; the whole group being surmounted in the valley of Bachmuth by the equivalents of the Permian system. One striking deficiency, however, attached to our reconnaissance, and fortunately it has been supplied by M. Le Play himself. Those members of the Society who heard our memoirs read, will recollect the importance we attach to the presence of the large *Productus giganteus,* as uniformly characterizing (over vast regions in Russia) the lowest beds of the carboniferous limestone; and, as we now learn from M. Le Play, that this fossil, of which he collected many individuals, occurs in the southern part of the region, our idea is thus completely confirmed of an ascending section from south to north.

In fact, the examination of the carboniferous region of the Donetz is one of the best examples that can be adduced, of the paramount importance to the practical miner of the close study of organic remains, in reference to the normal position of the strata; for, throughout deep sections in the northern part of the same territory, there is not a trace of this great Productus, whilst all the fossils of the middle and upper strata are present. Any one, therefore, who had felt as confident as we do, that this remarkable fossil was as clear an indication of a lower band as the *Spirifer Mosquensis* and Fusulinæ are of an upper, could not have doubted of the general relations and order of the strata in the chain of the Donetz.

Agreeing in the correctness of the general parallel which M. Le Play has drawn between the deposits of the Donetz and the carboniferous limestones of Great Britain, Belgium and France, I do not believe that beyond this point his comparisons can be sustained. The coal fields, for example, of the Low Countries and of Düsseldorf, with which I am well acquainted, do not offer, as he supposes, an analogy to those of the Donetz; for in the former, coal-seams are in no instance interstratified with the Mountain Limestone series of English geologists, but are invariably superposed to it. Again, in the Prussian and Belgian provinces, the mountain limestone with sands and shale but void of coal, reposes on a fine succession of

* The instructions of General Tcheffkine, the works of Captain Ivanitzki, and a map by Colonel Olivieri. See Journal des Mines, &c.

Devonian and Silurian rocks, loaded with typical fossils; whilst the group of the Donetz, exclusively carboniferous to its base, rests at once either on very ancient crystalline rocks, or upon porphyries and other eruptive masses, to the agency of which is to be attributed the extraordinary contortions into which the strata have been thrown. The true analogy, therefore, of the coal of the Donetz, considered in reference to other deposits of the same age, is to be found in the north-western English districts of mountain limestone, in which several workable seams occur; though in this comparison it must be stated, that the Russian beds contain much more coal than the British strata. But even if we admit that, to some extent, there is a similarity in the carboniferous rocks of South Russia and the Low Countries, in their being both flanked by cretaceous deposits, we must also not omit to recognise a great discrepancy, through the presence in the one case of overlying strata of the age of the Zechstein, and in the other by the total absence of that deposit.

To considerations of theoretical importance concerning the changes which the surface of Southern Russia may have undergone, and which are ably put forth by M. Le Play, I will not at present advert; reserving my views on these points for the concluding chapters of the work upon Russia, when all the elements which my friends and myself can bring together shall have been laid before our readers, to enable them to see the grounds upon which the conclusions are based.

For the present, then, I take leave of this volume of M. Le Play, which, though it contains some views of positive geology from which I differ, must still be regarded as an important addition to the records of physical science, and as possessing much more the character of a good monographic description of a given tract in Russia, than anything which, from the extensive nature of our researches, my friends and myself will ever be enabled to offer.

Permian Rocks.—On its eastern frontier, far removed from the tract to which allusion has been made, the uppermost member of the carboniferous limestones of Northern and Central Russia, distinguished by the presence of multitudes of the foraminifer *Fusulina*, is succeeded by the most widely spread of the Russian systems; to which, from its occupying the whole of the ancient kingdom of Permia, we have assigned the name of Permian. You have been told, that this vast group is composed of limestones, marls, great masses of gypsum, rock-salt and repeated alternations of cupriferous strata; and that it contains a flora and a fauna of characters intermediate between those of the Carboniferous and Triassic periods. The shells are, to a great extent, those of our Magnesian Limestone or Zechstein; and, like the conglomerate of that deposit near Bristol, the Permian rocks are distinguished by the presence of Thecodont Saurians. The interest attached to these vast deposits, which have been spread out on the western flanks of the Ural Mountains, is increased by the inferences which have been drawn, that springs and currents holding much copper in solution must have flowed from the edges of that highly mineralized and metamorphic chain, while the Permian strata were accumulating. But the great value of having worked out a fuller and richer type of a group of strata between the Carboniferous and Triassic epochs than any which exists in Western Europe, will be found in the fossil shells, the plates of which are already far advanced; for, with some species hitherto known in the Zechstein of Germany and Magnesian Limestone of England, we shall publish others which are identical with or analogous to forms that occur in rocks occupying the same geological position in North America, of which I will speak hereafter, and concerning the age of which great doubts had prevailed.

In America, indeed, as in Russia, these beds had been compared with every deposit, from the coal to the Keuper inclusive, whilst in our work they will be shown to have no connection with the New Red Sandstone or Triassic group, but to occupy a definite position, truly intermediate between that system and the carboniferous. At the same time it is manifest, that although they overlie and are, as they ought to be, very distinct from the Carboniferous system, yet they contain some species of shells which occur in that division. Thus it will be made evident, that after all there now remains scarcely any real difference of opinion on this head between Mr. Phillips and myself (to which I alluded last year); for I learn from him, that in England the analogy between the fossils of the Magnesian and Mountain Limestone obtains to a far greater extent than could be supposed from any published catalogues. I trust, therefore, that the ensuing year will not be without its fruits in the production of new works on the shells of the Magnesian Limestone of our own country; and I am glad to have it in my power to inform you, that Mr. King, the Curator of the Natural History Society of Newcastle-on-Tyne, is preparing some excellent materials for this purpose.

A better acquaintance with the Permian fossils, particularly the prevalent Mollusca, induces me, notwithstanding the arguments I employed last year, to infer that this deposit, so naturally connected through its characteristic fossils with the Carboniferous strata, must be classed with the Palæozoic rocks*. The physical structure of Russia is also greatly in favour of this view; for, in large portions of that country, there is an entire absence of the great rupture between the Carboniferous rocks and the Magnesian Limestone, which is so prevalent in the British Isles. The examination of rocks of this age in North America, to which I shall hereafter advert, leads to the same opinion; viz., that the Permian deposits must be viewed as the fourth or uppermost stage of the Palæozoic series, notwithstanding the occurrence of Thecodont Saurians.

Jurassic, Cretaceous and Tertiary Strata.—Overlapped as these Permian deposits are, in certain tracts of Russia, by red and white marls and sands, we are not positively prepared to state (in the absence of decisive fossil evidences) whether some of them may not

* My companions, M. de Verneuil and Count Keyserling, have long entertained the same views as Mr. Phillips on this point.

represent the Trias; though the fossiliferous limestone of Monte Bogdo, in the steppe of Astrachan, is probably of this age. With the Jurassic strata, however, which follow, and which occur at intervals from 65° north latitude to the countries south of the Crimea, we made ourselves well acquainted. Should the word *Jurassic* grate upon the ears of Englishmen, it is impossible to deny that this geographical term is much more applicable to the strata in question than our own word "Oolitic," which implies a structure scarcely ever seen in beds of this age in Russia. Whether examined at Moscow or on the Lower Volga, they consist of black shales and ferruginous sands, occasionally containing calcareous cement-stones, and thus they present a general lithological analogy to the Lias; a formation, however, which is not represented in Russia, for the fossils are all referable to the groups extending from the Inferior to the Upper Oolite, and many of them are identical with British species.

I must now pass over the Cretaceous deposits which occupy such broad spaces in Southern Russia, the Lower Tertiary beds, some of which, on the Volga, might almost be mistaken for those of Bognor and the London basin, and also the strata of the Miocene age, which occupy wide tracts in Volhynia and Podolia, merely remarking by the way, how the recent discovery in limestone of an herbivorous Cetacean (to which I shall elsewhere allude) is a very important addition to the fauna of that period.

Superficial Detritus—Ural Mountains, &c.—The discovery of accumulations containing recent shells of Arctic species, considerably to the south of Archangel, was important, as showing that the great northern blocks, which overlie them there, were brought to their present positions during a period which differed remarkably from the one preceding it, and also from that which has followed it, in the very general prevalence of a colder climate over large spaces; thus enabling us very safely to infer, that the great erratics of the North were transported in icebergs, which floated in an arctic sea and occasionally grated along its bottom. But this operation, gigantic as it was, had its well-defined southern limits, as is beautifully proved by the general survey of the Russian Empire; in the southern half of which all such erratics cease, and fine black slime (tchornozem) takes their place. Wherever the recent accumulations of the steppes indicate the desiccation of brackish seas, which like the present Caspian were inhabited by Mollusca requiring a warmer climate, then is there also a total absence of great boulders. On this point I would further beg to remind you, that in our examination of the Ural Mountains, even up to 60° north latitude, my companions and myself could trace no evidence whatever of boulders having been transported from these mountains to great distances upon their flanks; although the peaks rise to heights of 5000 and 6000 feet above the sea, and the chain extends from north to south through eighteen degrees of latitude. In every portion of the Ural Mountains, and on both their Asiatic and European flanks, the detritus is of a purely local character; and in it are occasionally entombed the bones of the Mammoth, *Rhinoceros tichorrhinus*, and other great extinct quadrupeds, mixed up with gold sand and gravel. Transporting ourselves to the south of Russia, we find the upper portion of the cliffs of the Sea of Azof composed of local detritus and clay equally charged with the same remains.

The general examination of Russia proves in the most emphatic manner, that the central masses of her continent, though exempt from all plutonic agency, have undergone grand but tranquil oscillations which have scarcely at all disturbed the physical outlines of the ancient bottoms of the sea—oscillations which have operated in a similar manner over this vast space from the remote Silurian age, to the close of the period antecedent to the historic æra. This survey has also taught us, that the great Russian continent is surrounded by rocks of igneous origin, the eruptions of which have corrugated and diversified certain portions of the surface at different periods.

On her eastern or Asiatic side it has been the wish of my friends and myself to endeavour to read off in the Ural Mountains the effects of such derangements, and to trace the sedimentary deposits of Russia through the mazes of that band of great disturbance. Having so recently laid before you the outline of our views concerning this chain, and being aware that you will soon be in possession of much additional knowledge respecting it from the pen of the illustrious Humboldt, I will confine myself to a single paragraph, by saying that our chief object was to refer these broken and altered masses to their normal types.

We found this highly metamorphic chain, so rich in metalliferous masses, to consist essentially of Silurian, Devonian and Carboniferous rocks, the fossils of which we traced at intervals, notwithstanding the countless ridges of igneous matter and the highly crystalline structure which has been communicated by its eruption to the contiguous sedimentary strata. A short period only has elapsed, since rocks having quartzose, micaceous and gneissose characters would not have been admitted into the same category with strata containing organic remains; but the theory of metamorphism, founded on patient observation and comparison, has prevailed over ancient doctrines. The sedimentary rocks of the Ural being palæozoic, must, indeed, be viewed as among the most ancient of the metamorphic class. Many other crystalline chains are of much more recent age, as long ago, indeed, shown by M. Leopold Von Buch and other observers. Of the truth of this I will first adduce proofs from the Caucasian chain which bounds the Russian Empire on the south. The second illustration of metamorphism will be derived from recent researches in the Western Alps.

Caucasian Chain.—We must now estimate the efforts of an observer, who, in common with Agassiz, does such honour to the little canton of Neufchatel. Though the name of M. Dubois de Montpereux has escaped the notice of my predecessors, an outline of his chief labours was laid before the geologists of France, in 1837, by M. Elie de Beaumont. Attention having been latterly much directed towards Russia and the adjacent regions, it becomes my pleasing duty, the additional researches of M. Dubois having been recently published, and having myself largely profited by them, in the construction of a map of that empire, to invite your consideration to his great work.

From its diversified and varied outline, and its early historical records, no region within the reach of Europeans seemed to have a greater claim upon the combined efforts of geologists and historians than the Caucasus, and yet of no country were we more ignorant. For although travellers have, from time to time, passed over it by one great road or another, from the thirteenth to the present century, and though Kupffer has well described the environs of one of its northern peaks Elbruz, and Eichwald has explored the coasts of the Caspian, we had never had a true picture of the physical geography and varied inhabitants, still less of the geological structure of this chain. No one, in short, struggling with the dangers of climate and uncivilized inhabitants, had so threaded these mountains and defiles as to make us familiar with them*. This Herculean task was undertaken by M. Dubois, and most successfully has he executed it, for his work of five volumes is that of a geographer, historian and geologist. The lovers of Homer, Strabo and Pliny will assuredly find in it a mine of classical recollections, a correct identification of ancient sites and vivid sketches of ancient customs, described by Grecian and Roman writers, some of which habits prevail even to this day. Regretting, as we must, that tracts formerly illustrious in song, and many of them still blessed with the richest gifts of nature, should, for the most part, be now tenanted by wild and barbarous tribes, let us the more admire the zeal and energy with which our author, surrounded by privations, has produced so clear a picture of this extraordinary region. Not only does M. Dubois place before us the physical features and the social condition of the various tribes, from the Circassians on the north to the Georgians and Armenians on the south, but he gives us geological sections, maps and descriptions, and thus brings the rocks of these wild and rugged tracts into a clear comparison with known European types.

No country is more entitled to the name of metamorphic than the Caucasus, for M. Dubois proves, that the oldest sedimentary rocks of which it is composed, are scarcely of higher antiquity than the Lias; whilst Ararat, in great part of recent volcanic origin, exhibits on its flanks streams of lava, which must have flowed since the land has assumed its present configuration. So modern is this mountain in the records of the geologist—so venerable as the cradle of the human race.

Let us however cast a rapid glance over some of the chief results of M. Dubois's researches. The central ridges of this mighty chain,

* Of the scenery, antiquities and costumes of such parts of the Caucasus as he visited, including special illustrations of Ararat and the north of Persia, my lamented friend Sir Robert Ker Porter brought away a rich series of beautiful sketches, a few only of which have been published. Though not a geologist, his faithful pencil conveys an admirable idea of the character of the highly inclined and metamorphic strata.

formerly supposed to be of primary age, are nothing more than beds of Lias and other strata of the Jurassic age, often so highly altered as to resemble ancient slaty rocks, and occasionally pierced by points of granite and greenstone. These grand and strangely changed strata of the Oolitic series are flanked by huge buttresses of the Cretaceous system, some members of which take the form of fucoid schists and greensand, whilst others are pure white chalk. Often, indeed, assuming ancient lithological aspects, and broken into striking defiles, covered by beauteous forests, the far-famed Circassia, from one end to the other, is simply the representative, on a grand scale, of our English North and South Downs, with their fringes of greensands*. The explanation of the violent disturbances to which these cretaceous rocks have been subjected, is seen in numerous points of porphyry and other igneous rocks; by which agents, the strata, altered and thrown into highly inclined positions, have been raised to heights of 10,000 feet above the sea. On each side of the flanks of these gigantic mountains, essentially if not entirely composed of the younger secondary rocks, are tertiary basins. To the north they range into the desiccated Caspians, which form the southern steppes of Russia; and to the south they lie inclosed among numerous ridges of plutonic and igneous rocks. Volcanic agency, of the same extinct nature as that with which we are acquainted in Central France, and with which English geologists are now familiar in Asia Minor, from the descriptions of our associates Hamilton and Strickland, abounds indeed throughout many parts of this region. Of the different phases of eruption, the porphyry cone, the crater and the coulée are the evidences; whilst the continued existence of the latent and repressed fires of antiquity is traceable in the naphtha springs of the adjacent lower countries, which are still in action, upon lines running from north-west to south-east, or parallel to the grand line of eruption on which the Caucasus has been upheaved. M. Dubois distinctly marks the great period of elevation of these tracts, when the ridges on the south of the chain began to be the centres of many distinct volcanic vents; and when, by the higher and lesser elevations of districts formerly submarine, the various "amphitheatres" in Georgia and Armenia were formed, all of which he has personally visited. This is truly the region in which, if it be possible, passages may be traced, from rocks of plutonic or submarine igneous agency, to those of pure volcanic and subaërial operation. To decipher order throughout a tumultuous sea of rocks, bristling with extinct volcanoes, is no small effort; and if M. Dubois should not have completely succeeded in neatly separating the porphyritic and later plutonic eruptions from those of true volcanic age, he has at all events offered proofs, that in many instances the former were covered by the most ancient tertiary accumulations (*quasi* uppermost-secondary), in which vast ac-

* The botanist will find a striking analogy between the vegetation of the western flanks of the Caucasus and the North Downs (Box Hill) in their respective groves of *Buxus*.

cumulations of rock-salt, almost mingled with lava of subsequent eruption, seem to favour this hypothesis, that the accumulation of this mineral may in some instances have been connected with igneous agency.

In describing the great elevation which converted the Caucasus from an island into an isthmus, and desiccated large portions of the adjacent seas, leaving them in the condition of steppes, M. Dubois attaches great weight to the evidences of upheaval of the masses in crateriform shapes; and in tracing the succession of the tertiary strata, he shows, that, as a great depression (Colchis) formerly existed between the Caucasus and Armenia, so the beds of rivers which flowed into this ancient gulf, graduate into and form the lowest part of such tertiary basins.

So attractive are his descriptions, that we can actually bring before our mind's eye each successive mutation; either when great and irregular elevations raised up the ancient sea-beds to different levels, or when volcanoes bursting forth (some submarine, and others under the atmosphere) barred up these basins, forming brackish and salt lakes, many of which have since been desiccated. Seeing that he first establishes all the fundamental points of his work on sound observation, and identifies each formation by organic remains, a geologist even may revel with M. Dubois, when, after speaking of the superb garland of volcanic cones, whose summits, ranging from 12,000 to 17,000 feet above the sea, surround the great desiccated basin of Central Armenia, he allows himself to speculate on the letting off of former inland seas and lakes, by the waters of which our progenitors may have been destroyed.

Receding, however, from these views, which connect our science with the history of man, I specially beg to notice the very clear order of the Cretaceous system, first pointed out by M. Dubois on the southern shores of the Crimea; a tract very analogous to the region of the Caucasus, of which, in fact, it is a prolongation. Of the trachytes, trap, pumice, lava and scoriæ of the southern flank of the Caucasus itself, we have no traces in its miniature the Crimea; but a perfect epitome of all the succession of its northern and Circassian slopes, showing a Jurassic series supporting a very complete Cretaceous system, which the author places in perfect parallel with the beds of similar age in Europe, with which he is acquainted.

In referring you to his table which marks twelve distinct stages in this cretaceous system, the uppermost of which contains *Trigonia* and *Ostrea gigantea*, and the lowest of which is an undoubted type of what foreign geologists call the *Terrain Néocomien*, I would here suggest that the greater part, if not the whole, of the series may be paralleled in the south of England, and that too without consulting other sections than those described by Dr. Fitton, and the natural phænomena which he has so faithfully represented. The uppermost seven divisions of the Crimea are all evidently referrible to our chalk and chalk marl, and contain many of our well-known fossils, the only striking difference consisting in the association of Nummulites and *Cerithium giganteum*, with the *Trigoniæ* and

Ostreæ of the uppermost chalk. The beds 8 and 9, *Craie chloritée* and *Grès vert*, containing, amid *Exogyræ* and some cretaceous fossils, the *Pecten quinque-costatus* and *P. orbicularis*, most unequivocally represent our Upper Greensand or "malm rock." The marly strata which lie beneath such beds are therefore, we may fairly presume, the representatives of the English gault; and, lastly, the yellow limestone and sand, immediately beneath it, which forms the Neocomian of M. Dubois, may, after all, be considered the equivalent of our Lower Greensand, or the expansion of its lowest beds which pass into the Wealden.

I have always regretted that so few foreign geologists have obtained an adequate idea of the dimensions and importance of the third or inferior division of lower greensand as exhibited on the southern shores of the Isle of Wight (Atherfield Rocks). In France the formation has been little recognized beyond the Boullonnais, where it has already almost lost its distinctive characters, and where there are no longer the divisions of upper, middle and lower beds, each, as shown by Dr. Fitton, characterized by peculiar fossils. In the south and east of France, where upper greensand and gault abound, it now appears* that the base of the Cretaceous system is composed of limestones identical with those of Neufchatel, and which, participating in all the flexures of the chalk, are usually broken off, as in the Crimea, from the Jurassic system.

It has been suggested that the Neocomian limestones may represent the Wealden of British geologists. But this is not, so far as I can judge, safe reasoning; for the latest researches of Professor Owen would lead me to believe, that the Saurians of that great estuary formation are much more nearly allied to those of the Oolitic or Jurassic epoch than to those of the Cretaceous period†; and Agassiz has assured us that the fishes of the Wealden are entirely distinct from those of the chalk.

I have before expressed my opinion on the head of Neocomian, both to French and English geologists‡, and I now repeat it, more however as a stimulus to those who have the means to settle this point accurately, and not because I entertain any objection to the foreign use of the word. The term may, indeed, be very well and appositely used in reference to the deposit throughout central and eastern Europe, where its lithological characters are so different from what is I presume the English type; and where they have been so well described by Swiss and French observers. I seek merely for the establishment of the truth; and I again ask if the Neocomian of Neufchatel and the Crimea be not the equivalent of the lowest Greensand of England, and of the *hils-thon* of Römer in Hanover? On revisiting the Isle of Wight last spring, in company

* See discourse of last year.

† See note p. 89, on the supposed Wealden of the Highlands.

‡ In referring to an opinion which I expressed at the meeting of the Geological Society of France in 1839 (Bull. Soc. Geol. tom. x. p. 392 *et seq.*), I beg to say, that it is specially to the Greensand as the chief equivalent to which I refer.

with my friend Count Keyserling, and on finding in these beds many true Neocomian species, I adhered to my old opinion*; and I now put this question in the hope that it will be completely answered through the labours of English geologists, and particularly of Mr. Austen, who has, I know, commenced an inquiry into this subject, and whose acquaintance with fossil shells and habits of field-research well qualify him for such a task.

There is yet one point connected with the researches of M. Dubois on which I beg to touch, from the admiration I entertain for any one, who pursues science for its own sake, and achieves durable results by his own unassisted endeavours. Occupied during ten years of his life as an instructor of youth, M. Dubois had no sooner realized a small independence than he resolved to enter upon this arduous undertaking. Repelled, in the first instance, by the war with Turkey and by the plague, he fortunately retired upon Berlin, where, passing two years in the admirable school of geologists of which that capital boasts, he once more set forth on his grand enterprize, with no other recommendation than that which his good name, and a short memoir on Volhynia and Podolia, had acquired for him, and no other means than his own very moderate private fortune. Disposed, as it has always shown itself to encourage science, the Russian government was no sooner acquainted with his designs, than it offered him conveyances in their ships of war, and subsequently gave other encouragement. Hence M. Dubois was enabled to reach parts of Circassia which would otherwise have been inaccessible; and thus he entered upon his remarkable journey. Revisiting the Crimea and parts of the south and north of Russia, he returned to Berlin, after an absence of four years, laden with much precious knowledge. But how was he to put this before the world? Not alarmed at the prospect of publications, from their descriptive nature necessarily very expensive, M. Dubois, encouraged by M. de Buch and M. E. de Beaumont, commenced the preparation of his works, of which five volumes and a splendid atlas have already been issued; and as these are to be followed by other works, it is to be hoped that all the productions of this spirited author will be adequately and liberally purchased by the discerning portion of the public. I have the less hesitation in making this appeal to my countrymen, because I really believe that the high class of merit which belongs to the researches of M. Dubois is yet known to very few of them†.

Asia Minor.—It is with great satisfaction I am now able to refer you to the work of one of our own Secretaries, as having con-

* Since this Address was read I have received a letter from Count Keyserling, dated Petersburgh, March 7, in which he acquaints me, that in a mass of shelly rock from Kyslavodsk in the Caucasus, which has been considered Neocomian, he has detected the same species of *Thetis*, *Trigonia*, and other fossils as those which we collected together in the Lower Greensand of the Isle of Wight.—*March* 31*st*.

† For the general geological views of M. Dubois, see his letters to M. E. de Beaumont, 'Bulletin de la Soc. Geol. de France,' vol. viii. p. 371 *et seq.* His researches have been justly appreciated in France.

nected the region described by M. Dubois with the southern Mediterranean types. Mr. W. Hamilton, who, with Mr. Strickland (his associate during a portion of his time spent in the East), has laid before you in former years a memoir on the geology of Asia Minor, including the Catacecaumene, a tract of extinct volcanoes, has now published an account of all his travels. Amidst a number of new facts which he has brought together to throw light on the geography and history of tracts held in veneration both by classical and biblical antiquaries, he has added much valuable geological information to our previous stock of knowledge of these little-explored countries, and for the greater part unknown to the scientific. In Armenia he shows the existence of vast basaltic plateaus within the visual horizon of Ararat, where he found deposits of tertiary shells extending over a surface of from 50 to 100 miles, at an altitude of upwards of 6000 feet above the sea, a phænomenon quite analogous to one of those instanced by M. Dubois: and they both demonstrate to what great distances the powerful action which elevated Ararat and the Caucasian chain extended. Mr. Hamilton points out that the limestone formations, probably cretaceous, between the Caucasus and Erzerûm are penetrated at numerous localities by basalt and trap; whilst along the southern coast of the Black Sea the rocks are shown to be chiefly igneous towards Trebizond, and cretaceous as they approach Sinope. The mountains of Pontus, from the Black Sea to Amasia, are composed, it appears, of semicrystalline limestone, accompanied by intrusive igneous rocks; but the former passes to the west or towards Galatia into red sandstone, containing numerous deposits of rock-salt. Lastly, the central plains of Asia Minor, occupying a great portion of Galatia and Phrygia, are supported by the semi-crystalline limestone, containing Nummulites (so well known in the Mediterranean basin, and which has been generally referred to the Cretaceous age), accompanied by numerous igneous outbursts, and consisting of wide expanses of white tertiary lacustrine limestone, some portions of which advance even to the northern range of Mount Taurus. Such extensive data are, you will agree with me, of essential value in enabling us to form a sound geological theory respecting the ancient condition of the crust of the globe, and in convincing us that tertiary sediments of lacustrine origin occupy areas of great extent Mr. Hamilton has furnished the most decisive proofs that, in such periods, the physical conditions of the surface were fast approaching to those which now prevail. I must, however, request every geologist who wishes to obtain a correct acquaintance with Asia Minor, to consult the well-filled volumes of our Secretary, which, pregnant with valuable truths, worked out with energy and fidelity under numberless difficulties, will be placed, I fear not, among the works which have considerably extended the boundaries of positive knowledge.

Turkey in Europe, Servia, &c.—Our indefatigable friend M. Boué has the merit of having united the distant regions of Asia Minor with Western Europe. Courting, as he has always done, a line of useful research, however difficult and repulsive, it was enough for

M. Boué to know, that all the great tracts to the south of the Danube and beyond the countries of Transylvania, which he had formerly described, were untrodden by geologists. Residing, I believe, more than two years in these rude provinces, he made himself master of their statistics and geography; and, publishing a geological sketch of Turkey in Europe, he has also furnished us with a geological map of that country*. Of palæozoic rocks, as distinguished by their fossils, Turkey affords few traces beyond the small tracts at Constantinople occupied by true Silurian strata, which Mr. Hamilton and Mr. Strickland made known to us. Great masses of the inferior rocks are stated by M. Boué to be in such a metamorphic and crystalline state, and to be so penetrated by a great variety of intrusive rocks, that it is very difficult to determine their age. With some very doubtful exceptions, no secondary rocks, in short, can be recognized as of higher antiquity than the Cretaceous system, which having, for the most part, the crystalline character which it puts on in all the Mediterranean countries, is still divisible into Lower and Upper deposits, the former consisting of schists and sandstones with fucoids, which represent our greensands, and the latter of a white marble with nummulitic strata, the equivalent of our chalk. Overlying these, our author mentions and lays down upon his map no less than thirty tertiary basins, thus showing a great analogy to Asia Minor. For such marked results our special acknowledgements are due to M. Boué, than whom no one has accumulated a greater number of facts in many parts of Europe; his numerous and difficult journeys having been performed entirely at his own cost, and chiefly for the pure love of geology.

Piedmontese Alps.—In the north of Italy and the Western Alps, considerable advances have been made by the labours of M. Sismonda, who is engaged in the formation of a geological map of the Piedmontese territory, which, with the map of Sardinia by the Cavalier Marmora, will give a complete view of the structure of the Sardinian dominions. To accomplish this, M. Sismonda has been labouring during the last ten years; and I am led to believe that in about two years his great map will be finished. In the mean time, and in addition to various memoirs with which you were previously acquainted, he has recently published descriptions of the Piedmontese Alps. Dividing the great mass of crystalline rocks, he shows that the inferior portion may really be called primary gneiss and mica schist; although other rocks, which have to a great extent the same lithological characters, but which alternate with quartzose grits, and repose unconformably upon the first series, are truly metamorphosed aqueous deposits. Considering the great derangement and changes to which these latter rocks have been subjected, the author does not, however, attempt to fix their age. On this point I may be permitted to observe, that Professor Sedgwick and myself have pointed out the

* A geological map of a part of Servia and Albania, prepared by Colonel Lassie, from the observations of M. Visquenil, has, by the assistance of M. Boué, completed our acquaintance with the geology of this distant part of Europe.

presence of Producti and Encrinites in crystalline rocks of the Eastern Alps; and hence it is probable that some of these masses, in which no organic remains have yet been discovered in the Western Alps, may occupy the place of palæozoic deposits. Again, a third group is, by its mineral aspect, also apt to be confounded with the primary rocks; and yet, as has long been known, the Lias and Jurassic strata are included in it.

Since the day when M. Elie de Beaumont first exhibited to the astonished geologists, Belemnites in chloritic and micaceous schist! these highly altered Lias rocks have excited the most lively interest; more particularly as the Belemnites were found associated with plants which M. Adolphe Brongniart identified with species well known in the Carboniferous deposits. Anxious to explain this apparent anomaly, M. Sismonda, who, on a former occasion as well as on a recent one, was the companion of M. de Beaumont, following these masses from Mont Blanc to the department of the Lower Alps, where they are most charged with fossils, has arrived at the conclusion, that whether crystalline limestones, quartz rocks or quartzose conglomerates, all these rocks belong to the great Jurassic series, from the Lias to the Portland stone inclusive; the respective formations being more or less metamorphic as they approach to, or recede from great centres of plutonic eruption.

On the curious and long-disputed point of the relations of the beds with Belemnites to those with coal plants, M. Sismonda, sustaining the views of M. de Beaumont, asserts that the sections fairly exhibit alternations, and that the difficulty cannot be set aside by supposing one of those reversals *en masse*, so common in mountain tracts, and by which older strata are often superposed on younger. M. Sismonda agrees, therefore, with M. de Beaumont in believing that the plants in question lived near the spots in which they are now found, and during the same period as the Belemnites of the Lias. It remains for naturalists to explain how certain plants, whose forms indicate a climate of high temperature, may have continued to grow during successive periods in favoured spots, though their congeners had long been destroyed in other parts of the world.

Proceeding upwards from the Lias as a base, and seizing here and there upon remnants of the strata from which the impress of their origin has not been obliterated, M. Sismonda refers certain limestones, grits and schists to the Great Oolite. Another group, composed of grits, quartzose conglomerates, psammites and schists, in some parts metamorphic and unconformable to the preceding, (and which, extending over the Genevese and Piedmontese Alps, is also largely exhibited in the Alps, in the Col di Tenda, and in the Tanaro) is referred by our author to the age of the Oxford clay; though preceding geologists, misled by the red colour and other characters, had referred it to the New Red Sandstone. Among the uppermost deposits of the oolitic series of the Alps, M. Sismonda recognizes in certain limestones highly charged with zoophytes, the representatives of the Upper or coralline Oolites and Portland rock of England. In the Apennines of Liguria he has observed the Jurassic formations covered by the cretaceous rocks with fucoids; and the greensand of Nice, formerly described by Sir Henry de la Beche, is now shown to repose on the Neocomian limestone of foreign geologists, a formation which, as has been stated, there is reason to think is the representative wholly or in part of our lowest greensand.

Nor has M. Sismonda neglected the Tertiary deposits; for by the aid of fossils he has clearly established, that two only of the great epochs of Mr. Lyell are represented in Piedmont; viz. the Miocene, the strata of which are extremely dislocated, and the older Pliocene or sub-Apennine, which is for the most part horizontal, marking however, by partial breaks, the period of elevation of the Eastern Alps, whilst the Miocene beds are thrown up in the direction of the Western Alps. In reference to this point, M. Sismonda has traced in the Alps, the signs of five distinct and well-separated periods of revolution or upheaval; and among the agents which have effected the changes, he particularly shows, that whatever part the serpentine may have played in these convulsions, it existed before the accumulation of the Miocene deposits, since fragments of that rock abound in the highly inclined pebbly beds of the Superga at Turin.

Such, Gentlemen, is a very brief sketch of some of the prominent results of the researches of M. Sismonda; and admiring, as you must, the ability and perseverance with which he has accomplished them, you will, I am sure, feel gratified in seeing that the sedimentary rocks named by the early school of British geologists in our own little island, have served as the base-lines or types by which order has been elaborated in a great disturbed region, where the chaotic assemblage of rocks and their crystalline and metamorphic characters seemed to forbid the hopes of any such comparisons.

North American Geology.

In considering this branch of my subject it will not be expected that I should attempt to give even the slightest sketch of the labours of all the men of science who constitute the enlightened school of geologists which has arisen within the United States. Possessed of a theatre of research in which natural phænomena are developed on a gigantic scale, the rapid progress of our transatlantic brethren has been most surprising; and the triumphs which they have achieved are doubly gratifying to ourselves, as they are founded, for the most part, on comparisons of their own rocks with those which have been classified in the British Isles. The past year has been unusually prolific in such communications, and I have therefore confined the following remarks to those researches which have been distinctly brought before us, referring my hearers who wish to study the subject of North American geology *in extenso*, to the original works, already forming a considerable library, including a vast number of communications which are to be found in that excellent periodical, the 'American Journal of Science,' conducted by Professor Silliman.

Palæozoic Rocks.—The value of the remarks of Professor W. R.

Rogers and his brother Professor D. H. Rogers* (one of our own fellows), in working out the complicated folds and contortions of a large region of palæozoic rocks, is well known to every English geologist who has visited North America. Placed at the head of the State Surveys of Pennsylvania and Virginia, these gentlemen took the occasion of the last meeting of the British Association to send to this country a joint memoir, entitled, "On the Physical Structure of the Appalachian Chain, as exemplifying the Laws which regulated the elevation of great Mountain Chains generally."

The Appalachian chain, including the Alleghanies, is the great back-bone of North America, having a length of nearly 1200 miles, with average width of about 100 miles, and it is essentially composed of one great mass of palæozoic deposits conformable to each other, which these authors and others have identified with Silurian†, Devonian and Carboniferous deposits.

And here an acknowledgment is justly due to our able associate and countryman, Mr. R. C. Taylor, well known to us before he left this country for the United States, as the author not only of good memoirs on the Crag of his native county, Norfolk, but also of an accurate survey and model of a part of the Glamorganshire coal-field. Mr. R. C. Taylor has, in fact, published several valuable sections and views explanatory of one of the coal-fields of Pennsylvania, in a separate work on that country.

Extending from north-east to south-west, the older rocks of the Appalachian chain have been thrown into a number of anticlinal ridges and synclinal valleys from 100 to 150 miles in length, and all more or less parallel to each other, but with certain deviations from rectilinear to curved directions; and of these Professors Rogers constitute nine principal groups, in five of which the axes are straight. Describing many of them, the authors show, that as the folds approach to the south-east, where igneous and crystalline rocks occur, convolutions are much more rapid, accompanied by many breaks and by complete inversion of the beds. This latter phænomenon is identified with that which has been recognized on the flanks of the Alps and other eruptive continental chains, where the older strata are incumbent on younger, and on the western flank of our own little Malvern Hills, where there is, as before said, a complete illustration of inverted dip. Seeing also that, in proportion as they recede from the main axis the folds are less abrupt, and gradually open out into broad and flattened anticlinals, which entirely die away at a certain distance from the crystalline and intrusive rocks, or towards the interior, the authors formed a theory which they conceive to be applicable to the bending and elevation of strata generally.

Comparing the undulations which mark the axes with the undu-

* See his Report on American Geology, published in the volumes of the British Association.

† The lowest rocks of the Appalachian chain were placed in parallel with the Silurian rocks by Mr. G. W. Featherstonhaugh in 1836. See Geol. Report. Washington, 1836, p. 101.

latory motion of the earth during earthquakes, they believe that all the grand ancient flexures of North America were produced at one time, and at the termination of the carboniferous æra, up to which period they were all beneath the sea, and consequently still in a flexible condition. These sediments were, it is supposed, subjected to flexures by the invasion from below of molten matter; and the peculiar and numerous convolutions are explained by calling into play an upheaving, wave-like oscillation, accompanied by a tangential or lateral pressure upon flexible masses which reposed upon a semifluid matter. English geologists will recollect that, in our account of the carboniferous strata of North Devon, Professor Sedgwick and myself distinctly referred their multitudinous flexures to lateral pressure; because in this case we had the eruptive wedge-like chain of Dartmoor on one flank and the older sedimentary ridge of the North Foreland and the Quantock Hills on the other, forming a resisting buttress, between which the intervening strata might very well be squeezed into their contorted shapes. In the American case lateral pressure was, it appears, applied on one side only of the bent strata; and hence the phænomena described, appear to me to indicate simply a dying out in a certain direction of the disturbing powers.

Admiring the positive geological results which have been derived from the survey of Pennsylvania, I regret that the theoretical inductions of the authors were suddenly brought before a body at Manchester unacquainted with the country which the authors had patiently worked out, and on which their reasoning was mainly founded. Unprovided also with the remarkable maps which have been prepared by Professor H. Rogers and his assistants, and without diagrams to illustrate the mechanical principles it involved, the geologists at Manchester could ill judge of the merits of the theory. A better acquaintance with the facts as well as with the objects of that memoir, induce me, however, to view it as a praiseworthy effort to establish laws of phænomena regarding subterranean movements; from a careful survey of the actual positions and relations of the masses moved in a definite but sufficiently extensive district. The manner in which these laws are expressed is perfectly (it must be admitted) in the spirit of inductive philosophy; and the intentions of the authors in presenting them, was truly stated to be "to call the attention of British geologists to analogous phænomena, which the authors think they detect in mutually parallel axes of some of the most interesting districts of Great Britain and the Continent." It is therefore my duty to invite your attention to the views which this communication embraces; and whatever may be your conclusions respecting the theory, to request you to bear in mind, that it was suggested by a wide and successful field-survey which is replete with sound research, and that the memoir was generously confided to the friendly feelings of the geologists of England.

I would next advert to the labours of Dr. Dale Owen of Indiana, who has presented this Society with a paper on the geology of the Western States of North America. In this memoir Dr. Owen comprises not only the results of his own observations since 1834, but also those of Dr. Troost* and Dr. Locke, the state geologists of Tennessee and Ohio. This memoir affords a general description of a vast country lying between 35° and 43° north latitude and 81° and 91° west longitude, including the States of Illinois, Indiana, Ohio, Kentucky, and Tennessee; throughout which enormous area, the deposits are stated to belong chiefly to the Carboniferous and Silurian systems.

Of the exceptions to this distinction, consisting of strata of the age of the Cretaceous system which overlap these palæozoic rocks on one frontier, and of other overlying deposits, to all of which the author alludes, I need now take no notice. Adverting to certain inferior masses beyond the Cumberland mountains which dip towards the granite (the phænomenon to which the Professors Rogers allude), it is shown, that these dislocated bands are surmounted by a series of strata often containing abundance of organic remains. One group of beds of shale, limestone and marl in the great Ohio valley, and estimated to occupy a surface of 10,000 square miles, is referred, from its fossils, to the Lower Silurian rocks. The next overlying mass consists, in great measure, of compact limestones, which mineralogically might be mistaken for the Great Scar or Mountain Limestone, but which the author now unhesitatingly compares with the Wenlock formation, pointing out that it is covered by other limestones and shales, and then again by a peculiar sandstone, the whole of which represent the Lower, Middle, and Upper Ludlow rocks. This vast series, characterized by Silurian fossils, sinks under enormous troughs of strata which are referable to the Carboniferous system, their base being composed of two bands of limestone, one of which (containing Pentremites, and called the Pentremital limestone) is compared with the Mountain Limestone of England, though from the previous observations of Dr. Troost this point may be doubtful†. Can the lower limestone and part of the supposed Upper Silurian represent the Devonian? Lastly, reposing upon these, are two carbonaceous masses of prodigious extent, one of which, as large as Great Britain, is commonly known as the great Illinois coal-field; the other, occupying parts of six states, covers an area of at least 50,000 square miles.

In estimating the value of this memoir, I must express on the part of this Society our obligations to Dr. Dale Owen, not only for his lucid description of the order of succession in those great and important limestones, and for the clear sections by which they were accompanied, but also for the very instructive suite of fossils characterizing each stratum, which he has presented to us. I have, on a former occasion, alluded to the value of similar contributions upon the older Rocks from the northern portion of the United States by

* In his Sixth Geological Report to the General Assembly of Tennessee (1841), Dr. Troost divides the Transition rocks of that state, and comparing the fossils, he distinctly refers a large portion of them to the Silurian system, saying that there are at least three or four divisions of that system in Tennessee.

† See Troost's Report, 1841, p. 21.

Mr. Hall; and I cannot but anticipate that the close study of the palæozoic fossils of America and of Russia, which have found their way into our museum within the last two years, will lead to results highly interesting to the naturalist, by showing variations of the same species when found in very distant localities; and most important to the great principles of geological classification, which, when rightly understood, can only be based upon the admission of such variations in widely remote contemporaneous deposits.

In presiding over the Section of geologists at the Manchester Meeting of the British Association, when this memoir was first introduced to the notice of my associates, I ventured to commend it for its truthfulness of research and practical value, and I was happy to find, that it was received in a similar spirit by this Society, the members of which will doubtless take a still deeper interest in it when they know that its author received his geological and chemical education in University College under the tuition of our lamented secretary, Dr. Turner.

Theory of the Origin of Coal.—American and European Evidences compared.—At the last Anniversary we were aware, from the independent evidence of Mr. Lyell, that both the bituminous and anthracitic coals of Pennsylvania were underlaid by *Stigmaria ficoides* and fireclay; and we have now before us the result of the labours of our associate Mr. Logan in the coal-fields of Pennsylvania and Nova Scotia, in examining which his chief object seems to have been to ascertain whether the facts relating to the theory of the origin of coal, as seen in North America, were analogous to those to which he has so successfully directed attention in England.

Availing himself of the prior researches of the American geologist, Professor H. Rogers and his assistant surveyors, who had prepared the valuable map of Pennsylvania above alluded to, Mr. Logan has laid before us a very clear sketch of the general relations of the Pennsylvanian carbonaceous deposits, and of their chief convolutions. Since that time the Governor and legislature of the Canadas have wisely selected this well-trained field geologist to execute a mineral survey of the whole province; and I am happy to acquaint you that he has already commenced his task in a very effective and vigorous manner, by laying down as the base-lines of his work some of the great anticlinals and synclinals of that region, and by connecting them with the already described feature of the United States. In comparing the coal-field of Pennsylvania with those of South Wales, with which he is familiar, Mr. Logan states, that he almost invariably detected beneath each anthracitic coal-seam a bed of fireclay or argillaceous materials filled with *Stigmaria ficoides*. In his description of the coal-fields of Nova Scotia, which have not yet been fully developed, but among which we hear of one bed of clear coal twenty-four feet thick, and affording 250 tons daily, Mr. Logan states he had also detected the *Stigmaria ficoides* in similar underclay. With such extended observation spread out before them, the evidences in which all seem to point one way, young geologists may well be led to suppose that the theory which, if I may so speak, has recently been rendered fashionable, of the origin of coal by subsidence of vegetable matter *in situ*, must be considered established as of general application. I, however, adhere to the cautionary remarks which I ventured to make last year, and will now endeavour to impress upon your minds the inapplicability of such a theory, however true under limitations, to large portions of the carboniferous strata in different parts of the world.

Since our last Anniversary statements have appeared in our own country, both supporting and impugning the probable truth of the theory. The last meeting of the British Association being held at Manchester, geologists were there assembled in the centre of a tract appealed to with great reason by the supporters of this theory as containing many proofs of its truth; for, in the immediate vicinity of that town there occur, as you all know, the beautiful examples of vertical stems of large trees apparently in their original position, which were formerly described before this Society. After giving an elaborate and satisfactory account of the great Lancashire coal-field, showing that its lowest members, formed on the flanks of the Penine chain, and subordinate to the millstone grit, contain marine shells analogous to those of the Mountain Limestone series, and stating that they are surmounted by a middle and an upper group, the former constituting the richest coal-field, Mr. Binney describes in great detail the composition and contents of all the numerous roofs and floors, as well as also of the coal-seams, which are included between them. He shows also that the roofs vary in their nature at different places, even over the same seam, and contain the remains of many vegetables, sometimes, as near Manchester, in vertical positions, *Sigillariæ* being in such cases a most abundant plant; other roofs of black shale in the lower field are loaded with *Pectens, Goniatites, Posidonia*, and fishes. The coal-floors, on the contrary, present a much greater uniformity of structure, fireclay similar to the underclay of Mr. Logan being most abundant; though it is admitted, that a different or siliceous clay also frequently occurs, and that two instances are known where the coal rests at once on coarse quartzose sandstone. Seeing, that with one exception, all the floors throughout an estimated thickness of near 5000 feet contain the plant *Stigmaria ficoides* usually with its leaves attached,—that both the roofs and floors indicate a very tranquil method of accumulation, —that the coal is free from admixture of foreign or drifted materials, and that large trees frequently stand upright, this author is induced to believe that the vegetables out of which the coal has been formed, grew upon the spot.

At the same meeting this view was contested by Mr. W. C. Williamson, also well acquainted with the structure of the country around Manchester. His chief arguments were, however, derived from other tracts, and they assisted in proving,—1st, the frequent association of marine shells with coal (as at Coalbrook Dale, and in Yorkshire); 2ndly, the very triturated and broken condition of the plants, as well as their great intermixture in the sandstone and grits, coupled with the fact that large quantities of vegetables are often matted together with marine and estuary shells, phænomena indicative of drift. Admitting that the floors of the coal or underclay present a great uniformity both in the absence of other plants and in the almost general occurrence of the Stigmaria, Mr. Williamson allows that a plant, found so very generally in such a position, may have grown in estuaries into which the other vegetables were drifted. Acknowledging that the drift theory is open to some objections, he stated that one of the greatest of these is, in his opinion, the extent and uniformity of some of the thin seams of coal. On this point, however, I must be permitted to say, that, if admitted, the difficulty must be applied to numberless other deposits of all ages, which every one knows must have been accumulated under water. Subaqueous action of a tranquil nature is, it appears to me, precisely the agency by which we can satisfactorily explain the uniformity of many thin layers containing vegetables which are extended over wide areas, as in the copper grits of Russia before alluded to. By what other possible means, for example, can we explain the wide extent of the thin copper slate of Germany with its associated fishes on the still thinner bone-bed at the base of the Lias? So far then from being a phænomenon which invalidates the formation of coal under water, it seems to me, that the very fact of a thin and equable deposit is an almost impossible condition, if we insist exclusively upon the submergence of forests or jungles *in situ*, in which considerable irregularities of outline must in all probability have prevailed.

On my own part, and that of my fellow-travellers in Russia, I have brought before this Society what we consider strong evidences against the too general adoption of this favourite theory. We have told you that in many instances the *Stigmaria ficoides* occurs in loose and incoherent sands, as well as in shales, and is frequently present where no coal is seen; but what we chiefly insist upon is, that all the coal-seams of the South of Russia, without exception, alternate repeatedly with beds of purely marine origin. In one section of the Donetz coal-field it has been stated, that at least twelve beds of marine limestone alternate in one vertical section with thirteen seams of coal and numerous bands of sandstone and shale, in which many species of plants, besides Stigmariæ, are confusedly heaped together. But we need not go to Russia for such examples. The whole of the mountain limestone or lower coal series of the north of England is charged, though not to so great an extent, with proofs of the alternation of marine deposits with coal and its associated sandstone and shale.

The coast of Northumberland, to the north of Alnwick, presents evidences of thin seams of coal resting at once on sandstone, and intimately connected with limestone full of sea shells. Advancing northwards to Berwick, and to beyond the Tweed, purely marine strata re-occur, charged with still more carbonaceous matter; and, in the same series on the north-western parts of England, we have frequent examples of the persistence of what must be called exclusively marine conditions. Throughout that vast succession of beds, all the animal remains with which geologists have become acquainted, occupying many distinct stages, have lived in the sea, whilst the plants, so far as I have been able to observe them (broken into fragments), consist of many species irregularly heaped together, the whole, together with the sands, grits, pebbles and shale, offering the clearest signs of the drifting action of water.

On the subject, then, of the origin of coal, it would appear, that as our inductions can never be sound, if they repose upon one class of phænomena only, so do some coal strata offer indications of the truth of the hypothesis, that in large tracts of the world, the mineral was formed from vegetables which were washed into bays and estuaries, and often carried far into the then existing seas. In other instances, flat and marshy tracts rich in tropical vegetation, being subjected to gradual depressions, may have been converted into lagoons and swamps without any direct encroachment of the sea; and in this peculiar condition (subjected, however, in all cases, to entombment beneath those waters in which the overlying sandstone and shales were accumulated), oscillations of the land may have raised the beds at intervals, again to be fitted for the growth of marshy vegetables.

In geology more than any other science, it must be our constant endeavour to unravel phænomena which at one time seemed inexplicable, and often opposed to each other; but with new discoveries the difficulties vanish, and the apparently conflicting testimonies are found to be in perfect harmony with the order of changes, which the surface of the globe has undergone. I repeat, therefore, my belief, that, whilst coal may have been formed in many localities by subsidence of vegetables on the spot on which they grew, as first suggested by Brongniart, MacCulloch and others, its origin unquestionably is also due, and over very large territories, to plants having been washed into estuaries and seas, and there equally spread out in successive layers with sand and mud.

Gypsiferous Rocks in North America.—Having now disposed of all the subjects relating to the known deposits of decided Palæozoic age in North America, I will endeavour to show how the examination of one continent throws light upon the structure of another, by inviting your attention to the great Gypsiferous deposits of North America, to which, in treating of Russia, I have already alluded.

The gypsiferous strata of Nova Scotia, with their associated sandstone, shale, and fossiliferous limestones, were at first referred by Mr. Logan to the triassic period; an inference which he drew from the general character of the fossils, and their dissimilarity, as a whole, to those of the Carboniferous rocks of that country. This opinion, however, is one from which I know this author receded, upon finding that some of the shells which he had brought home were recognised by M. de Verneuil and Count Keyserling, to be identical with species from the Permian deposits of Russia.

This comparison with the Russian strata has, indeed, received so much illustration by the arrival of a large assemblage of fossils brought from numerous localities in Nova Scotia by Mr. Lyell, and which he has obligingly submitted to the examination of M. de Verneuil and myself, that I have not much doubt of these gypsiferous deposits and associated limestones of Nova Scotia, being absolutely the same as the Permian rocks of Russia. Even lithologically there is the greatest similarity, whether in the large rock-masses of gypsum, red and green marls, conglomerates and sandstones, or in the magnesian and sandy limestones; and when we compare the fossils submitted to us, the parallelism is as firmly established as can be, between any two groups of the same age in distant localities. It is not merely that these American strata contain a few species identical with forms which typify the Magnesian Limestone of England, the Zechstein of Germany and the Permian rocks of Russia, but still more that such beds immediately overlying the carboniferous deposits, and even, according to Mr. Lyell, partaking of some of their flexures, should be found to contain exactly the same distribution of genera, and as near as possible the same proportions of species in each genus as in the synchronous deposits of Europe! Again, the fossils of this group are, for the most part, as badly preserved and limited in species in America as in Europe, and the striking agreement of those which can be detected is therefore the more remarkable. Even in negative proofs the similitude is great; for wherever these deposits have been traced eastward through Europe and to the confines of Asia, they have been found to be singularly deficient in chambered shells, and such Mr. Lyell finds to be the case in the various localities examined by him in North America. But having already sufficiently called your attention to the striking points of agreement between the American and Russian formations, I anticipate the pleasure you will shortly experience when Mr. Lyell brings the subject, as he intends to do, before the Society.

Seeing the great variety of lithological aspects of these strata in Russia, and that the flora as well as the fauna are of a type distinct from those of the carboniferous age, we proposed the name *Permian*, a term which I trust may be considered more applicable to the equally diversified deposits of North America than "Zechstein" or "Magnesian Limestone,"—names which point to one member only of this complex series as seen in Russia, and where it occupies a region larger than the whole kingdom of France!

Mr. Logan having also stated that he found slabs in some rocks in the bay of Fundy, which he considers to be of the same age, and which exhibit footmarks on their surface, is it possible, I would ask, to connect with the same formation, the red and green marls of the valley of Connecticut, though distant 400 miles, in which Ornithichnites occur, and which also contain remains of Palæoniscus, a genus of fish very characteristic of the Permian rocks? To this question we shall again revert under the head of Palæontology, in considering the Ornithichnites of Connecticut*.

* Since the Anniversary of the Society the fossils of the gypsiferous rocks of Nova Scotia collected by Mr. Logan have been examined by Mr. Phillips,

Newfoundland.—This very ancient British colony, viewed until recently as a mere fishing station, but now rising rapidly into importance through its internal sources, has recently undergone a geological survey by one of our members, which demands notice in this portion of my Address, because the author, Mr. Jukes, is of opinion, that this island contains no strata of younger age than the Carboniferous. The eastern parts are, it appears, composed of very thick deposits of slaty rocks, sandstones and conglomerates, which are divided into upper and lower masses. They are penetrated by different igneous rocks traced from north-north-east to south-south-west in a number of anticlinal and synclinal lines. Great masses of the central tract are usurped by granite and various igneous with metamorphic rocks, which are followed on the west by a band of gneiss and mica schist with crystalline limestone*. To what epochs any of the slaty rocks belong, has not been determined, as no organic remains have been found in them, but on the western shores, this ancient and crystallized series is overlapped by red sandstone, shale, gypsum, beds of coal subordinate to shale, marl, yellow sandstone and grit. I here quote the ascending order which Mr. Jukes assigns to the strata; but as he admits he never could observe consecutive sections, is it not possible that the great gypsiferous beds of Newfoundland may occupy the same place in relation to the coal-fields as in the opposite shores of Nova Scotia, and like them represent the Permian deposits? In fact, Mr. Jukes candidly states, that the gypsiferous, red and inferior portion of the coal formation (as he classes it) is so similar to the New Red Sandstone of England, that he was at first sight tempted to give it that name. Now as these rocks are seen in one section only beneath the coal, the following hypothesis may be adopted: that the coal in question is not a portion of the great old coal formation, but of the same age as the coal in the Permian rocks of Russia, and that the strata have been inverted where our author examined them, a phænomenon easily understood in a region so highly metamorphosed as Newfoundland, and where rocks of the age of the Magnesian Limestone may have been locally placed beneath true carboniferous strata. It would be wrong, however, to attempt more than mere suggestions from any evidence which has yet been brought before us, since Mr. Jukes has found no traces of organic remains even in these uppermost deposits of Newfoundland. In truth, our associate has evidently had to grapple with some of the most ambiguous rock-masses of North America, in a country obscured by moss and vegetation, as yet

who is of opinion, that they bear a most striking analogy to those of the Magnesian Limestone of England. It is satisfactory, therefore, to know that the beds containing the footmarks are proved to be of the same age with the gypsiferous rocks by the presence of the same group of fossils. Mr. Logan alludes to plants which I have not seen, and the exact comparison of these and others collected by Mr. Lyell with Permian types is still very desirable.—April 1st, 1843.

* See also some very interesting observations on the structure of Newfoundland in Sir R. Bonnycastle's 'Newfoundland in 1842,' vol. i. p. 179.

impassable to the casual traveller, and the coasts of which are of very difficult access. He deserves, therefore, so much the more our thanks for having pioneered the way under many difficulties, and for giving us this outline reconnaissance of the geological structure of a colony, to become well acquainted with which will require elaborate surveys, conducted by those who have previously made themselves masters of the keystones of succession in the adjacent continent. When, therefore, the true geological equivalents of Canada and Nova Scotia shall have been thoroughly established by the researches of Mr. Logan, and placed in exact relation to the well-developed rocks of the United States, the obscurity which shrouds Newfoundland may be dispelled*.

Secondary and Tertiary Rocks, and superficial deposits of North America.—In my Address of last year I had no hesitation in predicting, that geologists would reap great instruction from the visit of Mr. Lyell to the United States. The earlier sketches which he sent to us, including accounts of the Palæozoic rocks, might be taken, indeed, as some earnest of what was to follow, and as we are well acquainted with his powers of generalizing and habits of faithful research, we could not well over-estimate the amount of production at his hands. The documents which he has laid before you have fully justified our anticipations. One of his memoirs, on the Tertiary formations and their connexion with the chalk in Virginia, North and South Carolina, and other parts of the United States, has a very important bearing in showing the amount of agreement of those deposits with the strata of similar age in Europe. Noticing with due approbation the works of Professors W. B. and H. D. Rogers and Mr. Conrad, on the Tertiary rocks of Virginia, he shows, that certain deposits above the chalk are of true Eocene character, and never contain Secondary fossils or any forms intermediate between the newer Secondary and older Tertiary types. These Eocene beds are surmounted by rich shelly deposits, the contents of which bear a great generic resemblance to those of the Suffolk crag and the Faluns of Touraine, and are therefore referable to the Miocene epoch.

In North Carolina, black shales, first described by Mr. Hodge, are shown to be of the cretaceous age by containing Belemnites, Exogyræ, Gryphææ and Ostraeæ, a few of the species being well known in Europe, and found by myself in the distant parts of Russia. This cretaceous deposit is covered by a peculiar calcareous rock, the Wilmington limestone and conglomerate, which had been termed Upper Secondary, and supposed to indicate a passage from the Secondary to the Tertiary periods, but in which Mr. Lyell could detect no organic remains to support that opinion, the only

* I regret that I accidentally omitted to call attention in my last Address to a short memoir, read during the preceding session by Mr. Henwood, upon the Silurian Rocks of Lockport near Niagara. Having long been assiduously occupied in his native county Cornwall in studying the mineralization of rocks, Mr. Henwood is, I understand, about to publish a work on the metalliferous deposits of Cornwall and Devon.

determinable species being of the Eocene age. Again, in South Carolina, on the Santee river, a white limestone occurs, which lithologically so resembles one of the upper members of the cretaceous deposits of New Jersey, that even Mr. Lyell, at a first view, had no doubt it was a portion of the same formation: on examination, however, of the fossils, it proved also to belong to the tertiary series. This lithological resemblance had erroneously led to the admission of several well-known tertiary fossils into the Cretaceous system of America, an error which Mr. Lyell has removed. This correction is valuable, and, though it tends to negative a hope which I once entertained, founded upon what my friend Professor Sedgwick and myself believed to be very good evidence on the flanks of the Austrian Alps, that beds of passage would be discovered between the Cretaceous and Eocene epochs, I am bound to say that the transatlantic researches of Mr. Lyell go far towards the establishment of an extensive, though I still incline to consider not a general break between those periods; for he prudently admits, that evidences differing from those he obtained, may be found in the Southern states bordering the Atlantic, of which he explored but a small part. Referring you to the abstracts of his memoirs, and knowing that you will soon have from him more complete details, I will not occupy your time in attempting to give what would convey an imperfect idea of the succession of the widely spread tertiary deposits, which occupy nearly all the portion of Georgia and South Carolina between the mountains and the Atlantic. Illustrating the observation of Mr. Maclure, that the first falls of the Savannah and other rivers of this region are at the junction of the tertiary strata with granitic and hypogene rocks, Mr. Lyell shows, that at some points, as near Augusta in Georgia, where the former have been made up of the detritus of the primary rock, they have the aspect of gneiss; a fact quite analogous to that which I had the pleasure of observing in his company many years ago in Central France, where the oldest tertiary and freshwater beds repose at once upon the granites of the Puy en Velay. After a laborious comparison of a profusion of fossil shells from the American strata, in the determination of which he acknowledges the liberal assistance and co-operation of Mr. Conrad, Mr. Lyell sees fresh and strong grounds for adhering to his former views respecting the value of testing the age of tertiary strata, by the smaller or greater per-centage of existing species which are to be detected in each deposit; for he finds the same proportions which had been established between the fossils of European basins and the living mollusca of adjacent bays, to hold good in the Eocene and Miocene deposits of the United States, when compared with the existing fauna on their shores.

In supplying us with new evidences of the recession of the Falls of Niagara, which he described last year, Mr. Lyell has also given us a sketch of the ridges, elevated beaches, inland cliffs and boulder formations of the Canadian lakes and valley of St. Lawrence. After referring to the researches of Capt. Bayfield at and around Montreal and Quebec, he enters upon a general survey of the great boulder formations on the borders of the Lakes Erie and Ontario; and states that in the valley of the St. Lawrence, as far down as Quebec, marine shells of arctic character have been found associated with coarse detritus. As some of this shelly and boulder deposit lies at about 500 feet above the sea, and as Lake Ontario is at a much lower level, it is inferred that the sea in which the drift was formed extended far over the territory bordering that lake. That the same sea extended as far south as 44°, 30′ north latitude, is proved by the presence on the shores of Lake Champlain, of marine shells; which, in their Arctic forms and close agreement with those of Uddevalla in Sweden, formerly described by himself, are supposed to imply, like those of the St. Lawrence, the former prevalence of a cold climate when the drift originated. In regard to the far transported boulders, they have in one locality (Beauport) been found both above and below the sea-shells.

The parallel and continuous ridges of sand and gravel, which by Mr. Roy and other authors had been considered to be the shores of an enormous lake, successively let off, are said to rest on clay of the boulder formation, and yet to be occasionally capped by blocks of granite and other hard rocks. Comparing them with the *Osars* of Sweden, and stating, from the evidence of Mr. Whittlesey, that their base-lines are not so horizontal as had been supposed, Mr. Lyell inclines to the belief, though no shells have been found in them, that they were all formed under water, and probably beneath the sea, as banks or bars of sand, admitting at the same time that some of the less elevated ridges may be of lacustrine origin.

The last observation seems to open out the whole question of whether vast freshwater lakes, extending far beyond the area of those which now exist, may not, at one period, have covered the interior of America.

This opinion has been long entertained by our associate, Mr. Featherstonhaugh, who, in his researches eight years ago, amid the western and untravelled tracts, where the sources of the great rivers are separated from each other by very slight elevations, discovered fluviatile and lacustrine shells, wherever excavations existed or pits had been sunk, and at great distances from the courses of the present streams. I have the more pleasure in making this allusion to the geological labours of Mr. Featherstonhaugh, because he near fifteen years ago pointed out some of the chief phænomena connected with the retrocession of the Falls of Niagara. He was among the first persons, subsequent to his survey of large tracts of the far-west country of Arkansas, to assist in the introduction into the United States of an acquaintance with the most modern school of English geology; and who, after popularizing the subject by public addresses in 1828 and 1829, urged upon the government of that country that geologists should always accompany geographical surveyors *.

The view adopted by Mr. Roy, Mr. Featherstonhaugh and

* See Monthly American Journal of Geology, 1831, by Mr. Featherstonhaugh.

others, of the former presence of inland lakes in North America larger than those which now prevail, has recently been sustained by the Rev. Mr. Schoolcraft, an American geographer, in a memoir which he read before the Geological Section of the British Association at Manchester. This author, who has passed nearly twenty years of his life in their vicinity, believes that the former great lakes have been lowered by ancient dislocations. As examples of the bottoms and edges of these former sheets of water, he adduces large belts and tracts of sandy plains, which, from their scanty vegetation and undulated surfaces, have all the appearance of recent desiccation; and as proofs of the water having stood at various levels, he states, that it has left marks of erosion on the mural faces of the harder rocks. But the most original part of this communication, and which may indeed serve to explain the origin of some of the ridges respecting whose origin Mr. Lyell differs from the writers before alluded to, is the actual production of sand-storms by causes associated with these lakes. Indicating some of the most extensive energies of this nature proceeding from Lake Superior, and the powerful action of storms upon sandstone and grauwacke rocks, Mr. Schoolcraft is of opinion, that by a union of powerful currents and furious gales, dunes have been formed which rise to 300 feet above the water. The sand, being first worked up in great bars, has since been transported by the wind over wide tracts, which are thus rendered sterile; stagnant pools are formed in adjacent depressions, once highly productive, and prostrated and buried trees are there associated with freshwater shells; and thus by actual causes, formations of considerable thickness are accumulated. Geologists have long been aware, that wind has been an agent in heaping up some of the deposits whose origin they endeavour to explain, and very striking examples of this operation were adduced by Lieut. (now Capt.) Nelson, R.E., in his account of the modern shelly and sandy limestone of the Bermudas. As no one, indeed, has a better acquaintance with this class of phænomena than Mr. Lyell, it is enough for me to have attracted his notice to the vivid descriptions of Mr. Schoolcraft, which may, I think, aid in explaining some of the superficial appearances in the lake country of North America.

Let us return, however, to the memoirs of Mr. Lyell. Reviewing the series of changes which have taken place in the Canadian and Lake region, Mr. Lyell conceives, that after an early period of emergence, during which lines of escarpment and valleys of denudation were excavated in solid rocks, the surface of the country was submerged, and the cavities filled with the marine boulder formation; and that during the last elevation of the land, the parallel sand ridges were produced, the boulder formation partially denuded, and the different lakes probably formed in succession, leaving a partial sea channel, which, contracting first into an estuary, was eventually converted into the river Niagara. Reaching this point in his order of events, our author succeeds most happily in developing his views concerning the retrocession of the falls of this river; bringing forward arguments to show that during the re-emergence of the land from the sea, a succession of falls must first have been established near Queenstown. The first or uppermost fall, he argues, must have been of moderate height, when the land was sufficiently raised to wear away the Niagara shale, and undermine the incumbent limestone, which is of slight thickness at its termination near Queenstown. This upper fall having thus cut its way backwards, while the remainder of the escarpment was still protected from denudation by submergence, the second fall would next display itself on a further upheaval of the land, the river being thrown over a lower ledge of hard limestone ; finally the land continuing to rise, a third cataract would be caused over the hard quartzose sandstone, which rests on the soft red marl at Lewistown. These several falls would, at first, each recede farther back than the one immediately below it, their distance being greater or less in proportion to the slow or rapid rate at which the land emerged, but they would all at length be united into one fall, the uppermost limestone becoming thicker in its prolongation up the river, and thus retarding the retrogression of the highest cataract, while the two lower falls would continue to recede at an undiminished pace, until each had in its turn overtaken the uppermost.

In describing the coast sections of Massachussets, and in transferring our attention to the interior of Kentucky—localities already rendered classic by American geologists and palæontologists—Mr. Lyell has placed before us a clear view of other leading points of the changes which that great continent has undergone.

The tertiary deposit at Martha's Vineyard, on the coast of Massachussets, had, indeed, been described by Professor Hitchcock, who seeing the highly-inclined position of the beds, the great variety of structure as well as colour of the strata, and the obscure casts of shells which they contain, was much impressed with their apparent similarity to the Lower Tertiary beds, or Plastic and London clay of the Isle of Wight described by Mr. Webster. By a careful examination however of these strata, and by collecting a larger and more varied suite of organic remains than was known to Professor Hitchcock, Mr. Lyell has come to the conclusion, that so far from being of the Eocene age, this formation is at most of no higher antiquity than the Miocene. This result has been obtained by finding the teeth of several specimens of fishes which belong to species obtained by Mr. Lyell in the Miocene "Faluns" of Touraine, and determined by Agassiz; together with vertebræ, referred by Mr. Owen to two species of whale, the teeth of a seal, and the skull of a walrus; an association which cannot fail to convince geologists that the materials of this island, off the coast of New England, were accumulated at no very distant geological epoch. The high inclination of these party-coloured sands, clay and conglomerates, and the curvatures which some of them have undergone, probably through great lateral pressure, are clear proofs that they have been powerfully upheaved and dislocated; whilst the gravel and boulder formation which covers their edges horizontally, compels us to conclude, that the disturbed beds were submerged during the boulder period, and subsequently elevated to the position in which we now see them.

The presence at Big Bone Lick, on the Ohio, in Kentucky, of great quantities of bones of buffaloes near the spot where salt sources issue through marshy lands, and the existence of the beaten tracks by which these animals approached this spot, render it highly probable that they were allured thither during certain seasons in extraordinary numbers, and that many of them were engulfed and destroyed in the marshy ground.

Mr. Lyell endeavours to show that what occurred within the historic æra to the buffalo, in all probability occurred also to the extinct mammals, whose bones are found in the subjacent clay and marsh to a depth of twenty-five feet, and are associated with modern fluviatile, terrestrial and lacustrine shells, showing that floods of the Ohio have drifted and re-arranged buffalo bones at higher levels than the comparatively ancient marsh. Mr. Lyell suggests, that no great physical revolution of the surface has taken place since the Mastodons died and were buried on the spot, and at a period not very remote from that in which we live. All these remains of extinct quadrupeds, including a horse, which from the incurvated form of its teeth Professor Owen believes to have been of a different species from that which is now living, are said to have existed, as far as the author can judge, all over North America*, at a later period than the deposit of the great boulder drift when the continent was submerged beneath the sea which contained shells of modern species. In connexion with this subject, allusion is made to the observations in South America, of Sir W. Parish and Mr. Darwin; who found that the great Megatherioid quadrupeds lived at a very modern geological period.

The same conclusion respecting the relative age of these fossil quadrupeds and the recent molluscous fauna, is fully substantiated by a clear section and an interesting memoir by Mr. Hamilton Couper of Georgia, recently read before this Society. This author acquaints us, that a shelly post-pliocene deposit, which extends far along the coast, and embraces exclusively marine shells of existing species, is covered by a swampy accumulation, in which the tusks of mammoth and mastodon, often in excellent condition and little abraded, are grouped with the remains of the megatherium, horse, &c. All this indicates a very tranquil deposit, a slow and gradual emersion of the bottom of the sea, and a long-continued elevation of the land during the period of those great mammals which have since passed away and given place to man and the present races.

In bringing before us such a number of clear proofs of successive oscillations of the continent of America, drawn from his own observations and those of other authors, and in generalizing on them with his usual skill, Mr. Lyell further deduces a very important corollary from the Arctic character of the shells in the most recent

* Has any comparison been yet made between the teeth of the American and the European fossil horses?

marine or boulder formation of the northern part of the American continent. For, as there can exist no doubt, that whenever and wherever these shells were deposited, whether at Uddevalla in Sweden, near Archangel in Russia, in Great Britain or in America as far south even as Lake Champlain, a very cold climate must have prevailed; and as such submarine accumulations were elevated and formed land before the great mammals in question appeared; so it is manifest, as Mr. Lyell remarks, that these creatures could not have been destroyed by the same cold as that which gave rise to the Arctic shells, and with them to the correlative phænomenon of the transport of great boulders and the scratching and scorings of rocks. This clear reasoning appears to me to be an unanswerable refutation of a leading feature of the glacial theory as propounded in its widest sense. At the same time it must be admitted, that the surface of Great Britain does not offer the same neat division between a former submarine state and beds containing the remains of extinct quadrupeds, as the continent of America. In some cases, it is true, as at Market Weighton, described by Mr. W. Vernon Harcourt, there are accumulations of bones which lay in fine shelly clay, with gravel below and gravel above the clay, indicating changes from terrestrial and freshwater to submarine conditions. The Brighton breccia of Dr. Mantell is a fine example of a thick detrital mass, of whose grandeur, and of the powerful agents by which it was heaped up, any one who looks at its composition and at the extraordinary erosion of the surface of the chalk on which it rests, will be convinced; and the bones of elephants are impacted in the very heart of this mass.

Nay, nearly the whole of the cliffs of the eastern shores of England, and large tracts in Norfolk and Holderness in Yorkshire, exhibit, as you know, boulder and detrital accumulations of very tumultuary characters, in which the remains of these great mammals are entombed, sometimes, indeed, mixed up with broken fragments of the same species of shells which in America, it would appear, lie always beneath such bone deposits.

Seeing, therefore, these great differences in the character of the evidence, to what other conclusion can we come, than that the destruction of these great animals commenced at earlier periods in some regions than in others; and that, whilst in America a gradual and steady elevation of the land has preserved records of tracts, which, never since submerged, have been inhabited by successive races of quadrupeds, other countries have been affected from earlier periods by unequal and perhaps more intense oscillations, by which the relations of these animals to submarine and terrestrial conditions have been rendered much more obscure? In a word, the surface of the earth exhibits, in some of its last phases, numberless proofs that no simultaneous general destruction of any such lost races can have taken place; but that each great region, when studied in itself, presents, in the extended sense of the word, local phænomena of accumulation, destruction and renewal.

South America.

This year is marked by a great accession to our acquaintance with South America, by the appearance of the splendidly illustrated work of M. Alcide d'Orbigny, published at the expense of the French government, and for which geologists have been long waiting with impatience. During eight years of research, this gifted naturalist successively examined the coasts of Brazil, the Republic of Uruguay, the Argentine Republic from the frontiers of Paraguay to Patagonia, the coasts of Chili, Peru and Bolivia; and by a long residence in the last-named country he was enabled to survey, in many directions, a large region from the coast to the interior. The details of his labours form a first part of the work, illustrated by many sections and by one of most beautifully coloured geological maps which ever fell under my observation. In his general observations M. d'Orbigny remarks, that his own observations extend from 12° to 42° south latitude, and from 45° to 80° longitude west of Paris; a surface comprised between the coast of the Atlantic Ocean in Patagonia to Lima on the Pacific; whilst, by collecting the observations of other travellers and examining fossils from more distant localities, his general views may be said to apply to all the vast continent between Colombia on the north and the Straits of Magellan! This author reviews in chronological order the different rocks, and indicates each change which they have undergone, describing the granitic, porphyritic and trachytic masses in relation to their extension, composition and elevatory agency. He then considers in an ascending order of date the sedimentary deposits, which he classifies as *Gneissic* or Primary, Silurian, Devonian, Triassic, Cretaceous, Tertiary and Diluvial or Detrital; showing the dislocations which they have undergone at successive epochs, and the causes of these disturbances.

After an enumeration of all the facts, M. d'Orbigny, under the head of conclusions, sketches out all the great revolutions of which South America has been the scene; a subject on which he seems to display much vigour of thought, but which I cannot now attempt to analyse, without doing injustice to him, not having, in truth, had time to study his work. One only of his inferences I will advert to, as being clearly established by the order of the evidences; viz. that, as the increment of fresh matter has successively taken place from east to west, so the ancient beds of the sea have been heaved up successively on lines trending from north to south, and to the west of that primary, or original nucleus on the Brazilian shores.

Eastern Countries.

Hindostan, Affghanistan and China.—Long as Hindostan has been attached to the British Empire, vast lacunæ remain to be filled up before a general geological map of this peninsula can be published; and yet, in no part of the earth over which British rule extends, is an adequate acquaintance of the subsoil more required. Viewing it as the great centre of civilization of the East, I should hail the day when its governors, employing competent geologists, shall direct a comprehensive inquiry to be made into the whole of its mineral structure, the result of which must prove to be of the highest national value. Let me not, however, do injustice to the able men who have, from time to time, thrown light on this great subject; for in Cautley and Falconer we have recognized geologists whose researches in the northern parts have claimed our highest rewards; whilst Christie, Franklin, Sykes, Malcolmson, Grant and others, have been arduous and successful explorers of the central and southern tracts. Botanical science, warmly fostered by the Indian government, at home and in the East, has flourished under the researches of Wallich and of Royle; and much indeed even in geological inquiry has been accomplished by the latter, who is about to give us other proofs of his geological powers in a memoir on the Tin Mines of Senasserin. Rejoicing in such progress, I should, however, be better satisfied if a little more public encouragement were extended to our science, and that systematic geological surveys were patronized. It was, therefore most gratifying to me to receive the first volumes of the Calcutta Journal of Natural History, instituted by Dr. M'Clelland; because it is evident, that a work so ably conducted, and acting upon the intelligent classes in the metropolis of our Asiatic empire, must rouse the Indian government to combine the desultory efforts of a few geologists, who, to their great praise, have acquired their knowledge by their own labours, supported chiefly by the exertions of the lamented Mr. Prinsep*. The examples of the governments of the United States and of Canada may well be taken as models; and the truly valuable results which will follow from them, must fully satisfy those even who look to science only when it can be brought into useful operation.

I may here be allowed to express a hope, that our late occupation of Affghanistan, the travels of our envoys, and the marches of our gallant troops through gorges of such surpassing grandeur, have not been made without obtaining some gleanings of the structure of a part of the globe which we are not likely to be able soon to look upon again. Alas! these wars, with all their crowning glory, have deprived us of one on whom we might have depended for some recital of the natural history of those inhospitable defiles. When the adventurous Burnes explained to us, a few years back, within these walls the outlines of the structure of the wild countries of Bokhara, he taught us what we might expect from him, when he returned from the extensive missions into the lands beyond the Indus, to which the services of his country called him. Cut off in the midst of his brilliant career, and falling under the daggers of those in whom he placed implicit confidence, we have lost in him, if not the tutored geologist, at least the vivid delineator of natural phænomena, whose memory will ever be held dear to those who had the happiness to know him. Let us hope, however, that some officers of the gallant army which has so nobly avenged the death of Burnes and our other slaughtered countrymen, may be able to give us some record of the

* See also the Madras Scientific Journal.

structure of that diversified region. But if we should be disappointed in this wish, to China I trust we may turn with well-founded confidence, that so vast a region may not be laid open to British enterprise without bringing to us some accession of natural knowledge. Already, indeed, we learn that the quays of Nankin are stored with the finest native coal (as if stationed there to supply our invading steam-vessels), whilst from our former casual intercourse with the mouths of the southern rivers, we knew that tertiary deposits occur in their vicinity. We have now to ascertain whether the coal of Nankin is derived from a central ridge in that wide country, or whether, through the innumerable canals by which it is intersected, the mineral is transported from the Pekin or northern coalfield, to which I last year directed your notice. In short, by acquiring (that which is indispensable for a people like ourselves, whose commercial and maritime advancement depends so essentially upon the application of steam power,) a thorough acquaintance with the carboniferous sites in China, we shall at the same time obtain a general insight into the physical and geological relations of her rocks. I would even suggest, that agents, possessing sufficient knowledge of coal-fields and mining wealth, should be attached to those permanent stations which are to be occupied by our forces; whence, if a friendly spirit of intercourse is continued, excursions could be made into the interior. Thanks to the diffusion of knowledge, our rulers can now have no difficulty in procuring much useful geological information, even by directing their own officers to make the inquiries within their reach; and if consuls cannot be found, who to a familiarity with statistics add the powers of scientific research, it is at all events well known, that our highly instructed corps of Royal Engineers contains within it several good geologists. Let therefore British statesmen encourage our science; and, casting their eyes around our vast colonies, apply to them some measure of that geological research which they are so judiciously and liberally patronizing in our own islands.

From these anticipations of the exploration of China, we may turn with pleasure to the recent advances which have been made in Hindostan. Notwithstanding all previous researches, a great portion of the peninsula was believed to be slightly interesting to palæontologists, and to contain very few traces occupied by secondary strata, as interesting as those of the Run of Cutch described by Captain Grant. This opinion has, it appears, been much over-stated; for under the modest announcement of "a collection of fossils discovered by the writer in rocks in Southern India," Mr. Kaye has recently made known to us the presence of considerable masses of limestone near Pondicherry charged with Nautili, Ammonites, Baculites, and Hamites, with numerous genera of conchifers and mollusks, as well as with remains of Polyparia, Echinidæ, and Ichthyolites. Judging from this beautiful collection, which was exhibited at our rooms, there can be no doubt that the fossils belong to the Cretaceous system, of which we have hitherto had no account in southern

India; whilst other remains obtained from the neighbourhood of Trichinopoly and Verdachellum may possibly belong to intermediate and younger deposits, and thus a strong additional incentive is supplied to prosecute researches in Southern India, by the discovery of singularly well-preserved chalk fossils, where their existence had never been suspected.

Lt. Baird Smith, E.I.C., has furnished us with a faithful record of certain boring operations at Fort William; curious and instructive in showing the varying nature of the deposits which have for ages been accumulated to form the great Gangetic delta. The lower parts 350 to 480 feet below the surface, were found to consist of rolled pebbles and gravel of crystalline rocks, very analogous to those described by Capt. Cautley at the base of the Himalaya range, whilst the overlying beds were composed of clay and sand, including some hard detritus, and much of the peculiar substance termed Kunkur, and the uppermost strata contained portions of peat and fragments of trees.

Another short memoir on India, by the Rev. R. Everest, is upon the high temperature of wells in the neighbourhood of Delhi. Giving tables of the temperature of numerous wells around three different localities, the most remote being about ninety miles from Delhi, he finds in all a sensible increase of warmth from the surface downwards. The author endeavours to explain the higher temperature of these wells as compared with those of Sincapore, by supposing, that in this sandy tract, entirely devoid of rivers, rivulets, or even springs, the water is exclusively derived from the hot south-west monsoon, which, blowing nearly from the equator, transports and lodges a vast quantity of aqueous vapour having a temperature of 77° to 81°; and as little or no rain falls in the cooler seasons, this fact alone would, he supposes, account both for the high temperature of the surface and that of the interior. Applying this to geology, Mr. Everest says, "it may be easily conceived, that, when a much greater portion of the globe was covered with water and the evaporating surface was consequently larger, currents of air charged with aqueous vapour prevailed still more and modified the ancient climate, *even in still higher latitudes.*"

Egypt.—Let us now consider what amount of information has recently been laid before us concerning the structure of Egypt. Prefacing his sketch of the geology of that country with a view of the physical features which divide it into productive and sterile tracts, and which are intimately connected with the nature of the rocks, Lieut. Newbold* shows, that the horizontal position of the great masses of depository strata affords no traces of dislocation except in Upper Egypt, where inclined beds, fissures, and altered rocks attest the agency of eruptive matter. An account of the hypogene rocks, and of the peculiar "breccia di verde," is followed by a sketch of the great sedimentary masses in ascending order, and these consist of three formations only, viz. a lower sandstone, a marine lime-

* Of the East India Company's Service.

stone, and an upper sandstone. On the age of the first of these rocks (much used in statuary by the ancient inhabitants), Mr. Newbold, not having acquired fresh information, simply states that Ehrenberg has referred it to the "Quader Sandstein," whilst the French author, Lefevre, has classed it with the "Keuper," or "Marnes iriseés." The next, or the marine limestone, is the well-known building stone of the pyramids, which, from the remains it contains, has, I believe, been classed with the *calcaire grossier*, though the list of fossils given in this memoir points to Cretaceous and Miocene as well as Eocene ages. This limestone is inclined and altered in the proximity of the plutonic rocks. In the upper sandstone, which extends into the Numidian and Libyan deserts, and even to Abyssinia, our author found a few casts of marine shells, but too imperfect to enable him to speculate on the precise age of the tertiary rock. Much interest is attached, however, to this deposit, in consequence of its being the matrix of the trees which constitute the petrified forest of which this Society formerly received specimens from Lord Prudhoe, and of which my noble friend gave me a very clear verbal description, stating that the trunks of the trees were occasionally in a vertical position, their whole aspect conveying to him the idea of their being in the place of their growth. Lieut. Newbold describes the stems as chiefly resembling those of a fallen or prostrated forest, the trees being generally directed to the north-west. On clearing away, however, the sand from one of the few stems which are vertical, he found no traces of an ancient soil, like the dirt-bed of our Portland Cycadeæ, but, on the contrary, the end of the trunk was imbedded in the conglomerate which is associated with the sandstone*.

From the remains in the limestone and sandstone Mr Newbold infers, that those parts of Egypt around the country of petrified trees had twice formed the bed of the ocean, and twice been elevated into dry land, and that the trees in question lived in the period between the two submergences. Posterior to those movements of oscillation, which, from the horizontality of the strata, was probably very gradual, the land has undergone additional elevation around the head of the gulf of Suez, and between the Red Sea and the cliffs which skirt its western shores as evidenced by a fringe, in parts about fifty feet high, of calcareous shelly deposits, charged with the remains of Radiaria, Testacea, and Corals which now inhabit the Red Sea.

However comparatively recent this elevation may be, Mr. Newbold contends, that the great dissimilarity of the faunas of the Red Sea and the Mediterranean, renders it probable, that there was an ancient barrier of separation, and that therefore the isthmus of Suez has not been formed in a recent æra. On this point, however, we have gained still more definite information by the researches of our Curator, Mr. E. Forbes, and to these I have already alluded.

* Mr. Robert Brown has pronounced these trees to be dicotyledonous.

For an account of the various intrusive rocks, and for much information respecting the alluvial accumulations, including the mud of the Nile and the changes of the Delta of that river, as well as of the sand-drifts which have sterilized such large tracts, I must refer you to the Memoir itself, which indicates great assiduity on the part of the author, and who seems to have neglected no sort of information which could be brought to bear upon the illustration of his subject.

After all, it must be allowed that, with the exception of the fossil forest, and the recent elevation of her shores which separated the Mediterranean from the Red Sea, Egypt presents fewer phænomena to interest the geologist than any region of similar range over which researches have extended; for this mass of land seems to have been above the waters during the whole of the ancient periods of which other regions afford such long registers in the contents of the Palæozoic and succeeding deposits.

We have, however, but to advance northwards to the Lycian Taurus, where Mr. E. Forbes has made known to us the elevation to great heights of tertiary marine shells; or north-eastwards to Syria, where the Dead Sea, as now computed, lies upwards of 1300 feet below the level of the Mediterranean, and we are furnished with the most remarkable proofs of the mighty oscillations to which the surface has been subjected, even in recent epochs. In receding from the Mediterranean to the Dead Sea, the Lake of Tiberias marks the first depression, being 328 feet beneath the sea, and from this lake to the Dead Sea the declination is nearly 1000 feet! A few years back only and we were startled at the announcement, that the level of the Caspian Sea was 300 feet below the Mediterranean; and more accurate measurements have, indeed, reduced the depression to 82 feet; but that any cavity on a portion of the present surface should be 1300 feet beneath the level of the adjacent seas, proves an amount of vibration within a limited area, which is truly astonishing*.

Palæontology.

Ichthyology.—Geologists who have commenced their career since the glacial theory has been in vogue and have read the numerous memoirs and heard the exciting discussions to which it has given rise, are chiefly acquainted with Professor Agassiz as one of its most ingenious expounders. I have now the pleasure to acquaint you that M. Agassiz is once more completely absorbed in his great work on fossil fishes—that work which you so justly honoured, in the year 1835 to 1836, with your Wollaston Donation and Medal. Of his progress in this arduous undertaking, he has recently given substantial proofs, in the description of many ichthyolites of the Old

* See the last discourse of Mr. W. Hamilton, the President of the Royal Geographical Society, who points out this admeasurement as being at length fixed by the admirable trigonometrical survey of Lieut. Symonds, whose calculations of 1311 feet approach very nearly to the still higher estimate of M. Berthou, who, from barometrical observations, placed it at 1332 feet.

Red Sandstone of Scotland; and, in addition to this, he will shortly publish a series of fossil fishes, exclusively illustrative of the tertiary basins of London and Paris, from which an enormous number of species has been collected.

In reference to the geological researches of my friends and myself in Russia, I must here state, that as it is our one great object to place in correct parallel the Palæozoic types of Russia with those of the other parts of Europe, we could not hesitate in referring all our Russian ichthyolites to Professor Agassiz; for whilst it must be acknowledged that Russia contains naturalists of great merit, and that among them M. Pander and Professor Asmus had commenced inquiries into the nature of these fossils, it was obvious that, skilful as they undoubtedly are, they could not, for want of comparisons, afford us the knowledge of which we stood in need. Professor Agassiz, who has at his disposal fossil fishes from all those parts of Europe, the geological structure of which has been well explained, was alone capable of answering the following query; To what extent do the ichthyolites of Russia, which lie in beds superior to the Silurian rocks, and which are surmounted by the Carboniferous limestone, resemble those with which we are so well acquainted in Scotland and England? His reply has indeed been most satisfactory.

So complete, says he, is the identity of about ten species of the Scottish and Russian strata, that the specimens from the two countries may be confounded. Among them the *Holoptychius nobilissimus*, three species of the *Dendrodus* (Owen), *Diplopterus macrocephalus*, are forms which might strike any good observer, as they have been previously published by M. Agassiz; but from the more perfect specimens of other species which we brought from Russia, he has been enabled to recognize the presence in Scotland of the species of a common Russian genus, the *Glyptosteus*, and also of that gigantic genus the *Chelonichthys*, to whose remains I have before directed your attention as having been recognized to be of ichthyic character by Professor Asmus. To this enormous fossil fish, some of whose thoracic bones are as large as the breast-plate of a well-grown warrior, and a single bone of which measured nearly three feet in length, Professor Agassiz has given the name of *Chelonichthys Asmusii*; and he now informs me that he possesses fragments of the same creature from the north of Scotland. The knowledge of this fact will doubtless lead to redoubled activity on the part of Mr. Hugh Miller and those Scottish naturalists who inhabit the shores of the Cromarty and Murray friths, to produce a rival of the Russian giant; a hope which I cannot express without deeply lamenting the death of a most successful explorer of these remains, whose loss geologists have to deplore, in common with every one who could appreciate her range of thought, her accomplishments, and her goodness*.

The results, however, of the examination of the Russian ichthyolites go still further; for, on submitting to the microscope of

* Lady Gordon Cumming.

Professor Owen some teeth similar in outline to those of his genus *Dendrodus*, he discovered in them precisely the same dendridic disposition of the vascular canals as that which led him to establish the genus from Scottish fossils. Nor does the value of this application of the microscope stop here, for Professor Agassiz has informed me, that availing himself of the weapons which Professor Owen had so skilfully wielded, he has commenced a series of researches, not only into the teeth but also into the structure of all the hard enamelled bones of the Russian fossil fishes, by which he will be able to show the same distinction in the other bones of the genera of this class, which Professor Owen has successfully established in relation to the hard parts of the higher order of animals. In such hands, therefore, the microscope has become an instrument of great utility in identifying fragments apparently obscure; and, as it has been applied to the shells of Mollusca, and even to the lowest links in animal life, as well as to fossil plants, the geologist has thus acquired a new and powerful auxiliary. I am here, however, treading on ground now fortunately occupied by the Microscopical Society, the active promoters of which are well entitled to our gratitude.

Ornithichnites.—To American geologists we are indebted for our acquaintance with this new class of phænomena. The existence of the fossil bones of birds of ordinary size had, it is true, been ascertained by Dr. Mantell in the Wealden strata, but great was our astonishment, and I may add our incredulity, when Professor Hitchcock first announced, that in rocks of considerable antiquity (the exact age of which is still uncertain), there existed innumerable impressions in successive layers, which must have been formed by birds, some of them of gigantic size, and to which he boldly assigned the name of "Ornithichnites." Various opinions were entertained, and much scepticism prevailed concerning these impressions; but it is due to Dr. Buckland to state, that he never doubted that the views of Professor Hitchcock were founded on true natural analogies, and he accordingly published this opinion, with illustrative plates, in his Bridgewater Treatise. The recent visit of Mr. Lyell to North America, and a memoir he has read, as well as a communication from Dr. James Deane of Massachusets, have necessarily brought this highly interesting subject again before us; whilst a very remarkable discovery in natural history has at all events almost entirely dispelled scepticism regarding the true *bird-like character* of even the largest of the footsteps, however difficult it may be to imagine the presence of such highly organized creatures at a very early period. The observations of Mr. Lyell completely support the views of Professor Hitchcock as to the littoral nature of the footstep deposit in Connecticut, and that the prints in question were left by birds on the mud and sand of former estuaries, the bottoms of which were gradually submerged, and by the increase of fresh matter were permanently preserved.

Mr. Lyell illustrates the ancient phænomena by reference to impressions which he saw forming at low water on the mud of the sea shore of Georgia by racoons and opossums, and covered by blue sand before the flow of the tide, as well as by the recent footsteps of birds in the red mud of the Bay of Fundy, which if submerged would realize a complete analogy to the fossil footsteps through many successive laminæ of deposit*. He also believes with Professor Hitchcock, that the strata in question had been elevated and tilted since their original deposition, and he connected these movements with the evolution of trappean rocks, which in some places invade the Ornithichnite beds. In regard to the age of these beds no decisive opinion has yet been expressed, though they are referred to one of the older secondary rocks. However this point may be determined, and I will presently allude to it, the great question remained to be settled; how induce us to believe that the largest of these footmarks were made by birds? Is it not unsafe to call in the presence of creatures of such high organization when researches all over the world have taught us that in rocks of far less antiquity no traces of the bone of a bird or mammal have been found? May not the impressions after all be those of some singular Sauroid animal with trifid feet, of which we have no links in existing nature? Looking to such a possible explanation, and reflecting on the striking interference with the opinion heretofore very generally received, that a succession from lower to higher orders of creatures was invariably evidenced in ascending from lower to higher deposits, I candidly confess, that nearly up to the present moment, despite of the clear and faithful descriptions of the facts, I have clung to the idea, that the markings would not eventually be referred to the action of birds. My scruples as a geologist have, however, I confess, been much shaken, if not entirely removed, by a discovery in natural history, which I do not hesitate in characterizing as one of the most remarkable of modern times.

From the examination, in 1839, of a single fragment of a bone brought from New Zealand, Professor Owen, though at first startled by its enormous size, at length pronounced it to belong to a gigantic form of the lowest organized bird, analogous to the diminutive Apteryx of the same island, in which the lungs approach more closely than in any other bird to the structure of those in reptiles. To this monstrous winged animal he assigned the name of *Dinornis*, and many of its bones, in a very perfect condition, having been subsequently found in New Zealand and deposited in the museum of the College of Surgeons, his opinion has been completely confirmed†. When it is known that the tibia of this bird is so huge that the femur of the Irish giant is of pigmy dimensions when compared with

* A striking explanation of appearances, respecting which we were at first equally incredulous when pointed out on the surface of the Red Sandstone of England as fossil rain-drops, is given by Mr. Lyell in the actual formation of similar markings produced by rain on the mud of the shores of Long Island.

† The inhabitants of New Zealand believe that the Dinornis was in existence with their progenitors. On this point, however, doubts may still be entertained, as we know that in many uncivilized countries, where the bones of extinct quadrupeds occur, the natives connect them with their ancestors.

it, some conception may be formed of its entire size, which must have far exceeded that of the ostrich*.

Now to apply this discovery to our Ornithichnites, one of the great difficulties which many of us had to overcome was the gigantic size of the largest American footsteps, which measured fifteen inches in length; and it is a most curious fact, that upon placing the fossil cast alongside of the metatarsal bone and tibia of the largest individual of Dinornis, Professor Owen is of opinion, that if the feet of this great tridactyle bird be found, they will, from the usual proportions maintained in such animals, be fully as large as those of the American Ornithichnite. From this moment, then, I am prepared to admit the value of the reasoning of Dr. Hitchcock, and of the original discoverer, Dr. James Deane, who it appears, by the clear and modest paper lately brought before us by Dr. Mantell, was the first person who called the Professor's attention to the phænomenon, expressing then his own belief, from what he saw in existing nature, that the footmarks were made by birds. Let us now hope, therefore, that the last vestiges of doubt may be removed by the discovery of the bones of some fossil Dinornis; and in the meantime let us honour the great moral courage exhibited by Professor Hitchcock, in throwing down his opinions before an incredulous public†.

Still, however, comes the question, what is the age of the rock on which the Ornithichnites have been impressed. Consulting what Mr. Lyell has recently written, we find that he does not decide this point further than by saying, that they were formed between the carboniferous and cretaceous epochs, the only remains hitherto found in the deposit being ichthyolites of the genera Palæoniscus and Catopterus, with some fossil wood. The presence of a Palæoniscus would lead me to suspect that the deposit might be of the age of the Zechstein or Magnesian Limestone; for in Russia, wherever the calcareous matter which represents that rock thins out, vast tracts are occupied by marls, sandstones and conglomerates of red, green and white colours, which form the Permian system, and in these beds Palæonisci occur. If the fossil fishes from both localities be placed in the hands of Professor Agassiz, and a comparison be made of the fossil wood from Russia and North America, the query may be satisfactorily answered. In the meantime I cannot read the descriptions of this American deposit, and carry the Russian types in my recollection, without surmising, that in the sequel the Ornithichnite and Palæoniscus beds of Connecticut and the gypsiferous rocks of Nova Scotia, distant as they are from each other, will be found to belong to one natural group—the Permian; and if this view be borne out, it follows that a bird analogous to the Dinornis lived at a period when Saurian animals first began to appear upon the surface, and when

* See a most graphic sketch of this monstrous bird and its analogies from the pen of my friend Mr. Broderip, Penny Cyclopædia (*Unau*).

† See Geol. Proceedings, January 1843, Dr. James Deane 'On Ornithoidicnites.'

the last links of primæval or palæozoic life were not obliterated *. In this case the value of the philosophic caution given by Mr. Lyell will be very apparent, viz. that we ought not to infer the non-existence of land animals from the absence of their remains in contemporaneous marine strata †.

Saurians, Cetaceans, &c.—I am not aware that researches of the past year have added much to our acquaintance with new forms of vertebrata in the secondary deposits, though it must not be unrecorded, that our zealous contributor M. Hermann Von Meyer, has added to the list of Saurians of the Muschelkalk a new genus, which he describes under the name of Simosaurus.

In Russia a very curious discovery has been made by Professor Brandt, of which I have been just informed by my friend Count Keyserling. Pallas had spoken of a locality among the cliffs of Taman, in the southern steppes, where remains of whales were found; Rathke had mentioned the head of an animal of which the vertebræ were known, and which he described as approaching to a whale; and more recently Professor Eichwald considered this fossil as belonging to the Dolphins and named it *Xiphias priscus*. Obtaining possession of the specimen for the museum of St. Petersburgh, Professor Brandt worked the head of the colossal creature out of the rock in which it was imbedded, and pronouncing it to belong to a new family of whales, described it under the name of *Cetotherium Rathkii*. This fossil whale forms a new link in the animal kingdom, and is more nearly allied to the herbivorous cetaceans than to the Dolphins. Its position in the geological series is also most remarkable; for the rock in which it occurs contains shells similar to those of the tertiary deposits of the Miocene age, which extend from Volhynia and Podolia to the Crimea and Taman. It is also very remarkable, that along with this herbivorous cetacean the other organic remains (among which, however, banks of corals occur) have more the character of the inhabitants of a brackish sea than those of the subjacent rocks, whose fauna more resembles that of the Black Sea and the Mediterranean.

These relations are in accordance with modern conditions, and are, indeed, explained by an analogy in our own country, for an acquaintance with which I am indebted to our Curator, Mr. E. Forbes. The lake of Stennis, in the Orkney Islands, celebrated by Sir Walter Scott, has been converted, whether by elevation of the land or other cause, from a saltwater loch into a freshwater and marshy tract, and with this great but gradual change, certain marine genera have continued to live on amid their new associates of land and fresh water, whilst others have perished. That which is taught on a small scale in the Scottish lake has occurred over a vast area in the case of the Caspian Sea; which, in consequence of separation from the Black Sea has passed into a brackish state, and the same hardy and time-serving marine

* This view has been strengthened by the researches of Mr. Logan, see note, p. 546.

† Geol. Proceedings, vol. iii. p. 796.

genera as in Scotland have continued to exist in their new abode! The Miocene deposit of Taman, therefore, with its herbivorous cetaceans, brackish and marine shells, is only an example, in an earlier period of the world, of the formation of a true Caspian, the creatures in which necessarily differed from those of the pure marine period which went before them.

MASTODONTOID AND MEGATHERIOID ANIMALS.

For a season our metropolis contained within it a magnificent skeleton of a Mastodontoid quadruped, which, in common with all geologists and palæontologists, I hoped to see permanently established in our national Museum. This gigantic animal was discovered by a persevering Prussian collector, M. Koch, who for some time resided in the United States, and who disinterred it, together with a great profusion of heads, teeth, and numerous bones of similar animals, from amid the alluvia of a tributary of the St. Louis river, where the chief remains had probably been an object of superstitious tradition on the part of the Indian tribes. It does not appear whether the zealous Prussian had any scruples to overcome; but I presume they must have been considerable, if I were to judge from my own experience in other wild countries. In travelling along the eastern flanks of the Ural Mountains, it was my lot to visit many sites of gold alluvia in which bones of the mammoth and other extinct quadrupeds are found, and for these remains the poor Bashkirs, the original inhabitants of the tract, preserved so deep a veneration, that in freely permitting the search after the true wealth of their country which they were incapable of extracting, their sole appeal to the Russian miners was, "Take from us our gold, but for God's sake leave us our ancestors."

Overcoming, however, all difficulties, M. Koch succeeded in extracting, and afterwards in setting up, the most complete specimen of the species which has ever been seen. Applying to it the provisional name of "Missourium," he exhibited it for some time in the United States, and then brought it with many of the associated bones to London, in the hopes both of having the remains perfectly described and of obtaining for them a price worthy of the British nation.

The arrival of such a collection could not fail to excite the most lively interest and curiosity among our naturalists, and the bones having been attentively examined by many members of this Society, produced a diversity of opinion respecting the generic character of the chief remains. North America had long been a fertile mine of such reliquiæ, and the naturalists of the United States had not been backward in studying and describing them. It is not, therefore, a little remarkable that the same difference of opinion as to the generic and specific identity of the animals that prevailed across the Atlantic, is presented in the Memoirs which have recently been read before us; Dr. Harlan and Mr. Cooper having maintained opinions, with which, to a great extent, Professor Owen concurs, whilst Dr. Grant and M. Koch have supported the views of the late Dr. Godman.

Citing the American authorities on his side of the question, including Dr. Hayes, and enumerating no less than thirteen species of Mastodon and six species of Tetracaulodon, Dr. Grant has made a vigorous effort to vindicate the true generic characters of the Tetracaulodon as founded on the presence of a tusk or tusks in the lower jaw and certain variations in the form of the crowns of the molar teeth.

This view has been sustained by Mr. A. Nasmyth in an elaborate paper "On the Minute Structure of the tusks of extinct Mastodontoid animals." Microscopical examination of portions of the tusks believed to belong to five distinct species, viz. *Mastodon giganteus, Tetracaulodon Godmani, T. Kochii, T. Tapiroides* and the *Missourium*, has also led this author to the same inference as Dr. Grant; and he concludes with the remark, that, if it be established that specific differences positively do exist among all these animals, the value of such microscopic researches is great; but if the five animals are grouped as one, then such mode of observation is of no value in palæontological science.

Professor Owen had previously expressed opinions at variance with those of Drs. Hayes, Godman and Grant and Mr. Nasmyth, and his views have been supported within these walls by my predecessor, Dr. Buckland. Pointing out certain mistakes in the setting up of the Missourium, as exhibited in the Egyptian Hall, he compares the fossil with all forms with which he was acquainted; and, showing that it must have belonged to the Ungulata, he judges that the enormous tusks of the upper jaw constitute it a member of the proboscidian group of pachyderms, and that the molar teeth prove it to be identical with *Tetracaulodon* or *Mastodon giganteus*. He argues that the genus Tetracaulodon was erroneously founded upon dental appearances in the lower jaw of a very young proboscidian, and that Mr. W. Cooper was correct in suggesting that the Tetracaulodon was nothing but the young of the gigantic Mastodon, the tusks of which were lost as the animal advanced in age. A comparison of the whole of M. Koch's collection produced the result in Mr. Owen's mind, that, with the exception of a few bones of the *Elephas primigenius* (Mammoth), all the other remains of proboscidean pachyderms in it belong to the *Mastodon giganteus*. The remains of other animals found by M. Koch are referred by the Hunterian Professor to *Lophiodon, Mylodon Harlani, Bos, Cervus*, &c.; and in respect to the *Mastodon giganteus* he expresses his conviction that it had two lower tusks originally in both sexes, and retained the right lower tusk only in the adult male. Although unable to form a correct judgement on the probable structure of those extinct quadrupeds, I may call your attention to a recent work of Mr. Kaup, whose striking discovery of the Deinotherium is familiar to you, and who now seems to advocate, from perfectly independent sources of evidence, the same views as Professor Owen concerning the osteology and generic characters of the Mastodon founded upon the comparison of a series of bones and teeth belonging to the *Mastodon longirostris*, more numerous and complete than even those of the *Mastodon giganteus*.

Mylodon.—One of the most brilliant, and, I venture to say, not the least durable of the researches in palæontology, remains to be mentioned in the description of the *Mylodon robustus*, a new species of gigantic edentate animal, accompanied by observations on the affinities and habits of all Megatherioid animals. After a sketch of the labours of Cuvier, who first described the huge Megatherium and pointed out its analogy to the family of Sloths and Armadillos, of the succeeding writings of Jefferson and Harlan upon the genus Megalonyx, of Dr. Lund on the Cœlodon and Sphenodon of Brazil, and of his own researches which established the Mylodon and Scelidotherium, Professor Owen proceeds to describe the megatherioid animal which he has named *Mylodon robustus.*

Of the purely anatomical descriptions, it is not my province to speak, and referring you to the work in which, through the enlightened munificence of the College of Surgeons, all the necessary illustrations have appeared, I pass to the generalizations, and learn that the Mylodon, in common with the Megatherium and Megalonyx, are genera of the family of *Gravigrada*, as distinguished from the *Tardigrada* in the order *Bruta*.

Professor Owen then proceeds to a comparison of the anatomy of the Mylodon with that of all analogous creatures, and after an able analysis, he satisfies himself, and also, I am persuaded, every one who has followed his close reasoning, that he has at length ascertained the true habits and food of this family of mammifers. From their dentition, it is inferred that the Megatherium and Mylodon must have been phyllophagous, or leaf-eating animals; whilst, from their short necks, the very opposite extreme to the camelopard, they never could have reached the tops of even the lowest trees. Cuvier, on the contrary, suggested that they were fossorial, or digging animals; and we all recollect the animated manner in which Dr. Buckland attracted us, whilst he described the Megatherium as a huge beast, which, resting upon three legs, employed one of its long fore-hands in grubbing up whole fields of esculent roots; a habit which procured for it the significant popular name of "Old Scratch."

Dr. Lund, a Danish naturalist, had considered the Megatherium to be a scansorial or climbing animal; in short, a gigantic Sloth. After a multitude of comparisons, Professor Owen rejects the explanation of all his predecessors. He shows that the monstrous dimensions of the pelvis and sacrum, and the colossal and heavy hinder legs, could never have been designed, either to support an animal which simply scratched the earth for food, or one which fed by climbing into lofty trees, like the diminutive Sloth; and he further cites the structure of every analogous creature, either of burrowing or climbing habits, to prove, that in all such the hinder legs are comparatively light. What then was the method by which these extraordinary monsters obtained their great supplies of food? The osteology of the fore-arm has, it appears, afforded answers which are valuable, chiefly for their negation of erroneous conjectures, such as that the animal was an ant-eater, rather than for the habits which it directly elicits. It is, therefore, to the organization of the hinder limbs that Professor Owen mainly appeals to ascertain the functions of the forefeet and the general habits of the Mylodon.

Arguing that the enormous pelvis must have been the centre whence muscular masses of unwonted force diverged to act upon the trunk, tail and hind-legs, the latter, it is supposed, formed with the tail a tripod on which the animal sat. Professor Owen supposes that the animal first cleared away the earth from the roots with its digging instruments, and that then seated on its hinder extremities, which with the tail are conjectured to have formed a tripod, and aided by the extraordinary long heel as with a lever, it grasped the trunk of the tree with its forelegs. Heaving to and fro the stateliest trees of primæval forests, and wrenching them from their hold, he at length prostrated them by his side, and then regaled himself for several days on their choicest leaves and branches, which till then had been far beyond reach. After showing that from the natural inversion of the hind-feet the Mylodon approached to the scansorial animals, and thence inferring that it might have had climbing powers necessarily much limited by the other parts of its frame, Professor Owen states, that the inversion of the soles of the feet is least conspicuous in the Megatherium, whose bulk and strength would be adequate to the prostration of trees too large for the efforts of the Mylodon, Megalonyx and Scelidotherium. The Megatherium, in short, was the mighty tree-drawer, and had therefore no need of the adventitious aid of any climbing apparatus. Allow me to add, that, amongst other reasonings, those which lead to conclusions that one class of megatherioid animals was furnished with a hairy coating (like the Mylodon), whilst another, like the great Megatherium, was devoid of it, as evidenced by slight modifications of the bony structure of the hind-feet, appear to me to be not the least original and interesting.

Wholly incapable, as I am, to do justice to this masterly inquiry by the necessarily brief allusion which is imposed upon me by the nature of this discourse, I shall best execute my task in quoting the words with which Professor Owen sums up his reasoning.

"On the Newtonian rule, therefore, this theory has the best claim to acceptance; it is, moreover, strictly in accordance with, as it has been suggested by, the ascertained anatomy of the very remarkable extinct animals, whose business in a former world it professes to explain. And the results of the foregoing examination, comparisons and reasonings on the fossils proposed to be described, may be summed up as follows. All the characteristics which exist in the skeleton of the Mylodon and Megatherium, conduce and concur to the production of the forces requisite for uprooting and prostrating trees; of which characteristics, if *any one were wanting, the effect could not be produced*: this, therefore, and no other mode of obtaining food, is the condition of the sum of such characteristics, and of the concourse of so great forces in one and the same animal."

This, Gentlemen, is the true Cuvierian style, in which, as in numberless parts of his works, Professor Owen has continued to breathe out the very spirit of the founder of palæontological science.

It is by such labours that geology is steadily gaining a higher place among the sciences. Comparative anatomy has truly been our steadiest auxiliary, and well may we do honour to those who impart to us such truthful records; for, whilst the histories of the earlier beings of our own race are shrouded in obscurity, whilst the first chronicles of ancient Rome and Greece are now admitted to be exaggerated, and often even fabulous, we turn back the leaves of far more antique lore; and, not trusting to perishing inscriptions, mutilated by successive conquerors, and assuming a hundred meanings under the eyes of doubting antiquaries, we appeal only to the proofs in nature's book, and find that their reading is pregnant with evidences which must be true, because they are founded on unerring general laws.

In concluding this Address, I can assure you, Gentlemen, that, although not prepared without some labour, its composition has afforded me both gratification and instruction. Had I not felt a strong obligation to fulfil my duty, I should necessarily have been absorbed in the preparation of the work upon Russia to which I have alluded, and could not therefore have been imbued with an adequate sense of the vast progress which our science has recently made in all quarters of the globe.

The chief aim of this Society has been to gather sound data for classification; and, following out this principle, I have endeavoured to show, how the order of succession established in our own isles, is now extended eastwards to the confines of Asia, and westwards to the back-woods of America. From such researches, and by contributions from our widely spread colonies, we have at length reached nearly all the great terms of general comparison.

Besides ascertaining where the great masses of combustible matter lie, we can now affirm, that during the earliest period of life, conditions prevailed, indicating a prevalence over enormous spaces —if not almost universally—of the same climate, involving a very wide diffusion of similar inhabitants of the ocean. We have learned, that in the earliest of these stages of animal life, no vestige of the vertebrata has yet been found, whilst in the succeeding epochs of the Palæozoic age singular fishes appear, which, in proportion to their antiquity, are more removed from all modern analogies. In each of these early and long-continued periods, the shells preserving on the whole a community of character, differ from each other in each division—and in that later formation, where a very few only of the same types are visible, they are linked on to a new class of beings, the first created of those Saurians, whose existence is prolonged throughout the whole Secondary period; whilst we have this year seen reason to admit that even birds (some of them of gigantic size) may have been the cotemporaries of the first great lizards. With the close of the Palæozoic æra we have also observed a gradual change in the plants of the older lands, and that the rank and tropical vegetation of the Carboniferous epoch is succeeded by a peculiar flora. In the next, or

Triassic period, we have another flora, whilst new forms of fishes and mollusks indicate an approach to that period when the seas were tenanted by Belemnites and Ammonites, marking so broadly these secondary deposits with which British geologists have long been familiar, and which, commencing with the Lias, terminate with the Chalk. And lastly, from the dawn of existing races, we ascend through successive deposits gradually becoming more analogous to those of the present day, until at length we reach the bottoms of oceans so recently desiccated, that their shelly remains are undistinguishable from those now associated with Man, the last created in this long chain of animal life in which scarcely a link is wanting!—all bespeaking a perfection and grandeur of design, in contemplating which we are lost in admiration of creative power.

Such results, grand as they are—nothing less in short than the records of creation—are however but a portion of the labours of geologists. They have also struggled to explain the causes of those great revolutions. In some continents, it is true, the pages in the book of nature are, as it were, unruffled; for, by whatever agency effected, it is certain that beds of vast ancient oceans have been so equably elevated and depressed, and again so steadily elevated from beneath the sea, that the continuity of their rocky deposits over areas larger than our kingdoms of Western Europe is unbroken, and their original condition almost entirely preserved. In other regions, on the contrary, the sediments in the sea and the masses of the land have been pierced by numerous outbursts of igneous and gaseous matters, accompanied by violent oscillations and breaks, whereby the chronicles of succession have been sorely defaced, and often rendered more illegible than the most carbonized of the papyri found under the lava of Vesuvius. Nay, so intensely has this metamorphism operated, that obliterating all vestiges of former life, and concealing them from us, we have been sorely puzzled to ascertain by what powerful physical agency such mighty changes can have been accomplished,—changes by which the strata have been convoluted into forms grotesque as the serpent's coil, inverted in their order, or shivered into party-coloured and crystalline fragments. And yet in these broken and mineralized masses, as another branch of our science teaches, are found the precious ores and the metals most useful to mankind.

Such complicated relations and such changes in original structure call forth the application of the highest powers of physical science; not only involving the agency of that great central heat, to which geologists have willingly referred, but also invoking the aid of agents, some of them still mysterious, by which electricity and magnetism are bound together in the cycle of terrestrial phænomena. To few of us is it given to venture with firm steps into that region; and, though I hope to live to see some of these questions answered, I am well satisfied to have been among you when such solid advances have been made, in deciphering the mutations of the surface of the earth, and in the compilation of a true history of its earlier inhabitants.

Having now, Gentlemen, completed the term of my service, I bid you farewell, as friends in whose society, whilst acquiring knowledge, I have passed the happiest days of my life. Large as our numbers are, and branching out, as our inquiries do, into all the paths of philosophic research, the Geological Society has always held firmly together by a principle of good and high feeling among its active members. I have, indeed, deeply felt the honour of presiding over men who, in the course of a quarter of a century, have demonstrated, that there is no such thing as "*odium geologicum*," and whose members, rivals as they must be, have only sought to excel each other in their ardent search after truth.

By the choice of my successor you cannot fail to perpetuate this good feeling, for in him you recognize the philosopher, who, passing through other phases, returns to the object of his first love. In him you applaud one of the founders of your Society, a munificent supporter of geological works requiring assistance, one of your earliest contributors, and one, I will add, of the best Secretaries you ever had—whether as respected the performance of his own duties or the singleness of mind and integrity of purpose with which, abjuring all personal considerations, he improved the Memoirs of various writers which found their way into your Transactions. His fitting reward, therefore, is this Chair, which I resign to him in the full persuasion that he will view it, as I have done, in the light of the highest honour to which a geologist can aspire; and that as one of our old and sincere friends, he will ever be imbued with the strongest motives for preserving the harmony and prosperity of the Geological Society.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY OF LONDON.

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February 22.—James Baber, Esq. was elected a Fellow of this Society.

A paper was read "On some new species of Fossil Chimæroid Fishes, with remarks on their general affinities," by Sir Philip Grey Egerton, M.P., F.G.S.

The number of described species of Chimæra—soft-boned fishes of singular forms—is very small, whether existing or extinct. They were first recognised in a fossil state by Dr. Buckland in 1835. The original memoir comprised descriptions of four species; two others were added by Professor Agassiz. The list was soon afterwards augmented by two species from the Stonesfield slate, constructed by Dr. Buckland from some enigmatical specimens forwarded by the author under the impression that they had some resemblance to the subjects he was engaged upon. A ninth species came from the Caen oolite. A tenth has been described by Professor Owen in his 'Odontography' from specimens in the Hunterian collection, and Professor Agassiz has named an eleventh in the museum of Lord Enniskillen, from the gault. Sir P. Egerton, in the present memoir, doubles the number. With one exception he founds his characters on the lower jaws of the animals, avoiding the risk of ascribing specific differences to teeth derived from one and the same species, varying in form according to their position in the mouth.

The characters of the new species are as follows:—

1. *C. neglecta.*—Maxillary plate, left lower jaw: length 6 lines; depth at the symphysis 2 lines; ditto at the medial angle of the dental edge 3 lines; length of the dental edge $3\frac{1}{4}$ lines; anterior division of ditto $1\frac{1}{2}$ line; posterior ditto ditto $1\frac{3}{4}$ line; length of the heel $2\frac{1}{2}$ lines; exterior convex; exposed surface slightly furrowed; base expanded and vertically striated; two depressions, the anterior one broad, the posterior narrow and deep. Stratum, great oolite: locality, Stonesfield.

2. *C. bucklandi.*—Maxillary plate, right lower jaw (imperfect): length 2 inches 1 line; depth at the symphysis 1 inch 2 lines; ditto at the medial angle of the dental edge 9 lines; length of the dental edge 1 inch 6 lines; anterior division of ditto 1 inch; posterior ditto mutilated; exterior smooth and flat; inner surface rounded, diminishing in diameter towards the base; symphysis oblique and rounded; texture dense. Stratum, great oolite. locality, Stonesfield.

3. *C. psittacina.*—Maxillary plate, right lower jaw: length 8

lines; depth at the symphysis 4 lines; ditto at the medial angle of the dental edge 4 lines; length of dental edge 4 lines; anterior division of ditto $1\frac{3}{4}$ line; posterior ditto $2\frac{1}{4}$ lines; heel $3\frac{1}{2}$ lines; exterior flat, marked by horizontal undulating bands on the base, with a few vertical striæ near the heel; two depressions, broad and shallow; anterior outline abruptly curved upwards to the point. Stratum, great oolite: locality, Stonesfield.

4. *C. curvidens.*—Maxillary plate, right lower jaw: length 1 inch; depth at the symphysis 4 lines; ditto at the medial angle of the dental edge 5 lines; dental edge 7 lines; anterior division of ditto 3 lines; posterior ditto ditto 4 lines; heel 3 lines; exterior convex, curving rapidly inwards to the symphysis; exposed portion invested with a thick lustrous enamelloid coating, 3 lines in depth at the symphysis; base expanded and closely striated; one elongated depression near the heel; anterior division of the dental edge concave, posterior ditto straight. Stratum, great oolite: locality, Stonesfield.

5. *C. falcata.*—Maxillary plate, left lower jaw: length 1 inch; depth at the symphysis $3\frac{1}{2}$ lines; ditto at the medial parts of the dental edge 4 lines; heel 4 lines; dental edge 6 lines; tooth elongated, falcate, the point curved upwards; base shallow anteriorly, expanded and traversed by a broad depression near the heel; vertical striæ indistinct; horizontal bands broad and undulate; cutting edge concave, forming a single curve without any medial angle from the point to the heel. Stratum, great oolite: locality, Stonesfield.

6. *C. emarginata.*—Maxillary plate, left lower jaw: length 2 inches 5 lines; depth at the symphysis 1 inch 8 lines; ditto at the medial angle of the dental edge 1 inch 1 line; dental edge 1 inch 7 lines; anterior division 1 inch; posterior division 7 lines; heel (mutilated) 7 lines; exterior flat, marked by fine vertical striæ; depression at the heel circular, deep and broad; dental edge deeply indented in the form of two semicircles; symphysis straight. Stratum, great oolite: locality, Stonesfield.

7. *C. rugulosa.*—Maxillary plate, left lower jaw: length 1 inch; depth at the symphysis 4 lines; ditto at the medial angle of the dental edge 3 lines; dental edge $6\frac{1}{2}$ lines; anterior division 3 lines; posterior ditto $3\frac{1}{2}$ lines; heel $3\frac{1}{2}$ lines; exterior rugose; one strong depression near the heel striated vertically; anterior division of the dental edge concave; posterior ditto ditto nearly straight. Inner surface: triturating tubercles placed very obliquely. Stratum, great oolite: locality, Stonesfield.

8. *C. helvetica.*—Maxillary plate, right lower jaw: length 2 inches 5 lines; depth at the symphysis 1 inch 4 lines; anterior division of the dental edge 1 inch 4 lines; breadth of ditto 8 lines. This specimen being much mutilated, the measurements are incomplete. It approaches more nearly to *C. mantelli* than to any other species. Stratum, molasse: locality, Œtmaringen, canton of Argovie.

9. *C. dutetrii.*—Maxillary plate, left lower jaw: length 4 inches; depth at the symphysis 2 inches 2 lines; breadth of ditto 7 lines; depth at the medial angle of the dental edge 2 inches 2 lines; dental

edge 3 inches 6 lines; anterior division of ditto 1 inch 8 lines; width of ditto 8 lines; posterior division of ditto 1 inch 8 lines. This tooth is broad and strong; the exterior is marked with indistinct undulations; the depression at the heel is nearly horizontal. Inner surface: symphysis rather oblique; the triturating tubercles broad, and worn down less obliquely than in *C. townsendi*, to which species this most nearly approximates. Stratum, Kimmeridge clay: locality, Boulogne.

10. *C. beaumonti*.—Maxillary plate, right upper jaw: length of the outer margin 3 inches 5 lines; length of the inner ditto 2 inches 8 lines; breadth at the base 1 inch 6 lines; depth of the symphysis 5 lines; breadth of the principal tubercle 6 lines; the upper surface is marked by a deep sulcus, 7 lines in width, running parallel with the symphysis; the inner surface has four triturating prominences, one anterior, two basal, and one intermediate. Stratum, Kimmeridge clay: locality, Boulogne.

11. *C. dufrenoyi*.—Maxillary plate, left lower jaw: length 2 inches 4 lines; depth at the symphysis 1 inch 1 line; ditto at the medial angle of the dental edge 1 inch 4 lines; dental edge 1 inch 5 lines; anterior division of ditto 7 lines; breadth of ditto 5 lines; posterior division of ditto 8 lines; heel 1 inch; exterior slightly concave and uneven; inner surface contracts rapidly in diameter in the direction of the base; anterior tubercle 1 inch 6 lines in length by 6 lines in breadth, placed very obliquely; posterior tubercle small and narrow. Stratum, Kimmeridge: locality, Boulogne.

The author then enters into a detailed comparison of the fossil Chimæroids with the recent genera *Chimæra* and *Callorhynchus*, and after pointing out the discrepancies both of form and structure which they present, suggests the propriety of withdrawing them from the genus *Chimæra*, under which they have hitherto been arranged. The remainder of the memoir is devoted to a comparison of the fossil species with each other, and the author concludes by proposing to class them under three genera, as shown in the following tabular arrangement.

(1.) *Ischyodus* (*ἰσχὺς* robur, *ὀδοὺς* dens).

Two intermaxillary and two maxillary plates in the upper jaw; two maxillary plates in the lower jaw; intermaxillaries thick and strong, truncated more or less obliquely at their extremities. Structure: horizontal laminæ inclosed by parietes of coarse fibrous dentine.

Upper maxillaries: triangular plates articulating with each other and the intermaxillaries on the medial line of the palate; upper surface provided with a deep sulcus parallel to the symphysis for attachment to the jaw; under surface with four triturating prominences, one in advance, one on the outer margin, and two side by side near the base, the larger one occupying the inner position; structure of the tubercles coarse and tubular; the remainder of the teeth fibrous and bony. Lower maxillaries: large and broad, formed for crushing rather than cutting; two tubercles, one at the heel, the other in advance; symphysis broad; the base invested by the membrane of the mouth, the crown by a coat of hard enamelloid dental substance;

structure of the anterior angle as in the intermaxillaries, of the remainder as in the upper maxillaries; position of the plates more or less oblique.

SPECIES.	STRATUM.	LOCALITY.
ISCHYODUS, *Egerton.*		
agassizi, *Buckl.*	Chalk-marl	Hamsey.
beaumonti, *Egert.*	Kimmeridge clay	Boulogne.
brevirostris, *Agass.*	Gault	Folkstone.
bucklandi, *Egert.*	Great oolite	Stonesfield.
colii, *Buckl.*	ditto	Ibid.
curvidens, *Egert.*	ditto	Ibid.
dutetrii, *Egert.*	Kimmeridge clay	Boulogne.
duvernoyi, *Egert.*	ditto	Ibid.
egertoni, *Buckl.*	ditto	Shotover.
emarginatus, *Egert.*	Great oolite	Stonesfield.
falcatus, *Egert.*	ditto	Ibid.
helveticus, *Egert.*	Molasse	Argovie.
mantelli, *Buckl.*	Chalk	Lewes.
neglectus, *Egert*	Great oolite	Stonesfield.
oweni, *Buckl.*	ditto	Ibid.
psittacinus, *Egert.*	ditto	Ibid.
rugulosus, *Egert.*	ditto	Ibid.
tessoni, *Buckl.*	Oolite	Caen.
townshendi, *Buckl.*	Portland	Milton.
sedgwicki, *Agass.*	Greensand	Cambridge.

(2.) *Elasmodus* (ἔλασμα lamina, ὀδοὺς dens).

Two maxillary and two intermaxillary plates in the upper jaw? Two maxillary plates in the lower jaw; lower maxillary thick and strong; tubercle single, composed of a dental substance resembling in structure a tritor of Psammodus; in advance of the tubercle the tooth is composed of several series of laminæ, arranged in juxtaposition and inclined downwards and outwards; behind the tubercle the dental edge is notched, in consequence of a columnar structure pervading this region of the tooth. The outer surface is enveloped by a coat of dentine.

SPECIES.	STRATUM.	LOCALITY.
ELASMODUS, *Egerton.*		
1. greenovi*, *Egert.*		
2. hunteri†, *Egert.*	London clay.	

A single specimen in the Hunterian collection affords the type of a third genus.

(3.) *Psaliodus* (ψαλὶς forfex, and ὀδοὺς dens).

Upper jaw? Two maxillary plates in the lower jaw. Lower max-

* Chimæra greenovii, *Agassiz.* † Chimæra hunteri, *Owen.*

illary like *Chimæra*, but without a triturating tubercle; structure homogeneous; outer surface reticulated. Sp. *Psaliodus compressus*, Egerton. It is supposed to be from the London clay.

"On the Geology of the Neighbourhood of Bayonne." By Samuel Peace Pratt, Esq., F.R.S.

After noticing the published descriptions of the geological structure of the neighbourhood of Bayonne, by M. Dufrenoy, M. le Conte D'Archiac, and M. de Colligno of Bordeaux, the author proceeds to detail the result of his own observations in that locality in 1842.

Bayonne, situated at the junction of the rivers Adour and Nive, about four miles from the coast, is nearly surrounded by low hills of sand and gravel, those on the north side of the river being apparently a prolongation of the beds of pudding-stone and gravel which form a ridge extending from Tarbes to Pau, in a direction nearly east and west to the coast. The gravel and alluvium on the south differs in mineralogical character, and forms a thin coating to a succession of deposits of sand, clay and impure limestone which rise to the south-west towards the coast. The sandy limestone, which is composed almost entirely of *Lenticulites complanatus* and *Nummulites biarritzana* (*N. elegans?*), with a few fragments of shells, chiefly Pectens, forms for a short distance the north bank of the river Nive, rising at an angle of 20° or 30°. It is for the most part covered up by beds of sand and variously coloured clays, resembling the plastic clay. The gravel is very variable in thickness and contains no flint, but is chiefly composed of rounded and irregular masses of sandstone very like the Bagshot sandstone. The country in this direction has been much disturbed.

About four miles in a south-west direction from Bayonne is the village of Biarritz, near which there is an excellent coast section. The sands and clays have nearly thinned off before reaching the cliffs which rise from beneath the dunes, about a mile and a half to the north-east of the village, and vary in height from 20 to 80 feet. In a small bay called the Chambre d'Amour the beds are well seen, consisting of strata of sandy argillaceous limestone, from a few inches to five or six feet in thickness, all containing fossils in greater or less abundance. Several faults occur between the first rise of the strata and the village, by which the upper beds are repeatedly thrown to the level of the shore. The organic remains vary considerably in the several beds throughout the series, but lenticulites and nummulites characterize the whole; corals are numerous, but shells more rare. In the disturbed strata at Biarritz all the Echinodermata, which are very numerous, have been found.

Among the fossils at the Chambre d'Amour are, besides the foraminifera before mentioned and numerous corals, the following mollusca:—*Pholadomya margaritacea, Venus transversa, Pinna margaritacea, Spondylus radula, Gryphæa vesicularis? Pecten arcuatus* and *tripartitus, Solen strigilatus*, and *Teredo articulata*; also *Turritella carinifera, Pyrula nexilis* and *Triton appeninum. Ditrupa subulata* and several *Serpulæ* accompany them.

Passing the disturbed beds, strata of calcareous rock, more or less argillaceous or arenaceous, alternating with a bluish clay or marl, rise regularly at an angle of 60° or 70°, and are continuous for nearly a mile, forming cliffs above 120 feet high. The uppermost of these beds is chiefly composed of nummulites and lenticulites, the arenaceous strata contain numerous and well-preserved corals, the species of which have not as yet been determined, though referred by D'Archiac to cretaceous forms. In the lower beds the best identified tertiary forms were found mingled with species hitherto regarded as cretaceous, such as *Serpula ampullacea* and *S. rotula.* Among the mollusca occurred *Spondylus rarispina, Ostræa spathulata, Dentalium grande, Turritella carinifera, Scalaria semicostata* and *acuta, Cerithium turritellatum* and *cinctum,* with several undetermined species of various genera.

The cliffs cease for a quarter of a mile, being terminated by a fault, when the strata again rise at a small angle in the same direction. Their mineralogical character however is different, as they consist of a marly light-coloured limestone, abounding in fossils which are mostly distinct from those of the preceding beds, with the exception of the corals. The protrusion of igneous rocks has changed this limestone in places into a hard crystalline marble or dolomite. In this part of the series were found *Terebratula bisinuata* and *striatula.* Another fault throws these beds beneath the shore, and at an interval of a few hundred yards they are succeeded by a series of cretaceous beds resembling chalk marl, the general inclination and direction of which, on account of frequent disturbances, are difficult to determine, but appear to be the same with the last-mentioned strata. The cliffs formed by the cretaceous strata rise to a height of from 50 to 150 feet. Three or four species of Nautilus and Ammonite, and a few bivalves, chiefly *Inoceramus Cuvieri,* are found in them, but there is no fossil common to the beds separated by the last-mentioned fault.

The beds overlying these undoubted cretaceous strata have been referred by the French geologists, quoted by Mr. Pratt, to the upper part of the cretaceous system, both on account of the superposition and direction of the strata and of the contained fossils, which they regard as cretaceous species. But a closer examination of the organic remains shows that such as may be identified with known species are mostly tertiary forms, while such as appear to be cretaceous, belong to genera and species of variable and uncertain character. The Echinodermata, as identified by Dr. Grateloup, do not agree with the references, except one, which is a tertiary species. The variation in the mineralogical character of the beds sufficiently accounts for the gradual change of species observed from the first rise of the strata to their termination. Certain species were common to all the beds preceding the second fault. The deposit is apparently covered in its upper part by the plastic clay, to which it approaches nearest in mineralogical character. At Dax and at Royan similar deposits under similar circumstances were observed by Mr. Pratt.

On the whole, the author concludes that the characters of the deposits in question are tertiary, and that they may probably be placed earlier in the series than any described Eocene beds (unless we except the Diablerets and some other deposits allied to them in position and palæontological characters). The whole of the Biarritz beds have apparently been elevated at a period posterior to the elevation of the chalk, the elevating causes disturbing at the same time the neighbouring cretaceous beds.

March 8.—Rev. John Barlow, M.A., F.R.S., of Trinity College, Cambridge, Secretary of the Royal Institution, and Captain James, of the Royal Engineers, were elected Fellows of this Society.

A paper was read "On the Locomotive and Non-locomotive powers of the Family Crinoidea." By J. C. Pearce, Esq., F.G.S.

The author is induced, from an examination of the various modes of attachment among the Crinoidea, to separate those animals into two great groups, the *Non-locomotive* and the *Locomotive*. The former, when once attached to any solid substance by their base or foot, were immoveably fixed; the latter possessed the power of grasping with the foot any substance, and again relaxing their hold at pleasure. The non-locomotive Crinoidea he subdivides into *solid-footed* and *root-footed*. In the solid-footed the foot is formed like an irregular cone with the base downwards, and is composed of successive laminæ, which envelope the inferior part of the column and increase in number as the animal advances in age. This base or foot is generally found firmly adhering to the rock in the fossil state, although specimens are sometimes found detached which appears to have been caused by violence during life. The columns of all the species which Mr. Pearce has examined are very short and destitute of side-arms. He enumerates *Encrinites moniliformis* from the Muschelkalk, *Apiocrinites rotundus* from the Bradford clay, and *Cyathocrinites tuberculatus* from the Dudley limestone, as examples of this group. In the non-locomotive root-footed Crinoids the base is composed of many root-like branches, radiating in a more or less horizontal or downward direction from the lower part of the column, each branch bifurcating several times in an irregular manner. The branches are perforated by a central foramen, and appear to be composed in individuals of all ages, of a solid calcareous substance incapable of motion.

Mr. Pearce divides his locomotive Crinoidea into two sections, *Branch-footed* and *Sucker-footed*. The branch-footed are characterised by the organ of attachment, or foot, being composed of a number of jointed branches, in some species simple, in others bifurcating, or dividing in an irregular manner, and generally terminating in a minute blunt point. Each joint has a central foramen, and is articulated by alternate radiating ridges and grooves, admitting of the greatest degree of flexibility, forming an organ which the author regards as well adapted to crawl along the bottom of the ocean, or to steady the animal against the motion of the water. The columns of this group are generally furnished with side-arms, extending to a greater or less distance from the foot, and sometimes the whole length of the column. Examples are, *Apiocrinites ellipticus* from the chalk, *Pentacrinus Briareus* from the lias, *Actinocrinites tessellatus*, *Platycrinites gigas*, and several undetermined species from the mountain limestone; also *Cyathocrinites goniodactylus*, and several undetermined species from the Dudley limestone.

The sucker-footed locomotive Crinoids have the column destitute of side-arms, and terminating at its inferior extremity in a blunt point. Mr. Pearce subdivides them into *Crinoideform* and *Comatuliform*.

The following table exhibits Mr. Pearce's views of the classification of the family Crinoidea.

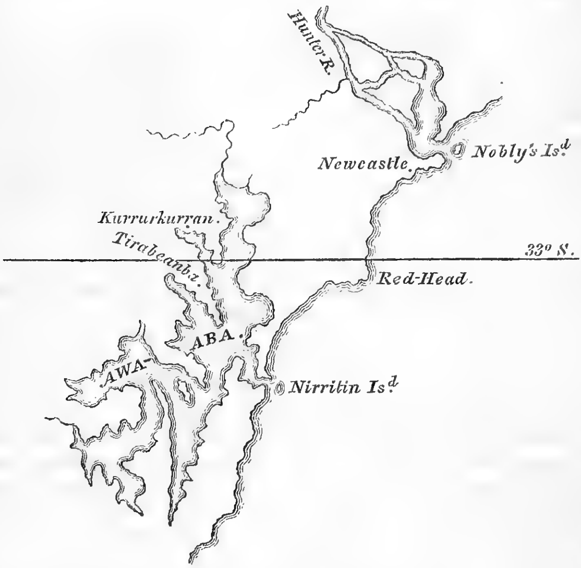
Fam.	Group.	Division.	Subdivision.	Genus.	Species.
Crinoidea.	Non-locomotive	Solid-footed ...	....	Apiocrinites	rotundus.
				Encrinites	moniliformis.
				Cyathocrinites	tuberculatus.
				Eugeniacrinites	nutans.
				———	quinqueangularis.
		Root-footed	....	Cyathocrinites	rugosus.
	locomotive	Branch-footed...	....	Apiocrinites	ellipticus.
				Pentacrinus	briareus, jun.
				Actinocrinites	tessellatus.
				Platycrinites	gigas.
				Cyathocrinites	goniodactylus.
		Sucker-footed	Crinoideform	Actinocrinites	moniliformis.
			Comatuliform.	Apiocrinites	fusiformis.

"On an entirely new form of Encrinite from the Dudley Limestone." By J. Chaning Pearce, Esq., F.G.S.

The fossils described in this communication were discovered by Mr. John Gray of Dudley. Mr. Pearce regards them as constituting a new genus which he proposes to name *Pseudocrinites*, including two species both having "the arms and fingers inserted in bands, which commence just above the column and pass over the plates of the head to its summit." The one form has two, the other four ranges of "fingers." They resemble each other in having "the columns at their superior part composed of rings, gradually increasing in size towards the head. The plates of the head are thin and broad, and marked on their outer surface by lines of growth, and radiating ridges resembling the plates of the marsupite. They are also furnished with four orifices of a lozenge shape, most singularly inserted in the plates of the head, and their arms and fingers are exceedingly short. The fingers are composed of two rows of bones, each bone on the one side being inserted between two of the opposite. These fingers appear to be placed in four rows on each of the hands, and pass off from the head in a radiating direction, commencing at the column and uniting at the summit." Mr. Pearce names the first species *Pseudocrinites bifasciatus*, and the second *P. quadrifasciatus*.

"On a Fossil Pine-forest at Kurrur-kurrân, in the inlet of Awaaba, on the eastern coast of Australia," by the Rev. W. B. Clarke, A.M., F.G.S.

Awaaba is one of those inlets which occur at frequent intervals along the eastern coast of New South Wales, and which, from their sea-entrance being usually narrow and blocked up with drifted sand, are by the colonists termed "*Lakes*." Awaaba is called Lake Macquarrie, and is the largest of the inlets of that description between Port Stephen and Broken Bay. Its sea-entrance lies fourteen miles to the south of the mouth of the Hunter river, nearly in 33° south latitude.



This inlet occupies a portion of that formation of conglomerate and sandstone, with subordinate beds of lignite, which extends from the Hunter river southwards towards Brisbane Water. The lignite constitutes the so-called Australian coal. This formation, owing to its beds along the shores of the inlet being placed horizontally, and being divided by nearly vertical joints, gives rise to regular lines of coast, both in a longitudinal and transverse direction. It forms along the coast a high range, which, except at the entrance, divides the lake from the sea. Within the lake a series of extensive bays, bounded to the water's edge by steep cliffs, run out like fingers, far up into the country. The water of the inlet is for the most part very deep.

On the western side of the lake, and nearly opposite its sea-entrance, a promontory, bounded on either side by a bay, is formed by the Tirabeenba mountain, which stretches from the S.E. to the

N.W., and in the latter direction ends abruptly in a lofty but not very precipitous escarpment: this sudden termination is occasioned by a fault. This mountain range then turns to the W., and afterwards to the S.W.; between it and the next range a wide valley intervenes.

The north-eastern flank of the north-western extremity of this range swells out into a hill of low elevation, from the base of which to the water's edge a low flat extends; the flat is about fifty yards broad, and is, in point of level, within a foot of the surface of the water; it continues along the base of the slope for the space of about half a mile: it is called by the aborigines Kurrur-kurrân. To the south and west of this flat the slopes of the mountain come down to the margin of the lake. The surface of the flat is composed of black sandy vegetable mould, and of detritus thickly interspersed with the roots of plants and grasses; trees of large growth, which are principally Eucalypti and Casuarinæ, together with some others of smaller dimensions, stand at intervals upon it, and grow even close to the water. Beneath the alluvial matter the rock occurs *in situ*: this is a sandstone, which is for the most part of a compact and semi-crystalline texture, approaching to chert; its strata run out to some distance, at a small depth below the surface of the water, and render the lake in that part very shallow.

Throughout the whole of the alluvial flat, stumps and stools of fossilized trees are seen standing out of the ground, and one can form no better notion of their aspect, than by imagining what the appearance of the existing living forest would be if the trees were all cut down to a certain level. In the lake also, where it adjoins the flat, to the distance of from 80 to 200 feet from the shore, numerous points are seen, like those of a reef of rocks, just peeping above the surface of the water; these points are the fossilized stools and stumps of tree, similar to those which are found on shore. The greater part of these stems, both of those on land and in water, stand vertically; many of those on shore have remains of their roots in the sandstone rock beneath the alluvial matter; and of those which stand in the water, one at the distance of three feet from the shore has portions of its roots imbedded in the sandstone on which it rests. The rock immediately round the roots is not of so harsh a texture as it is in other parts; in it, in the neighbourhood of the roots which are in the water, there appear numerous white spots, which give the stone a mottled appearance: this arises from a multitude of small cavities which contain powdery silex, similar to what is often found in the cavities of chalk-flints. On the shore, the surface of the rock near the stems is worn into a number of little holes, which are owing to the decay and removal of this powder. Mr. Clarke sees no other explanation of these specks, than that they mark the situation of the fibres which proceeded from the roots. The roots of the trees are in some instances surrounded by an accumulation of sandy rock, which forms a mound of a higher level than the rest of the stratum. The roots do not descend, so far as has been ascertained, very far into the substance of the rock, nor is there any appearance of a dirt-bed. The stools stand from two to three feet above the surface of the ground, and vary from two to four feet in diameter; but one in the lake is at least four feet above the level of the water, and five or six feet in diameter. In several of the stumps from 60 to 120 concentric rings of growth may be counted: a few of the stools are hollow in the centre, but others are solid throughout: the wood appears to be coniferous. Veins of chalcedony traverse the substance of the trunks between the concentric rings, and also in the direction of the radial lines.

Many of the stems at Kurrur-kurrân have the bark adhering firmly to the trunk, and the bark in one instance was of the thickness of three inches. Its appearance in one or two cases was such as to show that it had been partly torn from the tree while yet standing, as if it had been broken down and the bark had been rent by the fall.

The colour of the substance of the stems within varies from a greyish white to a clouded grey, but their surfaces, when exposed to the air, have become yellowish by weathering; many are overgrown by lichens, and have then exactly the appearance of the stumps of recent trees. The upper extremities of the fossil stumps present clean horizontal sections, which shows that they were not broken off while recent, since no mode of fracturing recent pinewood could have occasioned such neat, plain and parallel sections as the summits of these stumps exhibit.

In a fragment of the sandstone from the base of one of the fossil stumps, the silicified impression of part of the leaf of a Glossopteris was found.

Immediately below the flinty stratum in which the trees are found is a bed of lignite; above the level at which the trees occur, there are found, imbedded in the sandstones and conglomerates, immense quantities of broken fragments of trees, apparently stripped of their boughs and branches. These fragments are generally divested of their bark, and appear to have been drifted.

Fossil trees are found in this formation at other places, and nearly at the same level above the sea as at Kurrur-kurrân; they occur in sandstone similar to that of Kurrur-kurrân, at the southern extremity of the Tirabeenba mountain, immediately above and below a bed of lignite. At the spot referred to, pits have very recently been opened for working the lignite, at the level of about four feet above the surface of the lake. At the south head of Reid's Mistake, which is the name for the sea-entrance to the inlet of Awaaba, similar beds of sandstone occur, and these are traversed vertically by the trunks of trees, while other trees lie horizontally in the same beds. Lines of division, which appear to be owing to the contraction of the whole mass, intersect both the trees and their matrix: these trees are found at a somewhat higher level than the sea. At nearly the same level in Nirritinbali (or Mutton-bird Island), off the entrance to Awaaba, large stools and stems of trees occur in conglomerate, which conglomerate reposes on beds of lignite. Fossil trees are also found in conglomerate reposing on lignite on the coast north of the entrance to Awaaba, at Redhead, at Newcastle, and at Nobby's Island, off the mouth of the Hunter river. At Nobby's Island the trees lie in a pebbly grit, passing into conglomerate, and are mineralized by hydrate of iron; they are from 10 to 150 feet long. At none of the above places, however, do the trees occur in such profusion as at Kurrur-kurrân.

Fragments of roots and of the boughs of trees, divested of their bark, are found at Munniwarrée, Wollŏgong and Mulibinbak, imbedded in beds of sandstone at a higher level than the beds which contain the fossil trees. Similar fragments are found spread over the surface at Wollon Hill, at Holworthy Down, and elsewhere in the colony; it is probable therefore that the bed of sandstone containing trees in a vertical position, which is found nearly at the same level above the sea at Kurrur-kurrân and the other places abovementioned, is the true geological position of that ancient forest from which the enormous quantities of the fragments of wood which occur either spread over the surface, or imbedded in the sandstone above and below the lignite, have been derived.

The sandstones of this formation, and in this vicinity, have been powerfully affected by the action of intrusive rocks; they are traversed, at Nobby's Island and on the coast near Newcastle, by trap dykes. The author refers to the 'Voyage' of Flinders, page 131, for an account of mineralized fossil wood found in Bass's Straits, at Reservation Island, which is composed of granite and of schist, traversed by granite veins and trap dykes. He also refers to the 'Tasmanian Journal,' vol. i. p. 27, for an account, by the surgeon of H.M.S. Erebus, Dr. M'Cormick, of silicified wood found in association with trap rocks in Kerguelen's Land; and to the same volume, p. 24, for an account by Dr. T. D. Hooker, assistant-surgeon to H.M.S. Erebus, of fossil wood found at Macquarrie plains, in Tasmania.

The author infers, from the present position of the fossil trees at Kurrur-kurrân, that the land must have been alternately depressed and elevated. He makes mention in the course of his paper of two beds of lignite, one above the bed of fossil trees and one below it; but he does not describe the relative position and distance of these two beds.

March 22.—Major-General W. Morison, C.B. M.P., of the Madras Army, F.R.S. L. and E., 10 Grosvenor Street; Thomas Oldham, Esq., A.B., T.C.D., 7 Suffolk Street, Dublin; Thomas Falconer, Esq., Putney Hill, Putney; and Henry W. Bristow, Esq., of the Ordnance Geological Survey of Great Britain, were elected Fellows of this Society.

A paper was first read "On some Pleistocene Deposits near Copford, Essex," by John Brown, Esq.

The order of the component beds of these deposits was taken from a cutting made for the Eastern Counties Railway. The lowest bed noticed consists of blue clay, which the author refers to a great detritic accumulation called "till," and which occurs extensively over the northern portion of the county of Essex. The till varies considerably in character and composition; at the N. extremity of the section which the author exhibited, it was described as consisting of a stiff tenacious clay, but within a short space it changed to a sandy gravel, containing fishes' teeth and corals in great abundance: the rock fragments have been derived from basaltic and secondary beds; the latter afforded the fossils contained in the following list, for the identification of which the author states that he has been indebted to Mr. J. de C. Sowerby. *Serpula illium*, L.; *S. tetragona*, L.; *S. articulata*, G. S.; *S. granulata*, C.; *Terebratula rigida*, U. Ch.; *T. pisum*, Ch. M.; *T. striatula*, L. Ch.; *Gryphæa incurva*, L.; *G. dilatata*, K. C.; *Inoceramus*, C.; *Avicula inæquivalvis*, L.; *Exogyra virgula*, K. C.; *Crania striata*, C.; *Pollicipes maximus*, C.; *Ammonites Leachii*, K. C.; *A. annulatus*, L.; *A. dentatus*, G.; *A. spinosus*, K. C.; *A. serratus*, O. C.; *Belemnites acutus*, L.; *B. pistilliformis*, L.; *Littorina carinata*, G. S.; *Pentacrinites basaltiformis*, L.; *Encrinites moniliformis*, O. The remains of fishes were, *Otodus appendiculatus*, C.; *Galeus pristodontus*, C.; *Notidanus pristis*, C.; *Odontaspis rhaphiodon*, C.; *Hybodus*, U. O., which were determined for the author by Mr. S. P. Woodward.

The Pleistocene deposit at the Copford brick-field consists, in an ascending order, of a bed of black vegetable matter, or peat, from six inches to one foot in thickness, resting immediately upon the "till:" from this stratum the following shells were procured, which were named for the author by Mr. S. P. Woodward:—*Vertigo palustris*; *V. edentula*; *V. pusilla*; *V. pygmea*; *V. substriata*; *Azeca tridens*; *Acme fusca*; *Carychium minimum*; *Zua lubrica*; *Clausilia rolphii*; *Cl. nigricans*; *Cl. bidens*; *Succinea pfeifferi*; *S. putris*; *Aplexus hypnorum*; *Limnius palustris*; *L. truncatulus*; *Planorbis spirorbis*; *P. vortex*; *Pisidium pusillum*; *Helix nemoralis*; *H. hortensis*; *H. arbustorum*; *H. lapicida*; *H. rufescens*; *H. hispida*; *H. pulchella*; *H. lamellata*; *H. spinulosa*; *H. fulva*; *Zonites rotundatus*; *Z. ruderata*; *Z. cellarius*; *Z. radiatulus*; *Z. nitidulus*; *Z. luridus*; *Z. crystallinus*; *Pupa anglica*; *P. umbilicata*; *P. marginata*.

Above the peat is a bed of clay and detritus about one foot thick, containing many of the land and freshwater shells cited above; next above this is a second layer of peat with shells.

At the southern extremity of the author's section, the order of the beds was as follows:—1. Diluvial clay, 3 feet. 2. White sand with shells, 3 feet. 3. White calcareous marl with shells, together with the bones of the elephant, ox and deer. 4. Peat with shells (*Valvata piscinalis*), 6 inches. 5. Blue clay with freshwater shells.

The author suggests that this deposit is the bed of an ancient pond, which occupied a depression on the surface of the till.

A paper was afterwards read "On the Tin Mines of Tenassirim Province." By Prof. Royle.

The author commences by observing that though tin is found in few parts of the world, yet that it can be clearly proved to have been employed from very early historical times: he next enters into various interesting inquiries respecting the names under which it was known by the several nations of antiquity, and the country from whence it was procured, considering it more probable that the Greeks and Romans were supplied from the East, than that commerce should have extended in very early times to such a remote country as Cornwall.

After some short notices of the old geographers and travellers who have spoken of the tin of India, the author enters into an account of the several localities in which it has been discovered, the situations in which it usually occurs, the methods of extracting and smelting it.

The island of Banca, situated at the eastern extremity of Sumatra, is the most celebrated of the Indian tin districts. The surface of this island presents short ranges of granitic hills, flanked by inferior ones which abound in red ironstone. The tin occurs in the low alluvial deposits at the base of the granitic hills, and about twenty-five feet from the surface. The ore is a peroxide of tin yielding about 60 per cent. of metal. From 1813 to 1816, whilst the island was in possession of the East India Company, three millions of pounds were raised annually, and since that time the quantity is believed to have increased. It is stated on the authority of Captain Tremenhere, that some of the tin of Banca is extracted from the side of a hill about 300 feet high.

The island of Lingen, at the southernmost point of the peninsula of Malacca, particularly in the neighbourhood of Palemberg on the east coast, also produces tin, as does the island of Sumatra at various points along the eastern coast, and near Bencoolen on the western coast.

The whole peninsula of Malacca on its west side is also a stanniferous district. A range of lofty granitic hills runs from north to south through this country: the lower ridges of the neighbourhood of Malacca consist of conglomerate, with clay ironstone, which agrees in character and composition with a rock common on the Malabar coast, described by Dr. Buchanan under the name of Laterite. Severe shocks of earthquakes are occasionally felt in Malacca; and there are several springs with temperatures of 110° and 180° F. The tin ore is extracted from the low alluvial plains at the base of the granitic range, and is not unfrequently mixed with gold. The exported quantity of the latter amounts to about 19,800 oz. annually. The ore occurs in the horizontal seams of considerable extent, and from six to twenty inches in thickness, at a variable depth from the surface.

The author next describes the native processes for working and smelting the ore, and states that about 70 per cent. of metal is obtained at a cost of twenty-three shillings the cwt.: on the authority of Capt. Newbold, the gross annual quantity of tin raised in the peninsula of Malacca is given at 4,325,000 lbs.

The British provinces on the coast of Tenassirim contain about 30,000 square miles, having a north and south range of mountains for their eastern boundary. The mineral products of these provinces are tin, iron, and coal. The north and south range is stated by Dr. Helfer to be composed of granite and gneiss; and the northern and middle parts of the country to consist of transition slates and limestones. The country south of the Maulmain river, the province of Ye, towards Tavoy, is a sterile slate district covered with bamboo. Amherst province presents isolated ridges of limestone with fertile land at their bases: to the south are sandstones and conglomerates. Tertiary formations, chiefly argillaceous, occupy the higher parts of Amherst and Ye provinces, the plains of Tavoy and Kalleevung, those between Tavoy and Poilon, the valley of Jaun-biank and of the Tenassirim river, and the elevated land of Meta-mio.

In 1837 Dr. Helfer discovered tin near lake Loadut, about 110 miles N.N.E. of Maulmain, and in 1840 he reported the country to the north of the Pakehan river to be the richest stanniferous district within the Tenassirim provinces: the ore is found in the debris of primitive rocks, and the range is stated to be a continuation of the Siamese tin district of Rinowng. Domel island and the banks of the Boukpeer are also cited as localities yielding tin.

Capt. Tremenhere's account of the tin of the Tenassirim provinces is, that it occurs chiefly in the beds and banks of those rivers which issue from the primitive mountains: on the Thengodong river, in the immediate vicinity of the coal mines on the Great Tenassirim river, 11,889 grains of peroxide of tin were collected in an hour and a half. Along the courses of the streams which flow into the Little Tenassirim river it occurs in thin beds, in gravel; and Capt Tremenhere calculates, from a short trial he made, that two men could obtain by washing the gravel about 5 lbs. 2 oz. 464 grs. of tin per day.

At Kahan, on the right bank of the Great Tenassirim river, eleven miles from Mergui, Capt. Tremenhere found a vein of tin about three feet and a half wide, nearly vertical, and included in a white decomposing granitic rock. The ore is described as equal to that from Banca. It is conjectured that tin may ultimately be found in the small isolated granitic hills which rise out of the alluvial plain in the neighbourhood of Kahan.

April 5.—Edward Scott Barber, Esq., of Newport, Monmouthshire, Assoc. Inst. C.E., and Charles Crompton, Esq., Barrister, of No. 10, Endsleigh Street, Tavistock Square, were elected Fellows of this Society.

A paper was read "On the Geology of the South-east of Surrey." By R. A. C. Austen, Esq., Sec. G.S.

The observations embodied in this paper relate to certain points regarding the structure of the district on either side of the North Downs of Surrey, to the number and order of the component formations, and the evidences which they present of the conditions under which they were formed.

Mr. Austen regards the steep walls of the chalk formation as forming a more obvious physical boundary of the Wealden formation, especially on the south, than the great escarpment of the greensand. He remarks that the subdivisions of the eocene tertiary present lines of escarpment corresponding to the secondary series. He maintains that the Wealden in its present state is not a valley of elevation,—that at some former period it has been an elevated area, but that subsequent changes in the relative positions of the earth's crust have reduced the elevation which this particular portion must have had at a given time, and with reference to other circumjacent areas.

Numerous sections show that the lowest tertiary strata in the vicinity of the chalk escarpment are composed of rounded pebbles, fine sand, and beds of oyster-shells, the whole corresponding exactly with the Reading and other equivalent deposits. Mr. Austen infers from these facts that the movements of the earth's crust, which have been considered as having been confined to the Wealden district, can be traced into the tertiary area of Surrey and Hants, and that these movements and the process of removal did not commence until after the completion of the lower tertiary series.

Cretaceous Series.

The general character of that portion of the chalk which is exhibited in the range from Farnham to Dorking, as regards the distribution of animal remains, is as follows. Great as is the still remaining thickness of chalk in the south-east of England, we must always bear in mind that in every place in which we observe it, it has been extensively abraded and reduced. To what extent this has taken place we can only conjecture from such loose calculations as those made on a comparison of the beds of uninjured flints (such as occur over the surface of the North Downs), and the relative proportion of the flint seams to the beds of pure chalk.

If we compare the flints which are collected in heaps, either from the fields or dug near the surface along the North Downs, with such as are to be found in every quarry of the upper chalk, the difference is very striking. In the former every single specimen affords proof that it has been formed round some spongiform body, and this too is evident from the external form. With the flints *in situ* such forms are rare, and warrant the conclusion that these curious productions were much more abundant in the cretaceous ocean towards the close of that period than they had been in any other portion.

A curious fossil, to which Mr. Mantell has given the name of *Spongus,* is also not unfrequent in the flint and gravel beds, but has never been observed by the author in beds *in situ.*

The most abundant remains contained in the beds, which are now the highest, are *Belemnites mucronatus, Pecten nitidus, Ostrea vesicularis, Inoceramus cordiformis, Terebratula plicata, Marsupites ornatus, Ananchytes ovatus,* together with some undescribed *Pectens* and other bivalve shells.

Below these beds are found others, with *Inoceramus latus, Ventriculites radiatus,* and *Coscinopora infundibuliformis* in extraordinary abundance, the *Catillus concentricus* being the most common and characteristic shell.

Throughout this upper portion of the chalk it is very evident that the layers of flint are the equivalents of the partings between strata in other deposits; and sufficient time seems to have elapsed between the completion of one stratum and the commencement of another, to allow the lower one to become compact. The irregularities of the flints are always on the upper side; one seam in a pit near Merrow consists entirely of the silicified remains of *Ananchytes*. These were evidently all dead crusts which had lost their spines before they were drifted over the bed where we now find them. This species however is not confined to such layers, but is found in extraordinary numbers in each separate bed; and in another instance an *Astræa* had time to spread itself out over the surface.

Considering the small number of animal remains we yet possess from the chalk formation, when viewed with reference to its vast thickness, there being not more than four or five species to 100 feet, it seems hazardous to refer the whole of this wide-spread mass of calcareous matter to the destruction of animal structures; but the impression constantly produced by a microscopic examination of the white chalk in every place has been, that it was the deep sea deposit of a wide ocean, which in parts teemed with animal life, but of which the localities have long since disappeared in the extensive destruction which it has everywhere experienced; and that all we have to judge from is such portion as was not generally calculated to support animal life, with the exception perhaps of Foraminifera and Brachiopods: the specific gravity of shells and corals is in favour of the wide distribution of their materials when pounded.

Nor is this purely hypothetical: there are some remarkable beds a little below that portion of the deposit last described which bear it out: they are beds which were apparently deposited when the waters could drift rather coarser materials than usual; so that the greatest portion consists of broken branches of corals, shells and Echinoderms, cemented by the usual comminuted matter of the ordinary chalk strata. *Eschara cancellata, E. pyriformis, Cellepora bipunctata, Ceriopora madreporacea, Retepora truncata, Serpula plexus,* and *Cidaris vesiculosa* are the principal species met with.

For a very considerable depth below this, through that portion where the seams of flint are most regular, it is almost in vain to search for any traces of animal life. This condition of things is continued downwards as far as the chalk without flints, where *Inoceramus mytiloides* and *cuvieri, Lima hoperi, Plagiostomæ* and *Terebratulæ*, become abundant, together with the remains of fishes; and which beds are succeeded by others which afford a grey limestone, and contain *Ammonites rhotomagensis, A. mantelli, A. lewesiensis, A. varians, Turrilites tuberculatus, Scaphites æqualis, Pecten beaveri,* and *Ananchytes radiatus*.

This lower chalk, which through a considerable thickness had been gradually becoming more compact, thick-bedded and dark-coloured, suddenly changes to a rock, exactly resembling the upper white fragmentary beds. This portion of the series, taken in a descending order, slowly acquires an admixture of sand and green earth, so as to become first a *craie chloritée*, till by the further diminution of the calcareous matter we reach the bright green beds of the upper greensand with *Plicatula inflata*: below these strata of white, blue, calcareous matter again occur, containing *Ammonites rhotomagensis* and *mantelli,* offering a striking contrast to the beds above them and the rock gault immediately below: through this portion again traces of animal life are hardly to be found.

The gault clay contains *Ammonites splendens, A. interruptus, A. auritus, Baculites* and *Inoceramus gryphæoides,* in considerable numbers, which are continued down into the beds of marly green earth below.

This terminates a long-established division in the cretaceous series; and the abrupt manner in which some of the changes in mineral character, as from clays to sands or limestone, takes place, is very remarkable.

Greensand Series.

Dr. Fitton remarks *, that the tract on the south and west of Guildford forms one of the most extensive surfaces of the lower greensand to be found in England; and he illustrates the succession of the strata in this district by a section from Farnham across Hindhead to the Weald. This line, however, which is taken near the western extremity of the major axis of the Wealden denudation, does not exhibit the disturbance to which the preservation of this larger area of lower greensand is due; and a better line for this purpose is one which may be taken due south from the town of Guildford, and which will cut across the small valley of denudation, which occurs within the said area of the greensand formation, between the chalk range of the North Downs and the escarpment of the Weald valley.

This denudation has cut through all the beds of the greensand series, as represented, and has laid bare, in the lower parts of the valley, the clays of the Wealden series.

These clays are noticed by Dr. Fitton †, who states that his attention was first called to them by Mr. Murchison. The discovery of Wealden fossils has enabled the author to confirm Dr. Fitton's conjecture as to the age of the lowest clays of the Pease marsh, which, even without such aid, is sufficiently established by the general arrangement of the greensand series which succeeds it. This structure of the Pease marsh valley had been long known and mapped by Mr. H. L. Long.

This valley of denudation is rudely elliptical, and like that of the Weald, has its larger axes extended due east and west. The outward dip of the beds is most clearly marked, and the general nature of the disturbance can be easily traced by a series of transverse sections, along which the beds of the greensand will be seen to be raised on the north and depressed on the south of the line of disturbance.

The author considers that an interesting and important member of this group has been overlooked in England, and proposes to adopt (for the south-east of England at least) the following subdivisions:—

a. Upper, ferruginous.
b. Middle, containing Bargate and Kentish Rag.
c. Argillaceous [Neocomian of Leymerie and D'Orbigny].

* Geol. Trans., vol. iv. p. 143. † Ibid. p. 149.

a. Upper [ferruginous] division.—This section, though founded on an artificial character, is so decidedly marked, both as constituting an independent range of hills parallel with the chalk, as also by the absence of any useful vegetation, as to be most obvious of all the three divisions of the lower greensand. As a mineralogical division it is clearly defined. A clear line without any alternations separates it from the dark-coloured beds of the gault, and though less clearly marked below, yet its range across the country and numerous sections show that its thickness is uniform. A diagonal arrangement of the bedding is very evident in a portion of it. Organic remains are very rare. Mr. Austen has received one curious specimen from Mr. H. Long,—an ironstone cast of the umbilical portion of an ammonite. Fossil wood also occurs.

b. Middle division.—Next below the ferruginous division of the lower greensand strata are sands with subordinate bands of hard siliceous building stone, which have been fully described, first by Mr. Murchison and subsequently by Dr. Fitton. Mr. Austen confines his remarks to the indications which they afford of the condition of things at the period of their deposition. These sands, which at first sight appear non-fossiliferous over large areas, are found on closer examination to contain numerous minute corals of undescribed species, broken spines of Echinoderms and fragments of bivalve shells; all these are most abundant in the lines of the Bargate stone. Large specimens of *Nautilus radiatus* and *Ammonites nutfieldiensis* occur occasionally, and casts of a species of *Mya* are constantly found at right angles with the beds, and in the position in which they live.

Throughout the middle division of the lower greensand the component beds present a diagonal structure. Many of the changes which have taken place since the deposition of the strata, such as the consolidation of the Bargate nodulates and ragstone, have been in the lines of the cross-stratification. Mr. Austen regards this structure as indicating a moving power which acted constantly in one direction; and as in this case the inclination of the transverse beds is always southerly, the materials of the middle green deposits appear to have been, during a vast period of time, accumulated in a given direction, and consequently derived from an opposite one.

c. Argillaceous division (Neocomian).—The beds which rest immediately upon the blue Wealden shales of the valley of the Pease marsh consist of brown and yellow clays. The range of these strata at the base of the hills which bound this area is clearly marked, either by several brick-fields or by the prevalence of oak timber; and sections showing the place in the series which it occupies may be seen near the ford at East Shalford, and the Artington brick-field. These clay strata often run out at the base of the lower greensand, which gives them an appearance of greater thickness than they really possess.

Though the general character of this portion of the cretaceous series is argillaceous, it contains subordinate nodular concretions in the lines of bedding, of great size and thickness, and cemented into an exceedingly hard rock by calcareous matter. Corals and shells are abundant in these nodules; indeed these beds seem richer in organic contents than any other portion of the cretaceous series: good specimens however are difficult to obtain, as the outer surfaces of the shells adhere very strongly to the matrix.

Besides the fossils contained in the calcareous nodules, the intermediate clay-beds contain in great abundance a large oyster, with a coarse foliaceous structure. These beds form the lowest portion of the cretaceous series in this part of England, and are either peculiar to this locality or have been overlooked elsewhere.

A like argillaceous division occurs at the base of the greensand escarpment of the great valley of the Weald, where also it advances in the shape of an under terrace. At Parkhatch, near Hascomb, these beds were cut through in digging a well, and found to rest upon blue Wealden shales.

Strata have been described by some of the French geologists, which correspond exactly in position, mineralogical character, and included fossils with the argillaceous group above noticed. The French strata occur at the base of the cretaceous series of the Paris basin, and are described by Mons. Leymerie and Cornuel under the names of the *argile ostréenne,* and the *calcaire à Spatangues,* and belong to their Neocomian group. On this subject Mr. Austen has the following remarks:—

In thus comparing the lowest argillaceous division of the greensand of the south-east of England with the Neocomian group of continental geologists, it may be well to consider what is the value of that group, and how far it has hitherto been recognised in this country. The fossils of the upper Neocomian beds of Vassy and the department of the Aube are forty-two, of which only one (the *Corbula punctum* of Phillips) is regarded as an English species, and even that is quoted with a doubt. So far, then, the establishment of an additional group to the cretaceous series, as described by English geologists, has been strictly in accordance with the principles on which most recent divisions have been made in older rocks; and in the absence of figures and descriptions of some of the remarkable shells which this group contains, the continental geologists very naturally concluded that it was wanting in the English series, an inference which has led to some erroneous generalisations.

The grounds on which this subdivision is proposed are the following:—

1. Distinct mineralogical characters, in a constant position in the series; in which respects it is of the same value as most other geological arrangements.

2. Agreement in this respect with the nearest portions of the cretaceous series in France.

3. Its position beneath the lowest portion of the series which is to be found described in works on the subject.

4. A distinct and peculiar suite of organic remains.—

Ostræa, n. s. common.	Corbula punctum.
Pholadomya neocomensis.	Astarte beaumonti.
——— solenoides.	——— substriata.

Astarte transversa.	Pecten interstriatus.
Thetis minor.	Hinnites leymerii.
Cardium hillanum.	Exogyra, sinuata. var.
——— subhillanum.	——— subsinuata.
Cucullæa raulini.	Ostrea leymerii.
Modiola archiaci.	Terebratula biplicata.
——— lanceolata.	——— elegans.
Trigonia scabra.	——— sella.
——— palmata ?	Auricula incrassata.
——— fittoni.	Natica.
Pinna sulcifera.	Turritella lævigata.
Perna mulleti.	——— dupiniana.
Gervillia anceps.	Rostellaria ——— ?
——— aliformis.	——— ——— ?
Avicula —— ?	Nautilus pseudo-elegans.
Pholadomya prevosti.	N———
——— rhomboidalis.	———
Lima elegans ?	Pycnodus ——— ?

There is still direct evidence in the Isle of Portland that a part of the south of England rose into dry land at the close of the oolitic æra: and other considerations make it very probable that at that time the extent of dry land in the northern latitudes was very considerable. The range of the Neocomian deposits along the south of Europe shows the amount of submersion, next after the oolitic epoch, and we see in the Boulonnais, in the Pays de Bray, in the Paris basin, Franch Cerate, Neufchatel, and part of Germany, how very close the upper marine Neocomian beds approach to our own freshwater or tertiary Wealden: so that consistently with the views of the continental geologists, we seem to have ascertained some interesting points in the physical geography of a part of the surface of the earth during the secondary period; such as the direction from which the waters of the vast Wealden stream flowed, and the line where (approximately at least) they joined those of the sea. No one who has either traced the cretaceous series in the range along the southern portion of England, has seen it abroad, or studied the numerous fossil remains which the formation contains, together with their geographical range, can entertain the least doubt but that the sea which deposited it was brought from the south northwards by a gradual process of overlap. For this reason it is that the cretaceous series of the continent, and of the south of Europe in particular, is so much more fully developed than our own; and it becomes of interest to ascertain at what precise period it was that its waters reached our latitudes; in other words, how much of the series is represented here. The groups of this country must cease to be the measure and type of the cretaceous epoch, of which they only represent a part.

"Notice of the occurrence of Beds containing Freshwater Fossils in the Oolitic Coalfield of Brora, Sutherlandshire." By Alexander Robertson, Esq., F.G.S.

Among the reefs of shale and coal opposite the old salt-pans at

Brora, Mr. Robertson has discovered two beds abounding in *Cyclas* and other freshwater fossils, approachable only at low water. The rise of the tide on the occasion of his visit to the locality, prevented a minute examination of their relations. Their position was however satisfactorily made out, and is, in the descending order, as follows :—

a. Beds of calcareous sandstone, considered by Mr. Phillips to represent the gray limestone of Cloughton and other localities in Yorkshire.

b. Shale and coal, several feet.

c. Shale with fossils about an inch.

d. Shale and coal similar to the beds *b*, two or three feet.

e. Clay with fossils about thirteen inches.

f. Shale with a few plants.

The bed *c* has yielded,—

Fishes.—Scales of a species of *Lepidotus*, strongly resembling *L. fimbriatus*, Ag. Scale of *Megalurus*?

Mollusca, Paludina, several new species. *Cyclas*, one or two new species.

Crustacea.—*Cypris*, new species. Plant, obscure impressions.

From the bed *e* the following have been obtained :—

Fishes.—Scales of two or three species of *Lepidotus*. Teeth of *Acrodus minimus*, Ag.? Teeth of *Hybodus minimus*, Ag.

Mollusca.—*Paludina*, same species as in the upper bed. Two or three species of *Perna*, some of which are probably new. *Unio*, one new species. *Cyclas* numerous, new species chiefly belonging to Lamarck's genus *Cyrena**.

Crustacea.—*Cypris*, same species as in the upper bed.

Plants.—Minute fragments of carbonized wood.

Nearly the whole mass of both beds consists of fossils. No marine fossils (with the exception perhaps of the scales of *Lepidotus*) are found in the upper bed, and it seems therefore to be properly a freshwater deposit. The mixed nature of the fossils of the lower one conclusively point out its estuary character.

"Observations on the occurrence of Freshwater Beds in the Oolitic Deposits of Brora, Sutherlandshire; and on the British Equivalents of the Neocomian System of Foreign Geologists." By Roderick Impey Murchison, Esq., F.G.S.

In this communication the author confirms the interesting discovery announced by Mr. Robertson in the preceding paper, and remarks, that as the reefs of rock exposed at low water at the mouth of the river Brora unquestionably lie beneath the Oxford clay, and are not far above the roof of the coal, there can be no doubt that the beds containing the freshwater shells, being fairly intercalated with the other strata, are thus inclosed in the heart of the oolitic series.

* Among the specimens sent to the Society by Mr. Robertson were several examples of *Cyclas media*, identical with the Wealden shell. The *Perna* referred to is altogether new, and will probably form the type of a genus, bearing a relation to *Perna* analogous with that which *Dreissena* bears to *Mytilus*.

They had escaped the notice of Mr. Murchison, probably from having been covered by sea sand at the time of his visit.

An examination of the freshwater specimens collected by Mr. Murchison and Professor Sedgwick at Loch Staffin, in the Isle of Skye, has identified the principal forms with Mr. Robertson's specimens from Brora, and has led the author to adopt a different view respecting the position of the beds from which they were derived. Instead of supposing that the oolitic series of the cliffs near Portree was overlaid by a true equivalent of the Wealden*, the freshwater beds of Skye will it is now believed be found, like those of Inverbrora, to be interstratified with the middle oolite, a conclusion rendered probable by the natural sections and form of the coast, and by the circumstance that the fragments not found *in situ* which contained freshwater shells were collected near the escarpment and not on the dip of the oolitic strata. Mr. Murchison is inclined to take a similar view of the freshwater deposits near Elgin, compared by Mr. Malcolmson to the Purbeck beds of England.

The author remarks, that with the terrestrial evidences in the plants of Portland, Scarborough, Stonesfield and Brora, we might naturally expect at any day to hear of the associated lacustrine or river shells. But Mr. Robertson's discovery further compels us to believe, that the same species of freshwater shells prevailed, not only during the whole of the Wealden epoch, but that they were in existence at periods long antecedent, when the adjacent lands poured forth rivers into the sea in which the middle and lower oolites were accumulated, and thus we acquire a new element to enable us to reason upon the former conditions of the surface.

The facts stated by Mr. Robertson tend to confirm the idea, that the Wealden is more naturally connected with the Jurassic than with the cretaceous system, and must also have an influence in deciding that the Neocomian formation of foreign geologists ought not to be placed on the parallel of the Wealden. Mr. Murchison has for some years been of opinion that the Neocomian system is little more than an equivalent of the lower greensand of British geologists, a view which he upheld at the meeting of the Geological Society of France at Boulogne in 1839, on the ground of the identity of their stratigraphical relations and typical fossils. Further researches during last May along the coast of the Isle of Wight, in company with Count Keyserling, led both that gentleman and the author to the same conclusion. Among the numerous fossils they there collected were many identical with, or analogous to, Neocomian species, particularly in that portion of the coast section so minutely described by Dr. Fitton and Sir John Herschel, viz. between Black Gang Chine and Atherfield rocks. Mr. Murchison observed that there seemed to be a gradual zoological as well as lithological passage from the Wealden beds below into the greensand and shales above them; for although the shale with *Cypris* occurs immediately beneath the marine deposit of Atherfield rocks, as remarked by Dr. Fitton, another band of flagstone with marine shells (*Ostrea* and *Terebratula*) also occurs beneath these uppermost beds of *Cypris*. In the

* Geol. Trans. vol. ii. p. 366.

still lower strata, however, we lose all traces of such marine alternations, and the whole becomes one great freshwater deposit. A similar phænomenon is seen in the southern part of the section at Red Cliff, extending into Sandown Bay, where beds with *Cypris* are intercalated between oyster beds. These alternations are indeed what we might expect to find, provided a former depression of the surface had converted a lake into an estuary, and subsequently into a marine bay. But notwithstanding the natural connexion between the Wealden and the lower greensand, it does not follow that the two formations ought to be merged in one system or natural series. Dr. Mantell as long ago as 1822 pointed out the analogy between the animals of the Wealden and those of the Stonesfield beds; and more recently Professor Owen has carried it out much further. Professor Agassiz has pronounced the Ichthyolites of the cretaceous system to be entirely dissimilar from those of the Wealden.

Mr. Murchison inquires, where are we to draw the line of separation which shall indicate precisely in our own country the base of the Neocomian of foreign geologists, or in other words, the base of the great continental cretaceous system? On this point he remarks that some small amount of compromise may eventually be found desirable; for whilst we have on the one hand full right to infer that the larger portion of the Wealden must be classed in the oolitic series, further inquiry may convince us that its uppermost part is of the same age as the lowest Neocomian strata; and thus we may connect that portion of it with the cretaceous system. In the mean time it is quite clear that a great part of the Neocomian is absolutely the lower greensand itself. This view is confirmed by Count Keyserling, who has identified fossils from the Neocomian strata of Kyslavodsk in the Caucasus, with specimens collected by him in company with Mr. Murchison in the lower greensand of the Isle of Wight.

April 26.—Lieut.-Col. Dundas, C.B., Royal Artillery, Woolwich, and George Grote, Esq., M.A., 4 Eccleston Street, Belgrave Square, were elected Fellows of this Society.

A paper was read "On the upright Fossil-trees found at different levels in the Coal strata of Cumberland, Nova Scotia." By Charles Lyell, Esq., F.G.S., &c.

The first notice of these fossil trees was published in 1829 by Mr. Richard Brown, in Haliburton's 'Nova Scotia,' at which time the erect trunks are described as extending through one bed of sandstone, twelve feet thick. Their fossilization was attributed by Mr. Brown to the inundation of the ground on which the forest stood. Mr. Lyell in 1842 saw similar upright trees at more than ten different levels, all placed at right angles to the planes of stratification, which are inclined at an angle of 24° to the S.S.W. The fossil trees extend over a space of from two to three miles from north to south, and, acccording to Dr. Gesner, to more than twice that distance from east to west. The containing strata resemble lithologically the English coal-measures, being composed of white and brown sandstones, bituminous shales, and clay with ironstone. There are about nineteen seams of coal, the most considerable being four feet thick. The place where these are best seen is called the South Joggins, where the cliffs are from 150 to 200 feet high, forming the southern shore of a branch of the Bay of Fundy, called Chignecto Bay. The action of the tides, which rise sixty feet, exposes continually a fresh section, and every year different sets of trees are seen in the face of the cliffs.

The beds with which the coal and erect trees are associated are not interrupted by faults. They are more than 2000 feet thick, and range for nearly two miles along the coast. Immediately below them are blue grits used for grindstones, after which there is a break in the section for three miles, when there appear near Minudie beds of gypsum and limestone, and at that village a deep red sandstone, the whole having the same southerly dip as the coal at the Joggins, and being considered by Mr. Lyell as the older member of the carboniferous series.

Above the coal-bearing beds, and stretching southwards for many miles continuously along the shore, are grits and shales of prodigious thickness, with coal-plants, but without vertical trees.

Mr. Lyell next describes in detail the position and structure of the upright trees at the South Joggins. He states that no part of the original tree is preserved except the bark, which is marked externally with irregular longitudinal ridges and furrows, without any leaf-scars, precisely resembling in this respect the vertical trees found at Dixonfold on the Bolton Railway, described by Messrs. Hawkshaw and Bowman. No trace of structure could be detected in the internal cylinder of the fossil trunks, which are now filled with sandstone and shale, through which fern-leaves and other plants are scattered. Mr. Lyell saw seventeen vertical trees, varying in height from six to twenty feet, and from fourteen inches to four feet in diameter. The beds which inclose the fossil trees are usually separated from each other by masses of shale and sandstone many yards in thickness. The trunks of the trees, which are all broken off abruptly at the top, extend through different strata, but were never seen to penetrate a seam of coal, however thin. They all end downwards either in beds of coal or shale, no instance occurring of their termination in sandstone. Sometimes the strata of shale, sandstone and clay, with which the fossil trunks have been filled, are much more numerous than the beds which they traverse. In one case nine distinct deposits were seen in the interior of a tree, while only three occurred on the outside in the same vertical height.

Immediately above the uppermost coal-seams and vertical trees are two strata, probably of freshwater origin, of black calcareo-bituminous shale, chiefly made up of compressed shells of two species of *Modiola*, and two kinds of *Cypris*.

Stigmariæ are abundant in the clays and argillaceous sandstones; often with their leaves attached, and spreading regularly in all directions from the stem. The other plants dispersed through the shales and sandstones bear a striking resemblance to those of the European coal fields. Among these are *Pecopteris lonchitica*, *Neuropteris* *flexuosa?*, *Calamites cannæformis*, *C. approximatus*, *C. Steinhaueri*, *C. nodosus*, *Sigillaria undulata*, and another species.

The genera *Lepidodendron* and *Sternbergia* are also present. The same plants occur at Pictou and at Sydney in Cape Breton, accompanied with *Trigonocarpum*, *Asterophyllites*, *Sphænophyllum*, and other well-known coal fossils.

The author then gives a brief description of a bed of erect *Calamites*, first discovered by Mr. J. Dawson in the Pictou coal-field, about 100 miles eastward of the Cumberland coal-measures before described. They occur at Dickson's mills, 1¼ mile west of Pictou, in a bed of sandstone about ten feet thick. They all terminate downwards at the same level where the sandstone rests on subjacent limestone; but the tops are broken off at different heights, and Mr. Dawson observed in the same bed a prostrate *Lepidodendron*, with leaves and *Lepidostrobi* attached to its branches.

From the facts above enumerated, Mr. Lyell draws the following conclusions:—

1. That the erect position of the trees, and their perpendicularity to the planes of stratification, imply that a thickness of several thousand feet of coal strata, now uniformly inclined at an angle of 24°, were deposited originally in a horizontal position.

2. There must have been repeated sinkings of the dry land to allow of the growth of more than ten forests of fossil trees one above the other, an inference which is borne out by the independent evidence afforded by the *Stigmaria*, found in the underclays beneath coal-seams in Nova Scotia, as first noticed in South Wales by Mr. Logan.

3. The correspondence in general characters of the erect trees of Nova Scotia with those found near Manchester, leads to the opinion that this tribe of plants may have been enabled by the strength of its large roots to withstand the power of waves and currents much more effectually than the *Lepidodendra* and other coal plants more rarely found in a perpendicular position.

Lastly, it has been objected, that if seams of pure coal were formed on the ground where the vegetables grew, they would not bear so precise a resemblance to ordinary subaqueous strata, but ought to undulate like the present surface of the dry land. In answer to this Mr. Lyell points to what were undoubtedly terrestrial surfaces at the South Joggins, now represented by coal seams or layers of shale supporting erect trees, and yet these surfaces conform as correctly to the general planes of stratification as those of any other strata.

He also shows that such an absence of superficial inequalities, and such a parallelism of successive surfaces of dry land, ought to be expected, according to the theory of repeated subsidence, because sedimentary deposition would continually exert its leveling action on the district submerged.

"On changes in the Temperature of the Earth, as a mode of accounting for the subsidence of the Ocean, and for the consequent formation of Sea-beaches above its present level." By Robert Harkness, Esq., Ormskirk.

The formations which are referrible to a period that succeeded the most recent tertiary epoch, and preceded the period when the earth was inhabited by man, and which the author terms the post-tertiary formations, may be divided into the so-called diluvium, the erratic blocks which have been transported by the action of glaciers, and the remains of ancient sea-beaches.

The so-called diluvium usually consists of clay and erratic boulders, of which the latter are often identical in substance with the rock of some more or less distant mountain-chain; and in such cases may be considered to have been derived from the chains in question. Since deep valleys, of anterior date to the diluvium, often intervene between the rocks *in situ* and the districts over which the derivative boulders are spread, the transport of these masses has in later times been attributed by geologists to the action of floating icebergs, an action which, according to the observations of Scoresby and others, is fully adequate to remove from the Arctic to more temperate regions great masses of earth and rock, and actually operates every year in the manner stated to an incredible extent. Were the bed of the ocean in which these icebergs, on melting, have deposited, and continue to deposit, their rocky freight, to be now elevated above the sea-level, it would present a striking resemblance to the so-called diluvium. What further tends to confirm this theory is, that the diluvium is often found to contain the remains of Mollusca, partly of arctic origin; and these are frequently in a state of perfect preservation; a fact which renders it probable that these remains have not been removed to any great distance from their native habitat.

The consequence of supposing numerous icebergs to have floated, at a former period, into latitudes in which icebergs are never seen at present, is, that the temperature of these regions and of the whole earth at that period was lower than it is at present; and the less the distance to which the icebergs were floated from the glacier they were originally launched from, the further must the then frigid have encroached on the now temperate zone.

The erratic blocks which are found at various elevations on the declivities of the Alps, and which sometimes form large mounds placed transversely to those declivities, resemble in that respect the morains formed by glaciers; and hence it has been inferred that it is by the action of glaciers that these alpine boulders have been transferred to their present sites. Supposing that to have been the case, the ancient glaciers must have extended to a much lower level than the modern glaciers; and the temperature of the Swiss valleys must have been lower than it is at present. The glacier theory therefore leads to the conclusion, that when these ancient morains were formed there existed a frigid climate in the now temperate zone.

There have been observed in many and very remote parts of the world, at considerable elevations above the present sea-level, extending through great distances of country, long terraces of transported materials, such as sand, clay, and pebbles; and these terraces geologists have agreed in considering as the remains of ancient sea-beaches. These beaches sometimes contain sea-shells, which belong partly to arctic species.

In the great majority of instances these terraces are horizontal; and when that is the case, and more than one of these terraces form continuous lines in the same district, they are all of course parallel to one another. Brongniart, in the year 1829, was the first to call attention to terraces of this description, the origin of which he attributed to the subsidence of the waters of the ocean. This supposition has by some geologists been considered as at variance with physical probabilities; and the more generally received hypothesis now is, that these terraces owe their present position to elevation by subterranean agency.

This explanation at first sight appears very probable; and the more so as there are some ancient beaches which are not horizontal but are inclined to the horizon. Of this description are the two observed in Norway, between the 70th and 71st degrees of north latitude, by Mons. Bravais; of which the upper descends from its summit level of 222 feet above the sea to its lowest level of 94 feet; and the lower descends from its summit level of 91 feet to its lowest level of 46 feet. The present position of these Norwegian beaches is probably owing to the same cause which has raised, and still continues to raise, a part of the Scandinavian peninsula above the level of the ocean, and which has given rise to the ancient sea-beaches in Sweden. It appears, however, from the discovery of a human habitation in connexion with these beaches in Sweden, that they belong, not to the post-tertiary, but to the historical epoch; and it is to the latter epoch, therefore, that we ought to refer the inclined beaches observed in Norway by M. Bravais.

The fact that the post-tertiary sea-beaches are, in the great majority of instances, horizontal, strongly militates against the notion that they owe their present position to elevation from beneath; as does also the fact of their wide-spread geographical distribution, which is so extensive indeed as to be almost universal. Were we to admit that wherever these beaches are found the land has been elevated, we must admit that in the post-tertiary period the elevating of the land was almost universal; a conclusion in itself so improbable, that we ought to seek to explain the difference of level between the post-tertiary beaches and the present ocean in some other manner.

The author then propounds a new theory to account for the post-tertiary horizontal sea-beaches. This theory he bases on the above stated conclusion, derived from the appearances which the diluvium and the alpine boulders present; namely, that during the post-tertiary period the temperature of the earth was lower than it is at present. From the observations of Kotzebue, Sabine and Scoresby, he infers, that at the depth of about 800 fathoms from the surface the temperature of sea water, whether near the equator or in high latitudes, is not very remote from 40 degrees of Fahrenheit, the point of temperature at which the density of fresh water is the greatest: and as the mean depth, according to Laplace, of the Pacific Ocean is about four miles, and of the Atlantic about three miles, and the mean depth, therefore, of the two oceans about 3000 fathoms (of which 800 fathoms is little more than a fourth part), he considers that the mean temperature of the whole of the seawater taken together, is not far remote from 40 degrees. He infers from the observations made by Captain Sabine on sea water in high latitudes, that sea water follows nearly the same law as fresh water in expanding with a reduction of temperature below 40 degrees of Fahrenheit. Hence he reasons, that if, during the post-tertiary period, the mean temperature of the earth was lower, the mean temperature of the sea was also lower than it is at present; and this reduced temperature of the sea below 40 degrees would cause it to occupy a greater volume than it now occupies, and consequently to rise on all the sea coasts to a higher mean level than it now rises; though not exactly in proportion to its expansion, since it would then not only be deeper but would occupy a greater surface than before.

The author seeks to account for the increase which he supposes to have taken place in the mean temperature of the earth since the post-tertiary period, by the extent of land within the tropics which since that period has been raised from beneath the ocean by subterranean agency, and which, since its upheaval, has been heated by the sun's rays.

He notices the fact, that in the south-west of Lancashire the diluvium is found resting only upon level, and not on inclined surfaces.

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PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY OF LONDON.

VOL. IV. PART I. 1843. No. 95.

May 10.—James Jerwood, Esq., A.M., F.C.R.S., of the Middle Temple, Barrister-at-law, Sothernhay, Exeter; Dr. Billing, M.D., of Park Lane; Lieut. Thos, A. B. Spratt, of the Royal Navy, Assistant Surveyor H.M.S. Beacon; and Gabriel Hamilton Lang, of Overton, Dumbartonshire, were elected Fellows of the Society.

A paper was read "On some new Ganoid Fishes." By Sir Philip Grey Egerton, M.P., F.G.S.

The specific characters of the fishes described are as follows:—

1. *Semionotus pentlandi*, Egerton.—Body deep; pedicle of the tail thicker proportionally than in *Semionotus latus*. Anal fin long, with 5 or 6 rays, articulated, subdivided, and decreasing in length from the first. Bases distant; 3 or 4 fulcral rays on the margin. Caudal fin large; upper lobe invested with scales for some distance. Margins fringed by elongated imbricated scales. Rays: 20, articulated, subdivided. Bases at greater intervals near the centre. Scales rhomboidal, smooth, with entire margins. Stratum, Lias.

Found by Mr. Pentland in a black bituminous schist at Giffoni, near Castella Mare. In the cabinets of the Earl of Enniskillen and Sir Philip Egerton.

Of the six species of *Semionotus* described by Professor Agassiz, one is from the quader-sandstein, the other five from the lias of Lufeld, Boll, Lyme Regis, and Schoven in Sweden. From a comparison of Mr. Pentland's specimens of this and the two following species with all those described, Sir Philip Egerton considers they approximate more nearly the species of the lias than those of the greensand, and infers from this zoological evidence that the Giffoni beds belong to the former.

2. *Semionotus pustulifer*, Egerton.—Fish large; operculum arenated; humerus and scapula pustulated; scales thick and lustrous; surfaces slightly uneven; upper and lower margins deeply undulate. Stratum, Lias; found with last. Cab. Egerton.

3. *Semionotus minutus*, Egerton.—Fish small; body slender; caudal pedicle thick; scales extended over the upper lobe of the tail. Stratum, Lias; found with last. Cab. Egerton.

4. *Lepidotus pectinatus*, Egerton.—Fish oblong, subfusiform; length 9 inches; depth $2\frac{3}{4}$; head small; fins small; scales marked with delicate radiating striæ; posterior margin finely pectinate; upper edge convex, lower one concave; dorsal, anal and caudal scales

rhomboidal, with entire margins. Stratum, Lias. Locality, Whitby. Cab. Enniskillen.

5. *Pholidophorus hartmanni*, Egerton.—Size of *Pholidophorus latiusculus*. Head rounded; orbit large; upper angle of operculum striated; preoperculum marked with few moniliform inequalities; humerus plicated; scales small, serrated on the posterior margin; its serrations decrease in number and increase in size on the posterior parts of the body. Stratum, Lias. Locality, Ohmden, in Wurtemburg. Cab. Enniskillen, Egerton.

6. *Pholidophorus crenulatus*, Egerton.—Rather larger than *Pholidophorus latiusculus*. Head rather pointed; humerus obliquely plaited; pectoral fins large, with 22 rays; caudal fins strong; the upper lobe bordered full two-thirds of its length with fulcral scales; rays 28—30; scales ribbed vertically on their bases, furrowed horizontally on their exposed surface, and crenulated on the posterior margin; the ventral scales deeply incised. Stratum, Lias. Locality, Lyme Regis. Cab. Egerton.

"On the Coal-formation of Nova Scotia, and on the age and relative position of the Gypsum and accompanying marine limestones." By Charles Lyell, Esq., F.G.S., &c.

The stratified rocks of Nova Scotia, more ancient than the carboniferous, consist chiefly of metamorphic clay-slate and quartzite, their strike being nearly east and west. Towards their northern limits these strata become less crystalline and contain fossils, some of which Mr. Lyell identified with species of the upper Silurian group, or with the Hamilton group of the New York geologists.

The remaining fossiliferous rocks, so far as they are yet known, belong to the carboniferous group, and occupy extensive tracts in the northern part of the peninsula, resting unconformably on the preceding series. They may be divided into two principal formations, one of which comprises the productive coal-measures, agreeing precisely with those of Europe in lithological and palæontological character; the other consists chiefly of red sandstone and red marl, with subordinate beds of gypsum and marine limestone; but this series is also occasionally associated with coal grits, shales, and thin seams of coal.

A variety of opinions have been entertained respecting the true age of the last mentioned, or gypsiferous formation; and it is the purport of this paper to show, first, that it belongs to the carboniferous group; secondly, that it occupies a lower position than the productive coal-measures. These last are of vast thickness in Nova Scotia, being largely developed in Cumberland county and near Pictou, and recurring again at Sydney, in Cape Breton. In all these places they contain shales, probably deposited in a freshwater estuary, in which several species of *Cypris* and *Modiola* abound. The plants of these coal-measures belong to the genera *Calamites*, *Stigmaria*, *Sigillaria*, *Lepidodendron*, *Pecopteris*, *Neuropteris*, *Sphenopteris*, *Nœggerathia*, *Palmacites*, *Sternbergia*, *Sphenophyllum*, *Asterophyllites* and *Trigonocarpum*, with which are the trunks and wood of coniferous and other trees. Upon the whole nearly 50 species of plants have been detected, more than two-thirds of which are not distinguishable from European species, while the rest agree generically with fossils of the coal formation in Europe.

The internal cylindrical axis of petrified wood in the *Stigmaria* of Nova Scotia exhibits the same vascular structure, and the same scalariform vessels, as the English specimens.

Mr. Lyell next describes the gypsiferous formation, especially the marine limestones of Windsor, Horton, the cliffs bounding the estuary of the Schubenacadie river, the district of Brookfield, and the cliffs at the bridge crossing the Debert river, near Truro. Several species of corals and shells are common to all these localities, and recur in similar limestones in Cape Breton. In this assemblage of organic remains we find a Crustacean intermediate between the *Trilobite* and *Limulus*, *Orthoceras* (two species), *Nautilus*, *Conularia*, *Encrinus*, *Cyathophyllum*, besides some species of the carboniferous limestone of Europe, such as *Euomphalus lævis*, *Pileopsis vetustus* ?, *Avicula antiqua*, *Pecten plicatus*, *Isocardia unioniformis*, *Producta martini*, *P. scotica* ?, *Terebratula elongata*, *Fenestella membranacea* ?, *Cerio-pora spongites*, Goldf. For assistance in determining these, the author has been greatly indebted to M. de Verneuil.

The plants associated with these limestones consist of several species of *Lepidodendron*, *Calamites*, and others agreeing with carboniferous forms. With these Mr. Lyell found in Horton Bluff scales of a ganoid fish, and in the ripple-marked sandstones of the same place, Mr. Logan discovered footsteps, which appeared to Mr. Owen to belong to some unknown species of reptile, constituting the first indications of the reptilean class known in the carboniferous rocks. Several of the shells and corals of this group have been recognized by Messrs. Murchison and de Verneuil as identical with fossils of the gypsiferous deposits of Perm in Russia, and it had been successively proposed* to refer these gypsiferous beds of Nova Scotia to the Trias, and to the period of the magnesian limestone. That they are more ancient than both these formations, Mr. Lyell infers not only from their fossils, but also from their occupying a lower position than the productive coal-measures of Nova Scotia and Cape Breton. In proof of this inferiority of position three sections are referred to, first, that of the coast of Cumberland, near Minudie, where beds of red sandstone, gypsum and limestone, are seen dipping southwards, or in a direction which would carry them under the productive coal-measures of the South Joggins, which attain a thickness of several miles.

Secondly, the section on the East river of Pictou, where the productive coal-measures of the Albion mines repose on a formation of red sandstone, including beds of limestone, in which Mr. J. Dawson and the author found *Producta martini*, and other fossils common to the gypsiferous rocks of Windsor, &c. Some of these limestones are oolitic like those of Windsor, and gypsum occurs near the East

* See Proceedings, vol. iii. p. 712, and vol. iv. p. 125).

river, fourteen miles south of Pictou, so situated as to lead to the presumption that it is an integral part of the inferior red sandstone groups.

Thirdly, in Cape Breton, according to information supplied by Mr. Richard Brown, the gypsiferous formation occupies a considerable tract, consisting of red marl with gypsum and limestone. In specimens of the latter Mr. Lyell finds the same fossils as those of Windsor, &c. before mentioned. Near Sydney these gypsiferous strata pass *beneath* a formation of sandstone more than 2000 feet thick, upon which rest conformably the coal-measures of Sydney, dipping to the north-east or seaward, and having a thickness of 2000 feet.

To illustrate the gypsiferous formation, the author gives a particular description of the cliffs bordering the Schubenacadie, for a distance of fourteen miles from its mouth, to Fort Ellis, which he examined in company with Mr. J. W. Dawson and Mr. Duncan. The rocks here consist in great part of soft red marls, with subordinate masses of crystalline gypsum and marine limestones, also three large masses of red sandstone, coal-grits and shales. The strike of the beds, like that at Windsor, is nearly east and west, and there are numerous faults and flexures. The principal masses of gypsum do not appear to fill rents, but form regular parts of the stratified series, sometimes alternating with limestone and shale.

The author concludes by describing a newer and unconformable red sandstone, without fossils, which is seen to rest on the edges of the carboniferous strata on the Salmon river, six miles above Truro.

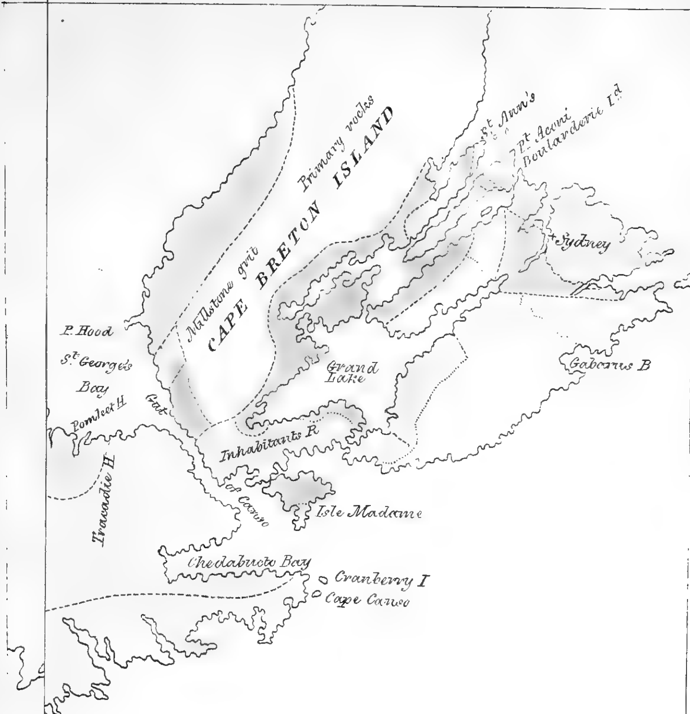
"A Geological Map of Nova Scotia, with an accompanying Memoir," by Abraham Gesner, M.D., F.G.S., was presented to the Society.

The surface of the province of Nova Scotia is for the most part very uneven, much of it being traversed from south-west to north-east by long parallel ridges of rock. The height of the hills seldom exceeds 800 feet. The geology, as represented in Dr. Gesner's map, is as follows:—

1. *Granitic rocks.*—The south-eastern coast of the peninsula presents an almost continual, though narrow band of granite, syenite, and other granitic rocks. A second band of very unequal breadth commences about the middle of the south-west coast of the peninsula, and ends near the course of the Ohio river. A third appears in the isthmus forming the Cobequial mountain, a narrow ridge extending from east to west. The granitic rocks of the province frequently send off dykes and veins into the stratified rocks incumbent on them.

2. *Stratified non-fossiliferous rocks.*—A belt consisting of mica-slate, hornblende slate, chlorite slate, greywacke slate, greywacke and quartz rock, intervenes between the first and second of the above-mentioned granitic bands. It is in the district occupied by these older schistose rocks that the long parallel ridges, running from south-west to north-east, are most clearly exhibited.

3. *Silurian group.*—The stratified non-fossiliferous rocks are suc-



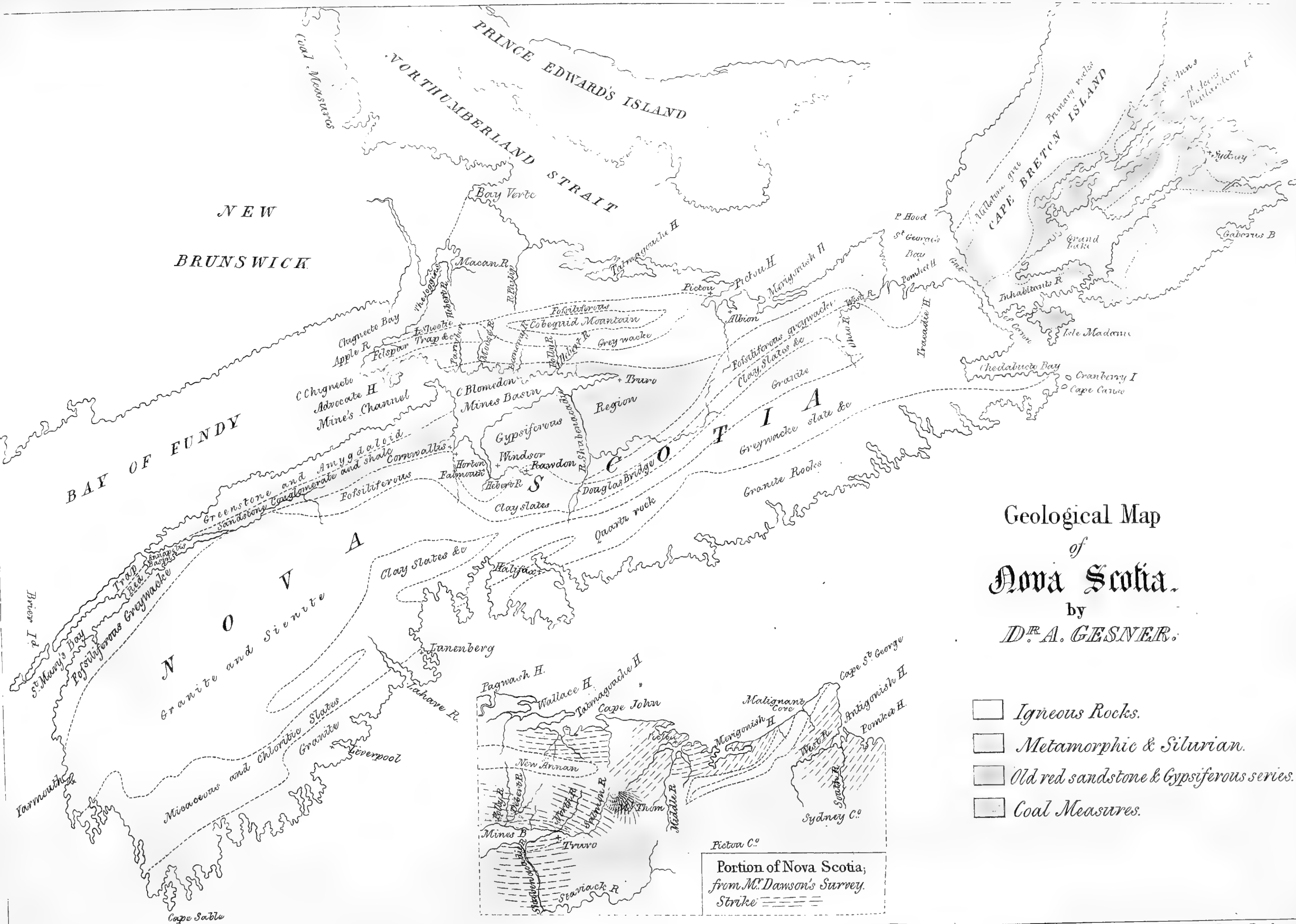
Geological Map

of

Nova Scotia.

by

Dr. A. GESNER.



Printed by Reeve Brothers.

ceeded by stratified fossiliferous clay slate, greywacke, and greywacke slate. Fossils of a Silurian character occur in the latter. The lowermost of these deposits, where they have ceased to afford organic remains, may be regarded as Cambrian. A complete zone of Silurian beds encircles and immediately covers the Cobequial granitic range. The non-fossiliferous slates and the Silurian beds of the province agree in the circumstance, that their strata dip away from the adjacent ridges of granitic rock at angles of high elevation.

4. *Old red sandstone, or Devonian group.*—Above the Silurian beds there occurs, in several parts of the province, a bright red micaceous sandstone or conglomerate, accompanied by thin beds of red shale and marly clay, and in some places containing seams of fibrous gypsum. Hitherto no organic remains have been found in it. At Advocate Harbour and on the Moose River this sandstone is seen lying unconformably beneath the coal-measures. At the latter locality the sandstone dips W. 21°, and the coal-measures dip N.N.E. 60°. It is from a joint consideration of the mineral character of this formation, and its relative position as compared with the coal-measures, that the author has regarded it as the equivalent of the old red sandstone.

5. *Coal-measures.*—Unless the calcareous deposits of the districts of Pictou and Stewiack should be found to belong to the carboniferous limestone of New Brunswick and of Great Britain, the author is not aware that there are any beds in the province which are referrible to that formation. The coal-field which skirts nearly the whole of the northern coast of Nova Scotia, and which occupies the greater part of the isthmus, is a small part of that extensive coal-field of which the remainder is situated in the province of New Brunswick. In Nova Scotia, the commencement of the coal-field towards the east is near Pomket Harbour, between the 45th and 46th parallels of north latitude and the 61st and 62nd meridians of west longitude. Hence it extends along the whole northern coast of the province of Nova Scotia to Bay Verte, where it enters the province of New Brunswick. The area of the coal-field in Nova Scotia is about 2500 square miles, and that of the coal-field in New Brunswick about 7500 square miles, making the total area of the coal-field in the two provinces 10,000 square miles, and in this computation is not included the coal-field of Cape Breton. The above coal-field may therefore be considered as one of the most extensive on the face of the globe, and as of great value to Great Britain and her North American colonies. The strata occupying this extensive area consist

1. Of gray, red and chocolate-coloured sandstones and conglomerates;
2. Of red, blue and black shales;
3. Of shelly limestones;
4. Of clay ironstone;
5. Of coal, of which the bituminous variety occurs throughout the district.

All the strata abound in the remains of the plants that are usually found in the coal-measures.

The coal-measures usually lie in long parallel troughs or in circular basins, towards the bottoms of which troughs or basins the strata dip in opposite directions. The prevailing strike of the strata is from south-west to north-east, which is also that of the more ancient slate rocks of Nova Scotia. The dip of the coal-measures varies from 5° to 45°. Throughout the whole of the coast-line, from Pomket Harbour to Point Miscou, the coal-measures undergo scarcely any fault or dislocation.

From Pictou Harbour, in Northumberland Strait, a belt of coal-measures, about six miles broad, runs in a westerly direction across the isthmus, passing between the southern flank of the Cobequial mountains and the southern coast of the isthmus, along the Basin of Mines, and thence running further westward to Advocate Harbour. The length of this belt is about 100 miles: the strata which compose it rest along the northern margin of the great part of the belt, on the fossiliferous slates of the Cobequial mountain; it is along its southern margin, that at Moose River and Advocate Harbour, the coal strata rest unconformably on old red sandstone. At Moose River the coal-measures contain a thin bed of marine limestone, and like the old red sandstone which they rest upon, thin beds of gypsum. The coal-measures lap round the eastern extremity, and pass along the northern flank of the fossiliferous slates of the Cobequial range; whence they pass nearly due west to Apple River on Chignecto Bay. All the isthmus north of this line consists of coal-measures.

The Nova Scotian or south-eastern coast of Chignecto Bay runs nearly at right angles to the direction of the coal strata, and presents an admirable section of them nearly thirty-five miles in length. Along this length of coast the strata lie in a trough, the base or synclinal point of which is Little Shoolie; and from this point, as you recede further in a north-eastern direction, the strata rise to the north and north-north-west, with an increasing dip. At the Joggins, twelve miles north-east of Little Shoolie, where the blue sandstone is extensively worked for grindstones, the dip is from 25° to 35°. In the opposite direction, as you recede from the base of the trough, the strata rise towards the south, until on approaching the intrusive rocks of Cape Chignecto the inclination is 45°.

In making a careful examination of the entire of this coast of thirty-five miles, only one fault was observed, and that occasioned a dislocation of only a few feet. By measuring the horizontal distances between the strata and making allowance for their inclination at a number of places, the author estimated the total thickness of the coal-measures on this coast at not less than three miles.

The chief part of the workable seams of coal is probably exposed on the Chignecto shore, and it is near the middle of the section that most coal-seams are seen. At the South Joggins, in the above coast-section, in the horizontal distance of three quarters of a mile and in a thickness of strata amounting to 1800 feet, nineteen seams of coal are seen, from six inches to four feet thick. Outcrops of coal have been observed to the south-west of the Joggins, on the Apple River, and to the north-east on the river Hebert; also on the Macan River, where one seam is ten feet thick and of good quality; and also near the river Philip. In the eastern part of the northern coast of the province coal first appears at Pomket; then at Fraser's mountain and at the Albion mines, and other places near Pictou. In the belt of coal-measures which lies south of the Cobequial mountain, two seams of coal have been discovered in the forest, ten miles north of Truro, dipping from that range. Outcrops of coal appear also in the same belt at Jolly River, at Debert River, at Economy River, and at Parr's Borough.

Along the northern coast which borders on Northumberland strait, and along the courses of the rivers which fall into that strait, coal-plants are very abundant. Among these are many large trees which were branching at their tops. The bark is generally converted into coal, and sometimes the whole trunk; and then the woody fibre remains very distinct. Several of these trees are four feet in diameter, and some have been seen six feet in length. Along this coast the trees are all prostrate, whether in the sandstones or shales, and they do not appear to lie more in one direction than another. On the coast of Chignecto Bay fossil trees also abound; and in most places they lie in all positions, parallel to the strata, or across them obliquely. They always increase in number in the proximity of a seam of coal. In one part, however, of the Chignecto coast, called South Joggins, where the nineteen seams of coal already mentioned occur for the space of three-quarters of a mile, and in a thickness of strata amounting to 1800 feet, the fossil trees which occur are all perpendicular to the strata. In tracing these seams of coal along the ravines to the distance of six miles from the coast, trees have been observed in the same vertical position in respect of the strata. The cliffs at this spot are from 80 to 100 feet in height, and consist of grey and reddish sandstone, bituminous blue shale, shelly limestone, clay ironstone and coal. The strata are rapidly degraded, so that at every successive visit which the author has made to the spot during the last ten years, he found that trees which he had originally observed had disappeared, and that others were exposed in their stead. At the last visit he made, which was in July last, in company with Mr. Lyell, seventeen trees were exposed to view, and this number was rather less than he had seen on former occasions. The ordinary length of these trunks is from 10 to 30 feet, but some have been observed that were 50 or even 70 feet long. They vary in diameter from 6 inches to 3 feet; but one was 4 feet 6 inches across. Most frequently their lower extremities are situated in shale; but sometimes they spring from the coal itself, and when that is the case, they never pass through the seam of coal. Sometimes their roots branch out into the shale or sandstone they rest upon.

At the place above referred to, ten miles north of Truro, the strata above and below the coal abound in trunks, branches, and leaves of large fossil trees. The exterior of the trunks is coal; and the interior is usually sandstone and fine clay. In one tree the whole trunk was coal, except a flattened portion resembling the pith and extending through the centre of the tree from one extremity to the other. At the spot on the Moose River, where the coal-measures rest on old red sandstone, a fossil tree 30 inches in diameter is seen in black shale and dark-coloured sandstone.

Besides the coal district already described there is an area near Falmouth and Windsor of seventy square miles, in which though the coal has not been discovered, yet the ferns, *Stigmaria*, and other fossil plants which the sandstones and shales of that area contain, sufficiently establish the point that it belongs to the coal-measures.

6. *New red sandstone.*—At the Jolly and Debert Rivers the coal-measures are overlaid by a red sandstone, associated with gypsum and limestone. In the districts of Windsor, Rawdon, and Douglas, to the south of the Basin of Mines, and in that of Truro on the east of that basin, a bright red micaceous sandstone prevails, alternating with strata of red shale and indurated clay, and containing calcareous, gypseous, and red argillaceous marls. It is characterised by containing thick beds of compact gypsum and limestone, and by its being the seat of salt springs. The author regards it as agreeing in geological position with the sandstone above-mentioned.

7. *Intrusive Igneous Rocks.*—The whole north-west coast of the peninsula next the Bay of Fundy, from Briers' Island to Cape Blow-me-down, is one continuous narrow belt of trap, greenstone, and amygdaloid. This belt is bounded to the south-east in its southern part by St. Mary's Bay, and from the head of that bay to the Basin of Mines, by the old red sandstone formation already described. The trap overlies and pierces the sandstone at several points in its course along the Bay of Fundy. At Cape Blow-me-down it forms a perpendicular cliff 400 feet high, and rests on strata of sandstone.

If the axis of the Cobequial ridge be prolonged towards the west until it meets the head of the Bay of Fundy, that axis, after pursuing the Silurian zone which encircles the Cobequial granite, will enter a trappean ridge composed principally of red felspar and porphyry, about seven miles broad. The western extremity of the axis on the Bay of Fundy is at Cape Chignecto, to the north-east of which lies Chignecto Bay. The trap of Cape Chignecto is of two varieties, the red and the green. The red contains several large veins of sulphate of barytes. Near Shoolie, and at a place called Cranberry Point, a conglomerate appears which consists of masses of trap and of sandstone. It is near Apple River that the coal strata, which extend to the north of this ridge of trap, come in contact with it. The trap forms the axis from which the coal-measures dip away until they become horizontal at Little Shoolie.

May 24.—William Cubitt, Esq., F.R.S., V.P. Inst. C.E., was elected a Fellow of this Society.

A paper was read :—" On the Geology of some points on the West Coast of Africa, and of the Banks of the river Niger." By W. Stanger, M.D., F.G.S.

1. *Sierra Leone.*—The predominant rock is a highly ferruginous

sandstone, not distinctly stratified, rendered vesicular by removal of the iron on exposure to the weather. The iron occurs in concentric laminæ, and is found in masses occasionally powerfully magnetic. Under the sandstone is seen, at several places, a stiff aluminous clay containing fragments of wood. At a section at Kingstown the sandstone is forty feet thick. Hyperstene rock forms the side of the fort-hill and the tops of the hills around Sierra Leone. Neither volcanic nor granitic rocks were observed in the neighbourhood.

2. *Liberia.—Monrovia.*—The rocks in the neighbourhood of the Mesurada river are greenstone. Ferruginous sandstone, similar to that at Sierra Leone, occurs near the government house. The author saw fragments of gneiss, but none *in situ*, and was shown a specimen of large granular granite, said to be found forty miles up the country.

3. *River Sinoo*, lat. 5 N., long. 9 W.—On the south side of the river are small hills of gneiss, cut through in places by veins of granite running in all directions, and in one place by a vein of trap two feet wide, running W.N.W. and E.S.E. The author found greenstone in the neighbourhood passing into hornblende rock, but did not see its connection with the gneiss. The north bank of the river is low land covered with sand, in which was found a fragment of ferruginous sandstone like that at the preceding localities.

4. *Cape Coast Castle.*—The castle stands on a mass of granite, which is small, granular, and contains imbedded masses of hornblende slate. The felspar is flesh-coloured and in many places mixed with the quartz, forming a beautiful variety of graphic granite. About a mile north of the castle mica slate is seen in contact with and dipping under the granite to the south at an angle of 40°. The slate is not altered but much decomposed. Both granite and slate are cut through by veins of quartz; and in the town, a mass of mica slate is seen imbedded in the granite, which sends veins into the slate. In one place a greenstone vein, four yards wide, was seen traversing the granite, itself again traversed by a vein of granite. The mica slate is worn into valleys, and the granite stands up in masses which have been erroneously regarded as erratic blocks.

5. *Accra.*—The town is built on sandstone which dips to the S.E., and has joints running W.S.W. and E.N.E. In mineral character it resembles the new red sandstone of Liverpool. The surface of the country about the Salt Lake, which is to the north of the town and about thirty feet above the level of the sea, is a sandy clay or loam containing great numbers of shells of the genera *Achatina*, *Arca*, *Cytherea* and *Cerithium*. At the farm on the hill, fourteen miles from Danish Accra, the rock is quartz rock, white and red, dipping at 40° to the S.W. and traversed by joints at right angles to the dip. The joints are redder than the general hue of the rock, which the author regards as a metamorphic sandstone.

The gold which is met with at Cape Coast Castle, Anamabre and Accra, is procured from the sand by washing. This sand is usually white, and contains iron and hornblende. The felspar at

Anamabre is green, and in some places between Accra and Cape Coast Castle it is decomposed into a clay containing sparkling particles of mica, which are not unfrequently mistaken for gold.

6. *Grand Sesters.*—The rocks here are gneiss cut through by granite, as at the river Sinoo. The felspar of the granite is opalescent.

7. *Niger.*—The Delta is a flat swampy tract composed of clay, sand, and much vegetable matter, extending to Eboe, a distance of 120 miles from the sea. The banks of the river are elevated only a few feet above its level. From Eboe to Iddah, a distance of 100 miles, there is a gradual rise of the country, but still swampy and similar in constitution to the Delta. At Iddah the first rocks appear. They are 185 feet high (barom. measure) and are composed of sandstone, the strata of which are for the most part horizontal, but occasionally dip at an angle of 3° to the S.E. This sandstone is fine granular, and composed of transparent particles of white quartz. The upper beds are highly ferruginous. The strata are cut through by joints running in all directions. After the most careful search, one fossil only, and that a very obscure one, was met with in the sandstone. It resembled a *Pollicipes*. The cliffs of Iddah are formed by the outcrop of a ridge of hills running N.E. and S.W. From Iddah to Kirree the country is composed of sandstone of the same character, more or less ferruginous in places. The character of the country is that of elevated table lands, edged by cliffs, bordered by debris. At Kirree, strata of mica slate, dipping 85° due west, appear standing up in high masses on the right bank of the river, in which bank, opposite to Kirree, is the Bird rock, composed of a mass of quartz evidently imbedded in the mica slate. The mica slate rests upon the granite composing Mount Soracte and the neighbouring hills, attaining a height not exceeding 1200 feet. Beaufort Island is formed of granite which is decomposed so as to leave the surface very rough, from the projection of felspar crystals. It contains little mica, and is composed of felspar and quartz with a small quantity of hornblende. The soil between the blocks of granite is a rich vegetable loam. The blocks are piled one upon another like masonry. At Okazi the granite is more largely crystalline, and contains very beautiful opalescent felspar. The granite extends to Adda Kudda, and at that place it is mixed up and complicated with gneiss which dips at an angle of 60° to the S. The gneiss contains veins of granite running in all directions. Further on, the granite again contains imbedded masses of gneiss. From Adda Kudda, up the river, as far as was explored, the country is composed of horizontal sandstone, generally more highly ferruginous than lower down. At Mount Stirling the iron occurs in the form of pea-iron ore. The granite appears to be the central axis, mica slate and gneiss occurring on both sides, or dipping at great angles. The granite is the line of the so-called Kong mountains, which in no case were observed higher than 1200 feet. The sandstone lies unconformably upon the mica slate. Dr. Stanger considers the phænomena observed on the Niger to indicate three geological periods:—1st, the eruption of the granite and elevation of mica slate and gneiss; 2nd, the deposition of

the sandstone unconformably on the flanks of the mica slate and granite; and 3rd, the upraising of the whole country, and the cutting through, by water, of the granite, slate and sandstone, and the formation of the Delta by the consequent debris.

"On the Classification of Granitic Rocks." By Robert Wallace, Esq.

Assuming that granite, syenite, and other granitoid rocks, as they exist in nature, agree with the definitions of those rocks respectively given by mineralogists, that is, in being aggregates, though in variable proportions, of certain determinate mineral species; and taking for granted the accuracy of the analyses which have been made, by the chemists in highest repute, of the minerals which enter into the composition of these aggregate rocks, the author directs his attention more particularly to the alkaline and alkalino-earthy ingredients of those minerals; and, inferentially, of the aggregate rocks into the composition of which these minerals enter; and finding that in certain of these aggregates the alkalies exist without any admixture of alkaline earth, whereas in others both alkalies and alkaline earths are contained, he proposes to classify granitoid rocks according to the above distinction in their chemical ingredients.

Among the alkalies, in addition to potash and soda, he places lithia; the alkaline earths which fall under his notice, are magnesia and lime. In subdividing his two principal classes of the aggregate rocks, the author also takes into account the fluoric and boracic acids, which appear to be essential to the constitution of certain of the component minerals.

Ternary granite, consisting either of quartz, binaxal mica and felspar, or of the two former minerals and albite, is the first of the aggregate rocks that comes under the author's consideration. Of binaxal mica the alkaline ingredients are potash and lithia; and one of the essential ingredients of this mineral appears to be also fluoric acid. Of common felspar the alkaline ingredient is potash; of albite*, soda; of glassy felspar, a mixture of potash and soda. Of ternary granite, therefore, the alkaline ingredients are limited to potash, soda, and lithia; the alkaline earths, magnesia and lime, not entering into its constitution.

The different binary combinations of some two of the three minerals, quartz, binaxal mica and felspar, belong to the second division of the author's first class of aggregate rocks; that is to say, of those which contain an alkali, but not an alkaline earth. The binary combinations which he mentions, are—

1. Common felspar and binaxal mica.
2. Compact felspar and binaxal mica, called eurite, whitestone, and felspathic granite.
3. Common felspar and quartz, which may be either an uniform mixture of the two minerals, or may consist of imperfect crystals of

* Albite has been found to contain a very small variable proportion of lime, not exceeding 5 parts in 1000.

one, or the other, or of both of them, and is then called pegmatite, or graphic granite.

4. Quartz and binaxal mica; which, if the mica is regularly interspersed, is called avanturine; but if it occurs in parallel layers, forms a passage into mica-schist.

The second class of the author contains those aggregate rocks, into one or more of the component minerals of which magnesia or lime enters as an essential constituent; and in the first division of this class he places syenite and the other rocks containing some of the ingredients of ternary granite, with the addition of hornblende, on the ground that in all the varieties of the latter mineral a trace has been found of fluoric acid; and in respect of the presence of this acid the rocks of this division are allied to the rocks of the first class.

Hornblende contains neither potash, soda, nor lithia; but it abounds in magnesia and lime.

The principal granitoid rocks into the composition of which hornblende enters, are the following:—

1. An aggregate of quartz, mica, felspar, and hornblende, or syenitic granite.

2. An aggregate of quartz, felspar, and hornblende, or syenite.

3. An aggregate of felspar, mica and hornblende.

4 An aggregate of felspar and hornblende. Quartz and hornblende is only an incidental variety. Actinolite or hypersthene sometimes replaces hornblende, and is sometimes superadded to it. Hornblende is the characteristic mineral of the granitoid rocks of Scotland.

The second division of the second class of the author consists of ternary granite, of which the binaxal mica has been replaced by talc, chlorite, or steatite (which rock has been termed protogine), or by uniaxal mica. The latter aggregate occurs principally among volcanic rocks.

Neither talc, chlorite, nor steatite contain lithia, nor fluoric acid; but the predominant alkalino-earthy ingredient is magnesia. Uniaxal mica contains magnesia, but no lime.

The third division of the author's second class of granitoid rocks, consists of those into the composition of which tourmaline enters, and this is the characteristic mineral of the granitoid rocks of Cornwall. With quartz, felspar and mica it forms the schorly granite; and with quartz and felspar, or with quartz alone, it forms the schist-rock of some mineralogists.

Tourmaline contains nearly equal quantities of silica and alumina; and oxide of iron is an ingredient of most of its varieties. It contains a trace of one or other, or of both of the alkalies, potash and soda, with a small but variable portion of magnesia, and occasionally a trace of lime. Boracic acid is its characteristic ingredient.

The author enters into some theoretical views respecting the origin of the various forms of granitoid rock.

Ternary granite, composed of quartz, felspar (or albite) and binaxal mica, constitutes, according to his view, the lowest accessible rock of the earth's original crust.

It has been uplifted and protruded through sedimentary strata at different periods, from the earliest to the latest age of igneous disturbance. It may have been elevated in a solid state, or in a state of partial or imperfect fusion. It may have changed its original character, either by being heated a second time, and again cooling, under circumstances different from those which attended its first consolidation; or by entering into fresh combinations with the rocks above it, or with those beneath it. The further the rock is removed from the reach of any such influences, the nearer does it approach in character, in respect of its mechanical and chemical structure, to true ternary granite. Even when granite has been so altered as to assume the character of porphyry or trachyte, the original character of the granite out of which those rocks were formed may often be traced in the gneiss with which those rocks are flanked.

The fine-grained varieties of ternary granite, which are often found in veins, have probably been fused a second time. The seat of the binary granites was probably below that of the ternary rock, but higher than that of the granites which contain alkalino-earthy substances. Granite containing other substances than quartz, felspar (or albite) and binaxal mica, has probably been again fused, and has derived the foreign matters intermingled with it, either from the sedimentary rocks through which it has been protruded, or from regions below that of ancient ternary granite. Hence the variations in modern granite are almost as numerous as the localities in which they are found. Thus the granite of Devonshire and Cornwall, which has been uplifted and protruded through all the stratified rocks that were incumbent upon it, not excepting even the culm, was in a fused state in its upper portion when in contact with those stratified rocks; and it probably brought up with it extraneous matters from beneath. Hence the granite of these counties no longer exhibits the characteristics of ancient granite; but in some parts porphyritic granite occurs; the granitic dykes, or elvans, consist mostly of eurite; in other parts we have talcose granite, or protogine, which produces the China clay; and schorly granite is generally found near the contact of that rock with the slates.

The fact that ancient granite sometimes graduates into syenitic granite, renders it probable that the latter is a modification of the former.

The substances which invaded the territories of ancient ternary granite, were probably those which occupied the regions immediately subjacent to it, while those which lay nearer to the earth's centre remained comparatively undisturbed.

In general, the conclusion of the author is, that the absence of mica, or the presence of minerals abounding in magnesia or lime, or that of metallic oxides, or a transition into syenite, porphyry, basalt, or volcanic rocks, are indications of an origin of later date than that of ancient granite.

"Additional note on the Geology of the South-East of Surrey." By R. A. C. Austen, Esq., Sec. G.S.

The subdivisions of the beds below the white chalk have been founded on differences of mineral character or colour, or the accidental presence of certain minerals, such as oxides or silicates of iron, seams of chert or flints, &c.; and though they may hold good and prove very useful in the south-eastern parts of England, they fail when applied to the whole area of the chalk and its subjacent beds, and will be found to interfere with the grouping of the remains of the animals which range through this system. Hence it is there have been so many doubts respecting the positions in the series which the deposits of several localities should occupy; as, for instance, those of Blackdown and Halden in the west of England, and the Speeton clay of Yorkshire.

Again, the subdivisions founded on mineral character, even when they are sufficiently marked to produce distinct physical features over the surface of a district (and which has been much insisted upon by geologists), will often be found to interfere most inconveniently with those derived from a consideration of the included organic remains: thus no contrast can be greater than that between the upper and lower chalk; the latter abounding in huge and varied forms of Ammonites, Scaphites and Turrilites,—which are altogether wanting higher up, where the Cephalopods are represented by one or two species of Belemnite only (passing over the differences which the other classes present); so that seven may nearly represent the number of species common to the two.

In this instance a great change in the conditions of animal life is unaccompanied with any very obvious change in the character of the deposit.

The grey calcareous beds of the lower chalk are underlaid by calcareous sands and bright green siliceous strata, forming a well-defined mineralogical group, and which has been formed into the upper greensand: but subordinate to these are beds of firestone and thick bands of limestone, and in these all the Cephalopods of the lower chalk reappear; so that here a change of some sort, sufficiently great to produce very different deposits, was not attended with any sensible change in the form of animal life.

The topographical arrangement of these several groups in an ascending order is as follows:—

The Neocomian group, or the equivalent of that for which the French and Swiss geologists have adopted that name, is found only within the Wealden denudations, and rests everywhere, in the south-east of England, on the blue Wealden clays, which were the central deposits of that ancient estuary.

The Speeton clay of Phillips has been referred to the gault, because it contains a greater number of species in common with that group than with any other; but the number is very small. Of the species supposed to be peculiar the *Corbula punctum* is generally quoted from the lowest beds of the French cretaceous group; and in addition, M. D'Orbigny has ascertained that the *Hamites pli-*

catilis belongs to the genus *Crioceras*, whilst the *Hamites intermedius* and *beanii* are both species of *Ancyloceras*, a genus which is characteristic of the lowest beds of the cretaceous series. To these we may add *Spatangus retusus*; so that it becomes very probable that the Speeton clay may also be the equivalent of the lowest argillaceous Neocomian strata of the chalk series of the south-east of England.

The lower greensand of the south-east of England, as round the Weald and in the Isle of Wight, rests on the Neocomian group; and it is when so placed that it attains its greatest thickness: it does not extend westward, but thins away beneath the great expanse of chalk of the counties of Hants and Wilts. It reappears a little south of Tetsworth, and increases in thickness in its extension to the north-east through Cambridgeshire. In this part of its course it outspreads the freshwater deposits, and rests unconformably upon subdivisions of the oolitic series.

The gault, though inferior in thickness to some of the other groups, is the best horizontal line by which they may be severally arranged, both on account of the well-defined lines by which it is separated from the groups both above and below it, and also from the peculiar fossils it contains. It occurs round the western district and in the Isle of Wight, immediately above the ferruginous sands. It reappears from beneath the chalk at its escarpment at Shaftsbury, and in the Vale of Wardour, where it has been fully traced out by Dr. Fitton, but cannot be identified beyond there. In the Vale of Wardour, instead of following upon the lower greensand, it occurs upon the marginal beds of the Wealden as well as upon Portland and Kimmeridge strata. As was noticed with respect to the lower greensand, the gault also seems wanting along a considerable interval, but reappears about Tetsworth, and acquires its greatest thickness in Cambridgeshire.

Reliance upon the mineral character of the gault, or rather of one particular portion of it, viz. the argillaceous, has caused it to be overlooked in its extension westward, over the counties of Dorset and Devon. The lower beds of the sands which cap the hills from Lyme to Sidmouth belong to the gault, and the shingle bed, which the author has noticed as occurring in this portion of the gault series, and which may easily be seen in Salcome Hill near Sidmouth, marks its upper limit. The pebbles he believes have been derived from the Portland sands of Dr. Fitton.

The interval along which neither the gault nor lower greensand are to be found is not owing, as is sometimes the case, to the substitution of one set of beds for another, but will be found to correspond exactly with the rise of the older strata from Frome westwards, and which elevation is of earlier date than any portion of the cretaceous series.

Everywhere intermediate between the chalk and the gault is the complex group (the upper greensand) noticed in the preceding page. In its extension west, this group becomes wholly siliceous, and forms the upper portion of the Blackdown range, and the entire thickness of the Halden greensand, and the other deposits to the west.

"Observations on part of the Section of the Lower Greensand, at Atherfield, on the coast of the Isle of Wight." By W. H. Fitton, M.D., &c.

The author having been present during the reading of Mr. Austen's paper "On the South-east of Surrey," on the 5th ultimo, stated verbally his belief that the deposits which that gentleman there proposes to distinguish as the "argillaceous or Neocomian" division of the subcretaceous series, must be the same as that which he himself had described*, as constituting the lowest portion of the lower greensand at Atherfield, in the Isle of Wight: but not having seen the place for more than sixteen years (1826), and at a time when the section was in a great part concealed by masses of ruin, he was desirous of examining it again. This paper contains an account of what he has recently observed there.

The time of the author's late visit to Atherfield was very fortunate. The sea, during severe gales having previously cleared away, not only a great part of the ruin which formerly concealed the base of the cliffs, but having entirely removed the shingle of the beach to a most unusual extent; so that the junction of the Wealden with the lower greensand was distinctly exposed for several hundred yards, while a very large surface of the adjacent strata, washed perfectly clean, was visible at low water, on both sides of it.

§. The strata composing the section thus beautifully exhibited, were the following:—

1. *Weald clay*, with the usual characters; which it is not the object of this paper to describe in detail. The very uppermost beds here consist of slaty clay, and contain some characteristic fossils of the Wealden, especially *Cyclas media*, and small *Paludinæ*; and along with these, at the top of the freshwater strata, were *Cerithia*, probably of a new species, with one or more thin-shelled oysters or *Gryphææ* in comparatively smaller number. These fossils occur within a very few inches from the junction with the sand above the Wealden; so that it would be possible, with care, to obtain portable masses, including both the Weald clay with its characteristic species, and part also of the incumbent mass with its marine shells.

2. *The junction*, which here occupies not more than six or eight inches in vertical thickness, is formed by an alternation or interjection of greenish-grey fine sand among slips or slices of the dark Wealden shale. The lowest portion of the next bed (3) which rests upon this sand includes a large quantity of a kind of gravel, containing numerous fragments of fish-bones.

3. The beds immediately above the sand at the junction (2), consist of a tough, greenish mudlike mass, which becomes grey in drying, and seems to be an intimate mixture of clay and sand. It is not more than from $2\frac{1}{2}$ to 3 feet in thickness; and at the top it is

* Geol. Trans., 2nd Ser. vol. iv. p. 196, &c.

very closely connected with the lower part of the indurated stratum (4): but after exposure even for a short time to the air and sea, the soft matter of (3) is rapidly removed, leaving the firm mass of (4) detached and prominent; and this being undermined, appears upon the shore in rudely quadrangular detached blocks.

The fossils of the lowest clay (3) appear to be the same, though the species are less numerous, with those of (4) above it. The most remarkable amongst them is *Perna Mulleti*. *Mya* and *Panopæa*, probably of more than one species, are especially numerous, even close to the very junction of the Wealden: and with these were *Arca Raulini, Mytilus lanceolatus, Pinna sulcifera, Pecten quinquecostatus*, and *P. striato-costatus* (Goldfuss).

4. The bed of firm, subferruginous and somewhat calciferous stone which next succeeds, formed, when the author first examined this place (in 1826), the most prominent feature of the cliffs: everything beneath, to a depth of about ten feet, being deeply concealed by ruin. It was now distinctly seen that the bottom of this remarkable bed is not more, at the utmost, than three feet from the top of the Wealden. By its greater firmness it contributes to sustain the cliff, the mass of which it traverses obliquely in rising westward; and from the base of the projecting land or point of Atherfield it runs out into the sea, declining very gradually, and forming a dangerous reef called Atherfield ledge. Though its average thickness is not more than $2\frac{1}{2}$ feet, this bed abounds very remarkably in fossil remains, among which are several of the species figured by M. Leymerie in his memoir on the geology of the Aube, and of those found by Mr Austen at Peasemarsh, in Surrey.

Ostrea (new species).
Spatangus (three or more species).
Mya mandibula.
Pholadomya acutisulcata (Leym:).
———— *Prevosti* (Leym:).
Corbula striatula.
Sphæra corrugata.
Thetis minor.
Trigonia dædalea.
——— *Fittoni*.
——— (two new species).
Gervillia aviculoides.
Pinna sulcifera.
Perna Mulleti.
—— *alæformis*.
Pecten quinquecostatus.
——— *striato-costatus*.
——— *obliquus* (*interstriatus* Leym:).
Gryphæa sinuata.
Terebratula sella.
——— (three or more other sp.).
Orbicula lævigata (Deshayes).
Natica (*Ampullaria*) *lævigata* (Leym.).
Pleurotomaria gigantea.
Nautilus radiatus.
Ammonites Deshayesii (Leym:).
———— (four or five species).
with many other genera.

5. Immediately above the stone-bed (4), is a thick mass of nearly uniform clay, with many of the properties of fuller's earth. It is divided apparently into two principal strata, each not less than fifteen feet in thickness: and these seem to be succeeded upwards by other argillaceous beds, which were so much obscured by debris as not to be traceable. The fuller's-earth is either of a lavender-blue or of a drab colour; it contains concretional portions (not seen *in situ*),

almost composed of fossils, including *Thetis minor, Rostellaria bicarinata,* with several small univalves. Other masses, also of uncertain place, occur in the fuller's-earth, containing numerous Crustacean remains, especially of *Astacus,* of more than one species. *Pinna sulcifera* abounds near the bottom of the lower bed, and *Ammonites Deshayesii,* with other *Ammonites,* is frequent.

§. From the preceding lists, it is evident that an accumulation of fossils, very remarkable for their number and variety, exists at Atherfield, in what has hitherto been considered as the bottom of the lower greensand. But while some of these fossils have been found, in England, only at Peasemarsh and at this place, they are here accompanied by others, which have a considerable upward range in the subcretaceous strata.

§. The cliffs on the shore between Atherfield and Rocken End, on the east of which latter place the lower greensand first rises, contain comparatively a much smaller number of fossils than the lowest strata just mentioned. Those which are found here, occur chiefly in concretions, due probably to the presence of the organized remains which they include; but lines of such nodules appear to be distributed at intervals throughout the whole series, as far at least as the middle of the cliff at Blackgang Chine. Of these ranges the following are some of the most prominent,—

a. A conspicuous group, composed of two parallel ranges of nodules, rises on the shore about half a mile east of Atherfield point, and there forms a slight prominence called "the Crackers," (from the sound caused by the sea during rough weather beneath the undermined cliffs). These nodules consist of a rough concretional calcareous rock (like coarse Kentish rag), which includes in great numbers, *Gervillia aviculoides, Thetis minor* in beautiful preservation: a profusion of *Terebratulæ,* especially *T. sella, Ammonites Deshayesii, Trigonia dædalea,* and other fossils;—most of which, it is supposed, occur also in the quarry-stone of Hythe.

b. Exogyra sinuata, with some of the principal varieties of that species figured by M. Leymerie, is of frequent occurrence, both in detached clusters, and in somewhat continuous ranges, throughout the cliffs between Atherfield and Blackgang Chine.

c. Very large and beautiful specimens of *Crioceras* (*Ancyloceras,* D'Orbigny), *Scaphites,* and *Ammonites,* have also been found in the face of the cliffs, or within the Chines, on this part of the shore. Of these, *Crioceras Bowerbankii** was found in Ladder-chine; *Scaphites gigas* loose upon the shore, its precise situation not having been ascertained†.

§. The author points out, as deserving of especial notice, the rapid and remarkable reduction in the proportion of calcareous matter in the lower greensand of the Isle of Wight and of Surrey, when com-

* Sowerby, Geol. Trans. 2nd Series, vol. v.

† Some fine specimens of these large fossils are in the lawn of Capt. Peterson, near Blackgang Chine; in the museum of Mr. A. J. Hambrough, at Steephill Castle; and in the splendid collection of Isle of Wight fossils, deposited by Capt. Ibbetson in the museum of the Polytechnic Institution.

pared with the calciferous district of Kent, from the coast to the west of Maidstone. No continuous beds of limestone occur in the Atherfield section; while the Kentish rag in the quarries at Hythe and Maidstone cannot be far short of a hundred feet in thickness.

§. *Sandown Bay.*—A section corresponding to that of Atherfield, is visible on the east of Sandown Bay, between the fort and the chalk of Culver Cliff. The author had formerly seen there a bed of concretional stone immediately above the Wealden and subjacent to a bed of fuller's earth; and on examining the place recently, in company with the President (Mr. Warburton), the resemblance of the two sections was confirmed, and some of the Atherfield fossils obtained from the Sandown bed. The President has since been there alone, and has been very successful in obtaining from the stony masses exposed at low water, specimens of the most characteristic fossils, especially of *Perna Mulleti*, with some new species of other genera:—*Panopæa, Astarte Beaumontii* (Leymerie), *Gervillia anceps* ?, *Perna Mulleti, Perna alæformis, Sphæra corrugata* ?, *Sphæra* (new sp.?), *Gryphæa sinuata*, &c. Beneath this bed at Sandown Bay, as at Atherfield, is a thin stratum of marine fossiliferous clay.

§. Since the recent examination of the coast at Atherfield, the author has obtained information respecting the corresponding strata in some other places.—

Surrey.—Mr. Murchison, in crossing the section of the lower greensand, exposed by the cuttings on the Dover railway, near Redhills in Surrey, perceived that the junction of the greensand with the Wealden must have been traversed near that place*; and having mentioned this observation to the President and Dr. Buckland, these gentlemen were so fortunate as to detect there several large concretional masses, brought out during the progress of the works, and evidently corresponding in situation with those of Peasemarsh discovered by Mr. Austen. This latter gentleman, with the President and the author, have since visited the place again; and from these united labours a collection has been obtained, including some of the most characteristic of M. Leymerie's Neocomian species, with a few belonging also to the quarry-stone of Hythe.—*Arca Raulini, Panopæa depressa, Pholadomya acutisulcata* (Leymerie), *Pecten obliquus* (*interstriatus*), *Pinna sulcifera, Gervillia aviculoides, Perna Mulleti, P. alæformis, Trigonia dædalea, T. Fittoni, Gryphæa sinuata, Nautilus radiatus.*

Vicinity of Pulborough, Sussex.—Mr. Martin, of Pulborough, has mentioned the occurrence at Stopham brickyard (where the junction with the Wealden was to be expected), of certain fossils, in a bed of clay at the bottom of the lower greensand. A collection of these, which he has recently sent to the author, includes *Arca Raulini, Pholadomya acuticostata, Panopæa plicata, Pleurotomaria gigantea, Ostrea carinata, Nautilus radiatus*, fossil wood with *Gastrochæna*, vertebræ and skin of a *Lamna*.

* The precise spot is on the top of the southern bank of the railway, south-west of a bridge over which a road crosses to Roberts-hole farm, of the Ordnance map.

Hythe, in Kent.—The section of the subcretaceous groups on the coast from Folkstone to Hythe being one of the most complete hitherto discovered, it is a matter of great interest to ascertain the relation of the component strata to those of Atherfield above referred to. The junction, however, of the Wealden with the greensand, so distinctly exposed at Atherfield, is unfortunately concealed at Hythe by *débris* of unknown depth, and everywhere covered with vegetation*.

The only intimation hitherto received by the author of the existence of any lower stratum containing fossils differing from those of the Hythe quarries, has come from Mr. Hills, now curator of the Institution at Chichester, who has long been possessed of specimens found near Court-at-street, his former abode in Kent, in a "*blue sandy clay below the bottom of the quarry stone.*" Amongst these are a large *Ostrea*, or *Hinnites*, like a species found at Atherfield, and *Pholadomya acuticostata* (of Leymerie).

Under these circumstances it became a question of great interest to determine the nature of the unknown interval at Hythe; and on going to the place with that object, the author found that Mr. Simms, who conducted the works upon the South Eastern Railway, especially the tunnel at Saltwood, had been for some time engaged in borings and measurements, with a view to a complete section of the country through which the railway and tunnel had passed. Mr. Simms was induced to extend his operations to the bottom of the subcretaceous groups; and finally determined on sinking a shaft from the bottom of the deepest quarry, continuously down to the Weald clay, for the purpose of obtaining a more satisfactory view of the fossils of the lowest beds. This undertaking was in progress when the present paper was read, and the results will be laid before the Society.

§. From the facts above stated, it is evident that the deposit of Atherfield, in the Isle of Wight, like that which contains the fossils of Peasemarsh enumerated by Mr. Austen, belongs to the lower greensand:—both being unequivocally superior to the Wealden clay.

* The nearest point to the stone quarries, where the author had seen the Wealden beds (in 1823), is thus mentioned in Geol. Trans., 2nd Series, vol. iv. p. 124.—'The shore beneath the town consists of soft bluish clay, 'which has the character of river mud, and differs much from the uniform 'slaty clay of the Wealden. But the latter (Weald clay) has been cut 'into in sinking wells above the main street of Hythe, which in some in-'stances have gone to the depth of seventy-five feet, entirely in clay. In 'one of these wells the succession was thus:— beginning at a point about 'sixty feet beneath the bottom of the lower greensand.

'1. Soil .... 2 ft. 6 in.	
'2. Reddish tough clay	6 to 7 ft.
'3. Greenish sandy clay in thin beds, alternately of dark and lighter hues	5 to 6
'4. Blue, uniform, slaty clay, containing *Cypris* about a foot from the top	&c.
'5. A band composed of argillaceous iron ore, abounding in *Paludina elongata* and *Cypris*	

If, therefore, these fossils are characteristic of the *Terrain Neocomien*, the hypothesis which supposes that formation to be contemporaneous with the Wealden can no longer be maintained.

The author, however, is far from denying that *a marine equivalent* of the Wealden may exist*. But whenever such an equivalent shall be discovered,—since it must be distinct from the Lower greensand and the Neocomian,—he thinks it ought to be regarded as a new deposit, and to receive a peculiar name.

The paper was illustrated by a section and a sketch of the coast near Atherfield; and it concludes with an expression of acknowledgement to Mr. Austen, for the new impulse which his inquiries have given to the study of the subcretaceous series in England.

June 7.—George Tate, Esq. of Alnwick, and Nicholas Wood, Esq., of Killingworth, Newcastle-on-Tyne, were elected Fellows of this Society.

A note was read from W. C. Trevelyan, Esq., F.G.S., "On scratched surfaces of rocks near Mount Parnassus."

On the way from Megara to Corinth the road descends to the border of the sea at a part named, on account of its badness, *κακι σκαλα* (the ancient Scironian rocks). It then runs along the base of the cliffs where the limestone bed is nearly vertical; and for above 200 feet in length and about 50 in height, wherever it is protected from the weather, it is highly polished and scratched, several of the scratches extending for several feet, so as to be nearly parallel with each other and vertical. Where they are not weatherworn, Mr. Trevelyan compares their aspect with those on the polished limestone of the Jura near Neufchatel, which they also resemble in texture and colour. Not having succeeded in detecting glacial phænomena at much higher elevations on Mount Parnassus, Mr. Trevelyan considered, that in this latitude, and at such a low level, the scratches could not be attributed to that cause or to floating ice. Having found a portion of rock apparently in its original situation in contact with the polished surface, he was led to conclude that this was a case of "slickenside," perhaps the effects of an earthquake; and that the scratches may have been produced by particles of sand or chert between the two surfaces when they were put in motion.

The only place in Greece where the author observed apparent marks of glacial action was at the opening of a gorge on the south-east flank of Mount Parnassus, above the town of Daulia (the ancient Daulis), where there are extensive mounds of gravel, debris and boulders, evidently derived from the upper part of the gorge, and resembling in form both longitudinal and transverse moraines, and including occasionally small lakes or pools. Not finding however any evidence of glaciers, Mr. Trevelyan concluded that the cause might be found in storms, melting of snow and avalanches, of which numerous recent evidences were seen in the neighbourhood.

* See Geol. Trans., 2nd Series, vol. iv. p. 396.

"On Ichthyopatolites, or petrified trackwings of ambulatory fishes upon sandstone of the Coal formation." By the Rev. W. Buckland, D.D., F.G.S.

These impressions were discovered by Miss Potts of Chester, on a flagstone near the shaft of a coal-pit at Mostyn in Flintshire, and were communicated by her to Dr. Buckland, with a remark on the novelty of footsteps in any stratum older than the new red sandstone. As they present no trace of any true foot to which long claws may have been attached, Dr. Buckland rejects the notion of their having been made by a reptile. They consist of curvilinear scratches disposed symmetrically at regular intervals on each side of a level space, about two inches wide, which in his opinion may represent the body of a fish, to the pectoral rays of which animal he attributes the scratches. They follow one another in nearly equidistant rows of three scratches in a row, and at intervals of about two inches from the point of each individual scratch to the points of those next succeeding and preceding it. They are all slightly convex outwards, three on each side of the median space, or supposed place of the body of the fish. Each external scratch is about one inch and a half in length; the inner ones are about half an inch, and the middle one about an inch long. These proportions are pretty constant through a series of eight successive rows of triple impressions on the slab from the Mostyn coal-pit. The impressions of the right and left fin-ray are not quite symmetrically opposed to each other on a straight line of progression; but the path of the animal appears to have been curvilinear, trending towards the right: each impression or scratch is deepest on its supposed frontal side, and becomes more shallow gradually backwards. All these conditions seem to agree with the hypothesis of their having been made by three bony processes projecting from the anterior rays of the pectoral fin of a fish. They are not consistent with conditions that would have accompanied the impressions of claws proceeding from the feet of any reptile.

Dr. Buckland refers to the structure of existing Siluroid and Lophoid fishes, and of the climbing perch (*Anabas scandens*), and Hassar (*Doras costata*), as bearing him out in the conclusions he has come to regarding those markings. He also refers to the observations of Prof. Deslonchamps, on the ambulatory movements under water of the common Gurnard, as confirmatory of his views. He has been informed of a slab of coal sandstone bearing similar markings in the museum of Sheffield; and remarks, that there are several fossil fishes of the carboniferous system approximating the characters of Gurnards, and capable of making such markings as those described.

"Observations on certain Fossiliferous beds in Southern India." By C. T. Kaye, Esq., F.G.S., of the Madras Civil Service.

The beds described in this paper are found at three localities; viz. Pondicherry, Verdachellum and Trinchinopoly.

1. *Pondicherry.*—This town, like Madras, is situated on a very recent formation of loose sand, which extends for a considerable distance along the eastern coast of India, and which in many places

contains marine shells in such abundance that they are dug up and burnt for lime. They are all species which now inhabit the Indian seas, such as *Pyrula vespertilio*, *Purpura carinifera*, *Cardita antiquata*, *Arca granosa* and *Arca rhombea*. The sand is usually bounded by granite, which appears at the surface at Sadras, Madras and other places. Immediately beyond the town of Pondicherry, however, the recent beds rest upon some low hills of red sandstone. A bed of limestone containing numerous fossils succeeds, and at the distance of four miles due west the red sandstone is again met with and there abounds with silicified wood. At about sixteen miles from the sea the sandstone is bounded by hills of black granite.

The surface of the country does not offer any section exhibiting the relative positions of the limestone and sandstone. In the former, numerous fossils in a high state of preservation were discovered by Mr. Kaye, including species of *Baculites*, *Ammonites*, *Nautilus*, *Hamites*, *Ptychoceras*, *Ancyloceras*, *Voluta*, *Cypræa*, *Conus*, *Tornatella*, *Rostellaria*, *Pyrula*, *Aporrhais*, *Trochus*, *Solarium*, *Natica*, *Eulima*, *Scalaria*, *Cerithium*, *Turritella*, *Dentalium*, and *Calyptræa*; *Ostrea*, *Exogyra*, *Spondylus*, *Pecten*, *Trigonia*, *Mytilus*, *Pinna*, *Arca*, *Pectunculus*, *Nucula*, *Cardium*, *Isocardia*, *Anatina*, *Cytheræa*, *Solen*, *Pholadomya*, *Clavagella*, *Lutraria* and *Terebratula*. Also some fishes' teeth, *Echinodermata* and corals, accompanied by wood (calcareous) bored by *Teredo*.

The fossil wood found in the sandstone exhibits no traces of worm-borings, and occurs in the form of trees denuded of their barks, some of them as long as 100 feet, and all apparently *Coniferæ*.

2. Six miles from *Verdachellum* in Southern Arcot, about forty miles from the coast and fifty from Pondicherry, the valley of the river is formed of a limestone which underlies the sandstone and contains marine fossils, including species of *Ammonites*, *Nautilus*, *Melanopsis* ?, *Pleurotomaria*, *Natica*, *Pecten*, *Arca*, *Artemis*, *Modiola*, *Exogyra*, *Lima*, *Cardita*, *Cardium*, *Lutraria* and *Terebratula*.

3. *Trinchinopoly*.—In this district, at about thirty miles from the town of the same name, one hundred from Pondicherry, and sixty from the sea, is a limestone formation which Mr. Kaye was unable to visit in person, but from which he procured a quantity of fossils belonging to twenty-seven species of various genera, including *Natica*, *Turritella*, *Triton*, *Fusus*, *Pyrula*, *Voluta*, *Melanopsis* ? (same species as at Verdachellum), *Aporrhais*, *Strombus*, *Mactra*, *Psammobia*, *Arca*, *Pecten*, *Ostrea*, *Cytheræa* and *Cardium*. A fragment of an Ammonite accompanied them.

None of the species appear to be common to the three deposits. Three species are common to Trinchinopoly and Verdachellum. From the latter locality there are 28 species of mollusca identical with lower greensand fossils found in Britain. A single species appears to be identical with one of those from Pondicherry; but none of the testacea from the last mentioned locality agree with those from Trichinopoly. The greater part of those from Pondicherry appear to be undescribed forms. Accompanying the very remarkable assemblage of molluscan genera at the latter locality was a single vertebra of a Saurian, which Professor Owen regards as most nearly resembling that of *Mososaurus*.

Mr. Kaye presented to the Society a series of the fossils from the several beds, all in the most beautiful state of preservation.

A paper was read, entitled "Account of a Section of the Strata between the Chalk and the Wealden Clay in the vicinity of Hythe, Kent." By F. W. Simms, Esq., F.G.S.

The section here described begins on the top of Tolsford Hill, the summit of the chalk escarpment, about 600 feet above the sea at low water, and about two miles immediately north of Hythe. It strikes nearly due south, passing very near to Saltwood Castle, and close to the church at Hythe, and reaches the sea beyond the low ground on the south of that town. This line cuts the strata, which successively rise towards the south from beneath the chalk, nearly at right angles.

The author, in directing the works of the South-Eastern (Dover) Railway, had caused borings to be made, with a view to the construction of one of the principal tunnels on the main line of road, at Saltwood. He afterwards extended his researches upward, for the purpose of illustrating the stratification; and ultimately sank a shaft, from the bottom of the quarries at Hythe, down to the Weald clay. The account of these operations is illustrated by large sectional drawings, without the aid of which it is difficult to convey a distinct notion of them; but the following summary includes some of the most important results.

§ The division of the subcretaceous series adopted by the author is that proposed in the Geol. Trans., 2nd ser. vol. iv. pp. 105–115; and his object was to ascertain the thickness, inclination, and general character of the successive groups, in a descending order. He found, however, unexpected difficulty in tracing the different strata to their outcrop, from the interference of ruins fallen from above, and still remaining even on the faces of the escarpments. Thus the top of the Gault was obscured by a mass of subsided chalk, which, if the measure had been taken on the surface, would have caused an error in the thickness of more than 44 feet; the upper division of the lower greensand would have given 41 feet in excess; the middle bed would have been *diminished* by nearly the same amount; "and the whole of the clay beds between the quarry-rock and the Wealden would altogether have escaped notice, as they are covered by the ruins of the superior beds, and their existence was until now unknown." The author therefore could not attain his purpose without having recourse to boring and levelling; the mode of conducting which processes, and the calculations connected with them, he has explained.

1. The *upper greensand* was found to be entirely wanting on the principal line of the section, the only trace of it being some grains of sand mixed with chalk-marl over the gault. A second boring, about half a mile eastward of the principal line, gave the same negative result; but at Folkstone Cliff, six miles distant, there is, in a corresponding place, a true greensand, 15 feet thick, indurated

to the condition of stone, with much pyrites, and passing gradually upwards into the chalk-marl through a thickness of 17 feet more. The junction between the upper greensand and the top of the gault below is decided and abrupt.

2. The borings through the *Gault*, at its lower part, were unattended with difficulty, and the limit between it and the lower greensand was very well defined.

3. *Lower greensand.—a.* The uppermost division of this group, rising and running out beyond the bottom of gault, disclosed a surface inclined at the same angle, and continuous with that beneath the clay, which appeared to have been removed by denudation. The beds of this upper division are enumerated in detail, and the places of some of the fossils specified.

b. The Saltwood tunnel being driven directly through the upper part of the *middle division* of the lower greensand, this portion of the series became an object of great interest to the author, and is fully described. In one boring, after ten feet of somewhat sandy yellow clay, came a very dark green, tough and adhesive mass, almost black when first brought to the surface, and containing very little sand. This, which the author calls clay, he considers as the chief characteristic of the middle division. At a depth of 53 feet sand was mixed with it; and at 56 feet a "rock" of limestone was reached, which the author regards as commencing the next lower division of this group.

c. The thickness of the third (or "quarry-stone") division of the lower greensand was ascertained by combining the results of several different borings. At this period the author was induced, by a communication with Dr. Fitton, to change the boring for a shaft, in order to bring up more extensively, and to preserve, the fossils of the unknown strata between the quarries and the Weald clay. This shaft was 5 feet by 4 in dimensions, and it was found necessary to support it throughout with timber. The strata thus cut through may be considered, in a general view, as consisting of clay, which was found to be 49 ft. 6 in. thick: and the bottom of this clay was separated from the uppermost beds of the Wealden, containing the usual freshwater fossils, by a layer of soft sand only one inch in thickness.

§ The measures of the several groups between the chalk and the Weald clay, thus ultimately obtained, were as follows; the general dip being due north, at an angle of about 1° 19′.

	ft. in.	ft. in.	ft. in.
Upper greensand;—on the principal line of section, wanting.			
[At Folkstone cliff			15 0
Gault			126 0
Lower greensand:—			
Upper division		70 0	
Middle division		158 0	
Quarry-stone, &c.			
Sand above the quarries	67 0		
Quarry "rock"	48 0	178 6	406 6
Sand and stone previously concealed	14 0		
Clay beneath the sand and stone	49 6		
Total thickness from the chalk to the Wealden			547 6

§. The lowest sand and stone, occupying 14 feet beneath the quarry-"rock", are stated by the author to contain the same fossils as the calcareous beds above.

The clay beneath the sand and stone appeared to consist of two principal portions:—the upper, about 34 ft. 6 in. thick, composed chiefly of a sandy greenish-grey clay, which in some places had the properties of fuller's earth; in this were two thin beds of brown sandy clay, and of clay indurated to the condition of soft stone.

The lower part of the clay, about 10 ft. 6 in. thick, was greenish-brown, apparently containing more fuller's earth, and becoming darker and more argillaceous as it descended; at 2 ft. 6 in. from the top of this division was a bed, more marly than fuller's earth, and two feet thick, which contained a greater number of fossils.

§. The fossils from this clay, which had been placed apart, and numbered during the sinking, occurred in the following order, beginning at the top:—

ft. in.		ft. in.	
0 0	to	25 6.	*Plicatula, Pecten obliquus* (*interstriatus*), *Pholadomya*, n.s.?, *Arca Raulini, Terebratula, Pleurotomaria gigantea.*
31 6	to	34 6.	*Plicatula, Arca Raulini, Pholadomya acuticostata*?, *Perna Mulleti.*
37 0	to	39 0.	*Corbula*, and *Pinna*, numerous; with a *Mytilus.*
39 0	to	49 6,—the bottom of this clay.	*Corbula, Lima*, two species; *Nucula, Pinna, Teredo, Cypricardia*?, *Venus*?, *Ammonites Deshayesii*?,

Beneath was the Wealden clay, with *Cyclas*, small *Ostrea* and *Paludina*.

§. Subjoined to the principal section, are sectional drawings of the Saltwood tunnel, and of a trial shaft sunk near it, illustrating particularly the junction of the upper and middle groups of the lower greensand. The summit of the tunnel is a few feet above the top of the middle group, and there was a constant discharge of water along the line junction, in such quantity as to cause great difficulty in its construction. This middle division, near its upper part, afforded some fine specimens of fossils, chiefly in ferruginous concretions, among which is *Nautilus radiatus*, with fossil coniferous wood eroded by a *Gastrochæna*. Another remarkable product was a new and beautiful fossil resin, found about 10 feet below the junction above-mentioned. A statement of a chemical examination of this substance by Mr. Edward Solly is here given in full: it partakes of the properties of amber and of retin-asphalt, and is principally marked by its clear red colour, its infusibility, and the difficulty with which it is acted upon by many chemical solvents.

"Comparative remarks on the Lower Greensand of Kent and the Isle of Wight." By Wm. Henry Fitton, M.D., &c.

§. The author having, since the last meeting of the Society, seen the result of the operations at Hythe described by Mr. Simms in the preceding paper,—and subsequently examined one of the principal quarries at Maidstone, belonging to Mr. Bensted, here mentions, on the authority of the latter gentleman, some facts which indicate a resemblance between the lower part of the section there and at Hythe.

In sinking a well about six years ago (1837), at *Barming Heath*, on the south-west of Maidstone, Mr. Bensted found the whole thickness of the stone and hassock (after passing through about 20 feet of loose stone and red clay), to be about. . . . . 130 feet.
Immediately below was dark greensand, including a *Venus*, *Gervillia*, *Ammonites*, and other fossils, about 10 feet. . . . . . Total 140 feet.
And finally clay, "*not that of the Wealden*," about. . . . . 30 feet. at which depth the sinking was discontinued.
Mr. Simms's section gives for the total thickness of the calcareous quarry-stone and hassock, at *Hythe*, 115 feet; beneath is sand and stone, supposed to belong to the calcareous group, 14 feet. Total 129 feet.
And then, down to the Wealden, a succession of clays which include peculiar marine fossils, amounting to 49 feet 6 inches; exceeding the thickness of the clay sunk into beneath the quarry-stone at Barming Heath by about 30 feet.

The sinking therefore near Maidstone accords, so far as it goes, with that of Hythe, in exhibiting a considerable thickness of marine clay between the quarry-stone and the Wealden.

§. The author remarked, in passing from the railway at Paddock Wood to Maidstone, through Nettlestead and Wateringbury, that a tract of very irregular heights projects beyond the line which he had coloured as greensand; and extends from East Peckham towards Lodington, in some places to more than a mile beyond what seems to be the plateau of the Kentish rag. Mr. Bensted has since informed him that, near Wateringbury, a bank of blue clay crops out, above the Wealden and below the greensand. This region therefore offers a point for inquiry; and there is great probability of its affording sections of this lower clay.

§. An examination of the fossils, and of the substances which include them, brought up from the shaft sunk by Mr. Simms beneath the lowest stone-beds at Hythe, leaves no doubt of the very strong resemblance of this part of the Kentish series, to that which has been described at Atherfield in the Isle of Wight. The principal difference between the lowest clay at the two places, consists in the absence, at Hythe, of any bed of stone, like that at the bottom of the Atherfield section, which abounds so very remarkably in fossils.

§. Although the section of the lower greensand on the Kentish coast is more full and complete than that between Blackgang Chine and Atherfield, the latter has the great advantage of being perfectly disclosed and continuous, from the top to the bottom, so that the whole succession can be readily examined in detail: while it is evident, from the perfect conformity of the beds and their general consistency of character, that their deposition was not only uninterrupted by stratigraphical disturbance, but probably unaccompanied by any great change in the conditions of the fluid by which they were deposited.

§. The absence, in the Isle of Wight, of limestone resembling that of the Kentish quarries, which is the chief point of contrast between the sections there and in Kent, is deserving of great attention. The *rag*, though very unequally distributed (as is not unusual with beds which have so much of a concretional character), extends without material interruption from the Kentish coast to the neighbourhood of Godstone; its greatest expansion being at Maidstone, where the thickness exceeds 120 feet; while Mr. Simms's section proves that the Hythe quarries are nearly of equal thickness. The decrease, therefore, in the proportion of calcareous matter, in receding from what may be called this central region of the limestone,—either inland, through Surrey and Hampshire, or westward, by the coast of Sussex to the Isle of Wight and Dorsetshire, is very rapid; and is the more deserving of notice in the Isle of Wight, as the total thickness of the lower greensand (both near Shanklin, on the east, and westward from Blackgang Chine to Atherfield), cannot be *less* than 400 feet,—the thickness of the groups below the gault at Hythe, according to Mr. Simms.

This reduction of the calcareous matter between Maidstone and Surrey is the more remarkable, as the sands throughout that interval are absolutely continuous: the distance from Maidstone to Redhills, where there is no appearance of limestone, being only 30 miles; that between the central limestone at Hythe and Atherfield being about 115 miles. The equivalent of these calcareous beds must be sought for in Surrey and Hampshire, in those ranges of concretional stone which are there distributed irregularly, but in a somewhat stratigraphical arrangement, through the lower greensand; as in the "Bargate stone;" the chert of Leith Hill, &c.; and generally, the sands of all that region ought to be examined attentively, with a view to their comparison with the cliffs between Blackgang Chine and Atherfield.

§. The separation of the lower greensand from the other subcretaceous groups, was founded on its obvious stratigraphical distinction, from the Gault on the one hand, and from the subjacent Wealden on the other: and the subdivisions were derived, from the prominence of certain natural features of the surface, evidently corresponding to the composition and succession of the strata. The expediency of these subdivisions in the coast section at Hythe appears to be confirmed by Mr. Simms's survey; his section, when reduced to the natural scale of height and distance, showing that the features of the country agree with the division of the strata between the gault and the bottom of the calcareous beds into three groups: and if the clay newly discovered beneath the quarries be added to the series, it will form another subdivision, accordant with the principle of arrangement above mentioned. The chief question remaining with respect to this lowest group of marine clay is, whether it will be necessary to detach it altogether from the other divisions of the lower greensand; and this cannot be decided without a deliberate review of the subcretaceous fossils,—and of the strata which afford them.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY OF LONDON.

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June 21.—The following papers were read:—

1. "Supplement to a Memoir on the Fossil species of *Chimæra*." By Sir P. Grey Egerton, M.P., F.G.S.

Since the author's former memoir was communicated to the Society, he has seen in the coll. ction of Mr. Dixon a new and striking addition to the genus *Ischyodus*. The specimen is from the chalk of Southeram, and presents two dental plates only slightly dislocated from their natural juxtaposition. At first sight these would appear to be the dental armature of the lower jaw, corresponding nearly in size to the lower mandibles of *Ischyodus mantelli*. A closer examination has satisfied Sir Philip Egerton that they are in reality the intermaxillary plates of the upper jaw of a most gigantic chimæroid. They exceed in size the corresponding teeth of *Ischyodus townshendi*, the largest species hitherto found by one third. As compared with the intermaxillaries of that species they are broader, more compressed and less robust in antero-posterior diameter, and less hooked at the extremity. The form of the cutting edge is not truncate, as in the recent *Chimæra*, but prolonged to an acute angle, and bent downwards like the upper mandible of a bird of prey, The symphysis is smooth and slightly hollowed. The thin polished investing laminæ of compact dentine is seen adhering to the surface of the tooth. On the interior surface this is marked with broad transverse irregularities similar to, although less distinct than, those seen in the recent *Chimæra*. A fragment in Mr. Dixon's collection gives evidence of having belonged to an individual of much larger size than that which furnished the specimens here described. Sir Philip Egerton proposes to name this species *Ischyodus gigas*.

2. "On the occurrence of the remains of Insects in the Upper Lias of the county of Gloucester." By James Buckman, F.G.S.

The remains described in this paper were discovered by Mr. Buckman in a thin seam of argillaceous limestone in the upper lias beds at Dumbleton, a village twelve miles from Cheltenham, to which his attention had been directed by Mr. Brodie, who had suspected the existence of insect remains in the stratum. The section of Dumbleton Hill, which is a liassic outlier, presents the following beds.

		ft. in.
1.	Sandy debris from the oolite, about	10 0
2.	Upper lias shale: this is traversed at twelve feet from its base by the thin bed of fissile limestone five inches in thickness	60 0
3.	Lias marlstone, about	20 0
		90 0

The thin seam of limestone included in No. 2 is remarkable for containing many organic remains not found in any other part of the lias, and most of them new, comprising land as well as marine animals and traces of plants. Among them are two undetermined species of fish with numerous fish-scales and coprolites, two species of Crustacea, the one allied to *Astacus* (Fabr.), the other to *Hippolyte* (Leach). A species of Loligo, a new Belemnite, a new Ammonite (which Mr. Buckman has named *A. murleyi*), *A. corrugatus* and *ovatus*, a small univalve in great abundance, and *Inoceramus dubius*. The remains of insects comprise one species of *Libellula*, which, from the reticulations of the fine wings, seems to belong to the genus *Æschna*, Fabr., and has been named by Mr. Buckman *Æ. brodiei*, in honour of Mr. Brodie; two species of Coleoptera of undetermined genera, and a wing supposed to belong to *Tipula*. None of these are of the same species with the insects found by Mr. Brodie in the lower lias.

From the presence of a similar band of stone with that containing the above mentioned fossils at Churchdown and Robin Hood Hill, liassic outliers presenting the same section as that of Dumbleton Hill, Mr. Buckman supposes that this thin seam is of constant occurrence in the upper lias of the neighbourhood. He concludes that the period, which the state of things which produced it continued, was not of long duration, and that its deposition was of a quiescent kind.

3. "Outline of Geological Structure of North Wales." By the Rev. A. Sedgwick, F.G.S.

§ 1. *Introduction.*

The author here describes in considerable detail the geographical limits of the country under notice. For the structure of the Isle of Anglesea he refers to a paper by Prof. Henslow, published in the Cambridge Transactions. The carboniferous series of Denbighshire and Flintshire is passed over with a slight notice, and without any detailed sections. His chief details are confined to the counties of Denbigh, Carnarvon, Merioneth, and Montgomery; and the southern limits of his survey is defined by an irregular line drawn from the Severn, near Welch Pool, to the coast near Aberystwith. The southern boundary is purely arbitrary, marking only the limits of his survey, and not any physical separation of the older rocks, which are continued in great undulations through all the higher parts of North and South Wales. He then describes the several connected traverses by which he was led to the general views now laid before the Society; and to the modifications his views have undergone in consequence of traverses made by him in 1834 and 1842 along the line of the Holyhead road, and from that line to the mountain limestone ridges of Denbighshire and Flintshire.

As a general conclusion from these details, he states that the older stratified rocks (including all the formations of the region inferior to the mountain limestone) may be separated into three great physical groups or primary divisions.

(1.) Chlorite and mica slate, &c., occupying the south-west coast of Carnarvonshire, and a considerable portion of the Isle of Anglesea.

(2.) Greywacke, roofing-slate, &c. (alternating with masses and beds of contemporaneous plutonic rocks), spread out from the Menai to the edge of Shropshire, occupying all the high ridges of Carnarvonshire and Merionethshire; to the south blending themselves with the system of South Wales; and to the north nearly bounded by the line of the great Holyhead road.

(3.) A great overlying (and sometimes unconformable) deposit of flagstone, slate, &c. (Upper Silurian), extending through the hills north of the Holyhead road, and overlaid by the mountain limestone.

These three primary divisions the author represents by three colours on a geological map; and the same system of colouring may be extended through all the older formations of South Wales. The middle group is however of enormous thickness, and may hereafter be further subdivided. Its lower part contains no fossils, and in its upper part they abound; but between its upper and lower parts there is no true physical separation, and the fossils seem gradually to disappear in the descending sections. He could indeed represent the fossiliferous and non-fossiliferous slates of Carnarvonshire by two colours; but in extending these colours through other counties of North Wales, he would be compelled, in the present state of his information, to adopt arbitrary, and perhaps inconsistent, lines of demarcation. Hence he has been induced, for the present, to adopt a more simple system of colouring than he at first attempted.

§ 2. *Physical structure of the county under notice.—Strike and undulations of the strata.—Structure and relations of the three great divisions, &c.*

South Carnarvonshire.—Carnarvonshire is divided into two physical regions,—one to the south-west and the other to the north-east of the road from Carnarvon through Llanllyfni to Tremadoc. In the south-western country, the coast, from Porthdinlleyn to the end of the great promontory, and to Bardsea Island, is composed of chlorite and mica slate. It forms a band on the average not two miles in breadth, but it is evidently the prolongation of a formation which is widely expanded in the Isle of Anglesea. At its north end it is associated with a mass of brecciated serpentine (like that subordinate to the same rocks in Anglesea), and it is here and there penetrated by veins of calcareous spar, sometimes so abundant as to replace the ordinary rock, which in such cases passes into great irregular masses of white crystalline limestone. Near its north end it is cut through by five or six nearly transverse vertical dykes of augitic trap of a later formation.

The other parts of the promontory are composed of greywacke, (sometimes passing into a coarse arenaceous rock), and greywacke slate, often of a dark colour and rather earthy structure; and these rocks are pierced and broken through by many great bosses of syenite (represented on a geological map), which rise into hills of remarkable and irregular outline. That the syenites are posterior to the slates the author shows by the evidence of sections: but the slates are little altered, except near the places of contact. Their prevailing strike is nearly parallel to the mean direction of the promontory (about north-east). Near the bosses of syenite these beds are sometimes almost vertical, and they contain one or two bands of organic remains, the most remarkable of which are found in a vertical ridge of coarse greywacke near Bodean*.

In the promontory near St. Tudwal's Island the rocks are thrown into low undulations, are traversed by mineral veins, and intersected by one or two trap dykes.

The author here notices five or six dykes of augitic trap which cross to the west side of the Menai near Bangor. They appear like great ribs locking together the mineral systems of Anglesea and Carnarvonshire. Similar dykes appear in three or four places in the higher parts of the Carnarvon chain; and all dykes of augitic trap above noticed are considered of nearly the same epoch, and of a later date than the mountain limestone and new red sandstone of the Menai Straits.

Near the line of road above mentioned the country is at a low level, and much concealed by drifted matter; it is however marked here and there by erupted masses of felstone porphyry, which in one or two places are finely columnar†. Near this line are some enormous faults which have thrown the south end of the Carnarvon chain about 2000 feet above the level of the road. Near Tremadoc the continuation of the same lines of fault have torn mountain masses of rock from the end of the chain, and placed their beds nearly at right angles to the beds of the great chain. The enormous dislocations are traced through Merionethshire beyond the mouth of the Barmouth estuary, but their description could not be understood without the help of sections.

North part of Carnarvonshire and Merionethshire, as far east as the line of the Bala limestone, &c.

On the north side of the county last mentioned commences the

* Among these fossils are,—1. many encrinital stems; 2. *Entomostracites punctatus*; 3. *Leptæna sericea*; 4. *Orthis flabellulum, O. pecten, O. canalis, O. testudinaria*, &c.

† By the word *felstone* the author defines many rocks commonly called *compact felspar*; an incongruous name he wishes to replace by a name (*Feldstein*) occasionally used in Germany.

great Carnarvon chain, prolonged, in fine serrated ridges, to the neighbourhood of Great Ormeshead. In the low country east of the Menai are slate rocks alternating with trappean conglomerates, and with great masses of porphyry ranging very nearly with the beds of slate. One of the larger masses of porphyry appears to have been protruded after the deposition of the slates: other masses are contemporaneous with the slates. To the east of the largest elongated mass of porphyry, which strikes with the beds for about fifteen miles, commences a system of undulations affecting the whole chain, the anticlinal and synclinal lines ranging very exactly with the strike of the beds, i. e. N.N.E. or N.E. by N. The same prevailing strike and the same undulations are continued into Merionethshire; but in the southern parts of that county the strike deviates to the north-east and south-west. One great anticlinal line is traced from the county about three miles east of Festiniog to a point on the coast a little south of Barmouth. Beyond this line is an ascending section (very little interrupted by undulations), as far as the Bala limestone. These facts are described by the author in detail, and are illustrated by parallel sections at right angles to the mean strike of the country.

The rocks occupying the region are chiefly composed of *felstone*, (compact felspar) and felstone porphyry, trappean conglomerates, plutonic silt (exactly like chloritic varieties of German *Schaalstein*), and other erupted or recomposed igneous products: and the above-named rocks alternate indefinitely with fine masses of roofing-slate, and with great masses of greywacke; and with greywacke slate, often calcareous, but rarely containing beds and masses of limestone. Three or four subordinate masses of such limestone are found near Great Arenig, and one or two on the flanks of Cader Idris. The author describes some sections where the igneous rocks predominate over the aqueous; others in which the aqueous almost exclude the igneous: but the two classes of rock are so interlaced that they cannot be separated, and are regarded as of contemporaneous origin. Among them are however masses of greenstone (sometimes syenitic, and more rarely basaltic), and other trappean masses among the slates which are considered of a later date.

Nearly all the slate rocks are affected by a *cleavage*, which often obliterates all traces of stratification, and very seldom coincides with the true beds. In the fine quarries of Nant Francon and Llanberris, the cleavage planes (as in the great quarries of Cumberland) strike exactly with the beds, but are inclined at a greater angle. The strike and inclination of these planes is not however governed by any fixed law; for cases are pointed out where cleavage planes are much less inclined than the beds, and others in which these planes, even in fine quarries, deviate one or two points from the strike of the true beds. Five cases are exhibited in the sections where the cleavage planes continue their strike and dip through all the contortions of the beds; and a few cases are given of a good second cleavage plane. From all the facts the author concludes that cleavage planes are true crystalline phænomena, produced by the mutual action of the elementary particles of the rock while passing into a solid state.

Jointed structure is also discussed at some length: and joints are divided into four classes, called *dip*, *strike*, *diagonal*, and *tabular* joints. The two former are most constant, often highly inclined, and divide the slaty beds into great rhombohedral masses. They are supposed to have been formed by mechanical tension while the rocks passed into a solid state. Cleavage planes are not parallel to them; and they cannot arise from molecular or true crystalline action; because, as shown from examples in North Wales, they cut through the pebbles of beds of conglomerate: sometimes however, among the *accidents of structure*, true cleavage planes and joints become confounded.

Bala limestone.—System of the Berwyns.—Fossiliferous beds on the line of the Holyhead road, &c.

This limestone ranges through Cader Dinmael to Glyn Diffwys on the Holyhead road, a few miles east of Corwen. Thence it is prolonged towards the south; but its continuity is broken, and for some miles its range has not yet been made out. Exactly on the line of strike (N.N.E. and S.S.W.) it breaks out again near Bala, and ranges thence to the neighbourhood of Dinas Mawddwy, dipping steadily to the E.S.E.

From this limestone there is an ascending section to the very crest of the Berwyn chain, south of the road from Bala to Llangynog. In this ascending section are higher calcareous slates, which in one or two places have been burnt for lime. But on the east flank of this part of the chain there is a synclinal line, beyond which for several miles the beds dip to the N.W.; and a series of slate rocks, alternating with a few bands of porphyry, are again brought up to the surface. Some of these are only a repetition of a portion of the slates and porphyries on the east side of the range of the Bala limestone. These older rocks abut against, and, in consequence of enormous convulsions, in one or two places seem to overlie the Silurian rocks (among the tributaries of the Severn) described by Mr. Murchison.

The synclinal line above noticed appears to strike about N.N.E.; but the mean direction of the water-shed of the Berwyns is about N.E.: hence the synclinal line, and the calcareous slates overlying the Bala limestone, are, near the Llangynog road, brought to the west side of the chain; and the crest of the ridge, extending beyond Cader Ferwyn, is composed of the older slates and porphyries dipping towards the N.W. Still further north, either from a great flexure or (more probably) from an enormous fault, we have for several miles a great series of beds dipping to a point a few degrees east of north. They alternate here and there with porphyry, contain many fossils, and in their highest portion near Llansaintfraid Glyn Ceiriog, contain two bands of limestone. At this place they seem to form a regular ascending section, conducting without a break to the overlying Upper Silurian flagstone.

The author then notices the undulating country east of the Berwyns, extending from the Severn, near Pool, through the ramifications of the Vyrnwy and the Tanat. Calcareous slates, with many fossils nearly resembling those of the Bala limestone, are repeated again and again by rapid undulations: the facts are illustrated by sections.

The beds have a prevailing strike about N.E.; but it is frequently interrupted, and they are twisted out of their course so as in some tracts to strike east and west; and in other places the strikes and dips are entirely anomalous. The whole system in some places seems to dip under the older rocks of the Berwyns, in others it is placed side by side with them, the junction planes being vertical; and again the same system is seen to be thrown off with an eastern dip from the flank of the older chain. Everything indicates great derangement, of a later date than those which gave the impress to the Carnarvon chain, and probably contemporaneous with the movements which placed the beds of the north end of the Berwyns in the anomalous position above described. Part of the system here noticed has been described by Mr. Murchison, and is classed in the Caradoc sandstone.

Lastly, the author notices a comparatively low country near the line of the Holyhead road, extending westward to the neighbourhood of Bettws y Coed, in which the strike of the Carnarvon chain (N.N.E.) is but feebly impressed. The beds undulate, and are sometimes almost horizontal; but here and there they are thrown into ridges with the N.N.E. strike; and in all these different positions they are overlaid by the Upper Silurian ridges. These beds are at the northern limit of the Merioneth and Carnarvon ridges, are high in the ascending sections, and near Penmachno, Bettws y Coed, &c., contain many fossils.

Upper division of the slate rocks.—Denbigh flagstone, &c.

The author traces in detail the line of demarcation between the rocks of this and of the preceding division. From Conway to a point a few miles south of Llanrwst, this demarcation is represented by a great fault; afterwards by an irregular line (traced on a map), partly south and partly north of the great Holyhead road. A few miles below Corwen it crosses the valley of the Dee, passes over the crest of the hills, and strikes down the valley of the Ceiriog, in the lower part of which it is cut off by the mountain limestone. The strike of this upper group is affected by great breaks and undulations, but on the whole is about west by north, and east by south; and its prevailing dip is towards the north. Its structure is explained in detail, and illustrated by three sections: the first (commencing with the slates, porphyries and calcareous slate of the older division, south of Llansaintfraid Glyn Ceiriog) passes through a peculiar mass of dark roofing-slate, and is thence continued through Llangollen and Dinas Bran to the terrace of mountain limestone. The second, commencing a few miles to the west of the former, crosses the upper groups of flagstone, which are contorted, and in some places nearly vertical; and it is prolonged to the tabular hills of the Denbigh flagstone, south-west of Ruthin. The third (commencing with ridges of sandstone and conglomerate at Garn Brys near Pen Tre Voelas) is carried over the whole group, nearly north and south, to the escarpment of the mountain limestone near Abergele.

The two first sections give the following ascending series :—

1. Hard quartzose slates alternating with greywacke and beds of porphyry : it is fossiliferous and of great thickness.

2. A great mass of calcareous slates with two subordinate beds of limestone and with many fossils.

3. Dark roofing-slate with a few Graptolites.

4. A great thickness of Denbigh flagstone, &c., extending to the mountain limestone. This is separated into three subdivisions :—(*a.*) Lower flagstone series passing into hard quartzose bands and into earthy semi-indurated shales. It has impressions of Orthoceratites, and numerous compressed traces of fossils mistaken for Orthoceratites, but considered by Mr. Forbes as a species of Pteropoda (*Criseis*). Some of its beds exhibit many impressions of *Graptolites ludensis*. (*b.*) Beds resembling the former, but more indurated, also contain here and there many fossils, among which *Cardiola interrupta* and *Terebratula wilsoni* are enumerated. (*c.*) Softer beds, more or less slaty, with few fossils, surrounded by harder and more quartzose bands with very numerous fossils (*e. g.* the summit of Dinas Bran).

In the preceding section Nos. 1 and 2 belong to the older division; No. 3 is considered doubtful; but the whole of No. 4 is unequivocally Upper Silurian.

The third section gives the following ascending series :—

1. Ridges of old rock with Caradoc sandstone fossils.

2. Great masses and beds of conglomerate and coarse sandstone unconformable to the preceding. The conglomerates disappear in the ascending section, and the coarse sandstones pass into a finer structure, and alternate with bands of dark coarse slate, here and there with a true cleavage. Among these beds are a few Upper Silurian fossils.

3. A great thickness of Denbigh flagstone, generally agreeing with No. 4 of the preceding sections.

4. Great ridges of roofing-slate alternating with thick beds of coarse greywacke. The group is contorted and traversed with a few mineral veins, which are worked near Bronhaulog. These beds contain fossils described in a memoir by Mr. Bowman (see the Proceedings of the Geological Society, vol. ii. p. 667).

5. A thick mass containing beds like those of the lower groups, but often passing into a rotten slate or mudstone.

6. Mountain limestone.

This last group (No. 5) is overlaid further to the west by red conglomerates described by Mr. Bowman. Red sandstones and conglomerates also appear under the mountain limestone near Ruthin, which the author refers to the old red sandstone.

He concludes that the groups of this upper division cannot be brought into any close comparison with the well-defined Upper Silurian groups of Mr. Murchison; neither do they closely resemble in mineral structure the Upper Silurian groups of Westmoreland :

but he compares the Denbigh flagstone with the fossiliferous slates and flagstones of Horton and Settle in Yorkshire.

§ 3. *Classification of the three preceding divisions of the Welsh slates.—Organic remains, &c.*

The group of chlorite, slate, &c. contains no organic remains, and forms no passage into the rocks of the other division; it therefore offers no sure means of classification; but it seems to be inferior to the other slate rocks in the southern promontory of Carnarvonshire.

The age of the middle division is decided by the organic remains. None have yet been discovered in the low country east of the Menai, but it is much concealed by alluvial drift.

Commencing with the line of the Nant Francon and Llanberris slate quarries, the author describes a series of regular ascending sections, continued through a horizontal distance of three miles, and intersecting beds without a single flexure, inclined more than 50°. In this great mass of strata are no described fossils. But at its top, fossil bands appear containing *Orthis flabellulum* and *canalis* in abundance; together with corals (*Turbinolopsis ?*) and stems of *Encrinites*. These bands are traced on the east side of the highest summits of the chain from Moel Hebog to Carnedd Llewelyn. All the country east of that range might be represented by a peculiar colour; but it is in physical structure identical with the eastern parts of the chain; and the author wishes not to separate it on supposed negative evidence, which may be upset by new observations.

After two rapid undulations, there is again a regular ascending section to Capel Curig; and thence over the shoulder of Moel Siabod to the bottom of the valley near Dolwyddelan. The ascending section (interrupted only by one very short undulation), measured on a horizontal base at right angles to the strike, is more than five miles long, and is through highly inclined beds. The thickness of this fossiliferous system must therefore be very great. But in the hills east of Penmachno, and south of Bettws y Coed, are calcareous beds (with more numerous fossils), which are placed in a still higher part of the ascending section. These calcareous beds (sometimes burnt for lime) the author places nearly on the parallel of the Bala limestone; though on general analogy, and not on any direct evidence of sections.

Again, from the great Merioneth anticlinal (above described) to the Bala limestone, there is a great ascending section; on two or three parts of which are found organic remains, *far below* the parallel of the limestone. And above the Bala limestone, to the crest of the southern Berwyns, is a series of beds, some of which contain many Lower Silurian fossils, and at least one more calcareous band.

Lastly, the fossiliferous groups south of Llansaintfraid Glyn Ceiriog, are (at least provisionally) brought into comparison with the Bala limestone and other fossiliferous beds in the trough of the southern Berwyns.

The author then gives the subjoined lists of fossils from different localities on the lines of the sections above noticed. It is a mere synopsis of the fossil evidence, but has been carefully made out by Mr. J. Sowerby; and by Mr. J. W. Salter, who accompanied the author in his last examination of the country along the line of the Holyhead road.

List of Fossils from several localities in the middle division of the Cambrian Slates.

I.

Penmachno and Conway Falls.

Trinucleus caractaci.
Asaphus tyrannus.
Leptæna sericea.
Orthis canalis.
—— testudinaria.
—— alternata.
—— actoniæ.
Tentaculites scalaris.

II.

Hills opposite Bettws-y-coed.

CRUSTACEA.

Trinucleus caractaci.

HETEROPODA.

Bellerophon bilobatus.

BRACHIOPODA.

Leptæna sericea.
Orthis canalis.
—— testudinaria.
—— alternata.
—— actoniæ.
—— flabellulum.
—— new (very convex), (half a mile above Conway Falls).

III.

Cerrig y Druidion.

Orthis alternata.
—— new (abundant)
Ophiura salteri.

IV.

Glyn Diffwys and Cader Dinmael Limestone.

CRUSTACEA

Tails of a Calymene.
Asaphus powisii.
—— tyrannus.
Trinucleus caractaci.

BRACHIOPODA.

Leptæna tenuistriata.
—— sericea (abundant).
Spirifer crucialis (new).
Orthis actoniæ (do).
—— vespertilio (do).
—— virgata (abundant).
—— canalis.

RADIATA.

Favosites polymorpha.
Round coral.
Hemispherical coral (new ?), and several other species of corals and shells.

V.

Sandstone bed on Cader Dinmael (scarcely examined).

CRUSTACEA.

BRACHIOPODA.

Orthis flabellulum (abundant).
—— canalis.

CONCHIFERA.

Avicula, n.s.

VI.

Bala Limestone.

CRUSTACEA.

Tails of a Calymene.

BRACHIOPODA.

Leptæna tenuistriata (none of sericea).
Spirifer crucialis.
Orthis actoniæ (do.).
—— vespertilio (do.).
—— canalis.
—— virgata (abundant).

RADIATA.

Round coral.
Hemispherical coral.
Tentaculites annulatus.

VII.

Calcareous Slates of Bala, Gelli Grin, &c.

CRUSTACEA.

Trinucleus caractaci.

BRACHIOPODA.

Leptæna tenuistriata.
—— sericea (very large).
Spirifer radiatus, M. C.
—— crucialis ?
Orthis flabellulum.
—— vespertilio.
—— canalis.
—— alternata.
—— virgata.

MOLLUSCA.

Turbo pryceæ.
—— angulatus ?
Euomphalus sculptus ?

RADIATA.

Ophiura salteri (pelvis)

VIII.

Slates. South of Llansaintfraid Glyn Ceiriog.

CRUSTACEA.

Trinucleus caractaci.
Calymene (tail).
Asaphus caudatus ?
—— powisii.

BRACHIOPODA.

Leptæna tenuistriata.
—— sericea.
Orthis inflata (new).
—— canalis.
—— alternata.
—— actoniæ.

RADIATA.

Turbinolopsis bina (abundant).

IX.

Llansaintfraid Limestones and Shales.

Leptæna sericea.
Orthis canalis.
—— actoniæ.
Euomphalus (new).

RADIATA.

Catenipora escharoides (abundant), and many others.

The fossiliferous series above described is called the great protozoic group of North Wales. It is stated, that there is no good fossil evidence for its separation into distinct formations; and that its inferior beds, although far below the Caradoc sandstone, contain comparatively few species undescribed in the work of Mr. Murchison. It is therefore neither Silurian nor Cambrian in the limited sense in which the words were first used; but it represents both systems, inseparable, as they are in nature, from one another.

The *upper division* of the Cambrian slate series is so obviously Upper Silurian, that the author adds very few details in illustration of those given in the previous parts of the paper. He however subjoins the following list of fossils, chiefly derived from the beds of the third section from Garn Brys to Abergele through this division.

1. In the highest beds near the north end of the section,—*Encrinites, Graptolites ludensis, Orthoceras virgatum, Leptæna lata, L. depressa, Terebratula lacunosa, Orthis orbicularis, &c.*

2. South of Bettws Abergele, and rather lower in the series,—*Asaphus caudatus, Orthis orbicularis, Leptæna lata, Terebratula lacunosa, Atrypa affinis, Cardiola interrupta, &c.*

3. In the valley of Llanfair Talhaiarn and Bronhaulog mines,—Encrinites and branching corals, *Bellerophon trilobatus, Leptæna lata, Spirifer ptychodes, Orthis orbicularis, Atrypa affinis, Turbo corallii, &c.*

4. Plas Madoc quarry near Llanrwst, under the great mass of the Denbigh flagstone, and therefore low in the descending section.

Corals:—*Fenestella, &c., Calymene blumenbachii, Asaphus subcaudatus, Bellerophon globatus, Leptæna euglypha, L. lata, Atrypa affinis, Spirifer ptychodes, Orthis orbicularis, O. lunata, Terebratula navicula, T. lacunosa, &c.*

5. To these lists the author adds the following from Dinas Bran near Llangollen, the upper part of the Denbigh flags.

Calymene (?) (in small fragments), *Lituiti* (in fragments), *Orthoceras striatum, O. ibex, O. ludense, Bellerophon expansus, Terebratula navicula* and *lacunosa* (in great abundance), *Orthis lunata, Nucula ovalis, Cypricardia retusa, Cardiola interrupta* (?), *Turbo carinatus, &c.*

The Denbigh flags contain impressions of Orthoceratites; but some which have been referred to that genus are considered by Mr. Forbes as species of *Criseis*, a genus of Pteropoda. They occur in the middle of the group associated with *Graptolites ludensis*, and sometimes with *Leptæna lata, Cardiola*, and other fossils.

From these lists it appears that the fossils of the upper division of the great Welsh series agree very closely with the fossils figured by Mr. Murchison, from the Wenlock shale to the tilestone at the base of the old red sandstone inclusive. But the mineral structure of the rocks being almost entirely different from that of the upper system of Siluria, the distribution of the species is also different; so that they are incapable of being arranged into distinct groups marking the successive parts of an ascending or descending section, so as to agree with the subdivisions of Mr. Murchison. The author confirms this remark by stating, that he now possesses more than ninety species of the *Upper* Silurian fossils of Westmoreland, that nine-tenths of them agree specifically with those described in the 'Silurian System,' and that their arrangement in the actual sections admits of no rigid comparison with the subordinate groups of the system.

§ 4. *Other formations over the preceding.—Successive dislocations of the Welsh system, &c.*

After briefly noticing one or two masses of red sandstone and conglomerate (referred to the old red sandstone), the author describes the extraordinary position of the mountain limestone in the Vale of Clwyd, and infers that it underwent its greatest dislocation before the period of the new red sandstone, which is found apparently in a great bay of the dislocated limestone. He then gives, in the following order, a synopsis of the principal movements which have affected the different formations within the limits described in the paper.

1. The oldest movements of which we have any distinct trace, were those which gave the north-eastern strike and threw the mountain masses into undulations.

The highest points of the Carnarvon chain (measured along the strike from Conway) are upon an arch, the crown of which is the top of Snowdon; and the south end of the arch is broken off by the Tremadoc fault. At what time this position was effected does not appear; but the tension by which it was produced broke the back of the chain in three places, producing the rudiments of the three great passes across the Carnarvon chain.

2. Afterwards, a series of movements gave the W.N.W. impress both to the older system at the north end of the Berwyns, and to the upper system in Denbighshire. The author considers that the extraordinary confusion in the position of the beds in some parts of the Berwyn chain to be caused by the intersection of the two lines of principal elevation, viz. the old movement to the N.E. or N.N.E., and the subsequent movement to the W.N.W. Probably after this period were formed the conglomerates at the base of the mountain limestone of Denbighshire.

3. At a later period was formed the great trough of the Vale of Clwyd. About the same time (and probably before the period of the new red sandstone) was formed a line of great dislocation, marked by a patch of mountain limestone near Corwen, affecting the dips of all the intermediate country as far as the great mineral veins of Minera; and lastly, bringing up a great mass of mountain limestone near Caergwrle in Flintshire.

4. The great break of the Menai Straits appears to have taken place after the new red sandstone: and probably about the same time was formed the *fault*, ranging up the lower part of the Conway.

5. Lastly, all the external inequalities of the country must have been altered, again and again, since the successive periods of impress, produced by the above lines of great movement. The whole country has, at very recent geological periods, undergone great changes of level. And the author confidently affirms, that the

mountain streams of North Wales, as far as he has examined them, have been flowing in their existing channels, and producing the effects of diurnal erosion (marked by deltas gradually filling up lakes, and by other alluvial accumulations) only during a few thousand years. He accepts the evidence of comparatively recent glacial action in the higher valleys of North Wales (*e. g.* near Llyn Ogwen, &c.), but enters on no details.

§ 5. *General conclusion.*

From a review of the facts stated in this paper, combined with the facts stated in a former communication (Nov. 1841.), the author suggests the following classification of the British Palæozoic rocks. They are considered zoologically as forming one great system separable into four primary divisions, as follows:—

1. *Carboniferous*, subdivided into four principal groups.

(*a*). Magnesian limestone and lower red sandstone, *zechstein* and *rothe-todte-liegende*. In this group are the drifted coal plants of the lower red sandstone of England, and the coal-beds of the Hartz, associated with the *rothe-todte-liegende*.

(*b*). Great coal formations of England, Scotland, Belgium, Westphalia, &c., freshwater beds, and many beds of plants not far drifted; sometimes unmoved from the spots where they grew.

(*c*). Millstone grit and shale, limestone, &c., with drifted plants and beds of coal; great scar limestone; culm-measures of Devon (?); great coal-fields in the West of Ireland.

(*d*). Lower limestone and limestone shale, &c.; imperfectly represented in England, but probably here and there replaced by the conglomerates at the top of the old red sandstone; lower limestone and carboniferous slates of Ireland; lower coal formations of Scotland. In this group are placed a part of the beds of North Devon under the culm-measures, and containing fossils like those of the carboniferous slates of Ireland.

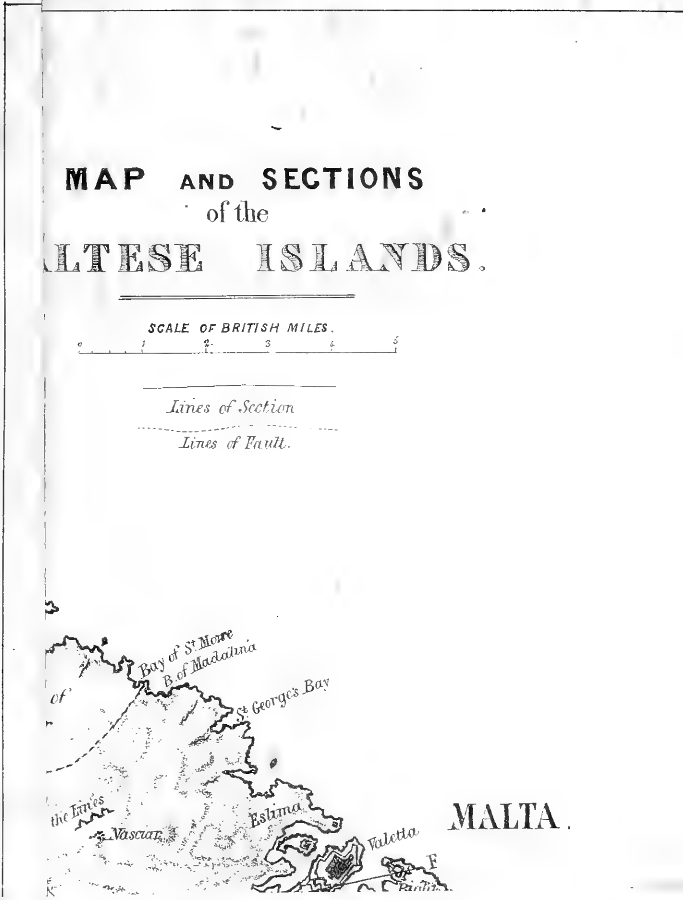
2nd *Division.*—Devonian and old red sandstone. In this division are placed the older fossiliferous slates, &c. of Devon and Cornwall; the beds below the carboniferous limestone of Belgium and Westphalia, as far as the Eifel and great Westphalian limestones inclusive; all the old red fish-beds, &c. of Scotland; all the central part of the old red sandstone series of Herefordshire; old red sandstone, &c. of Ireland.

3rd *Division.*—All the Upper Silurian rocks of Mr. Murchison, from the Wenlock slates to the lower part of the "tilestone" inclusive; Denbigh flagstone; upper division of the fossiliferous slates of Westmoreland and Lancashire; many portions of the fossiliferous rocks of the Flemish provinces, and various parts of France; some small fossiliferous groups in the south of Scotland (?); a part of the fossiliferous series in the north and south of Ireland (?)

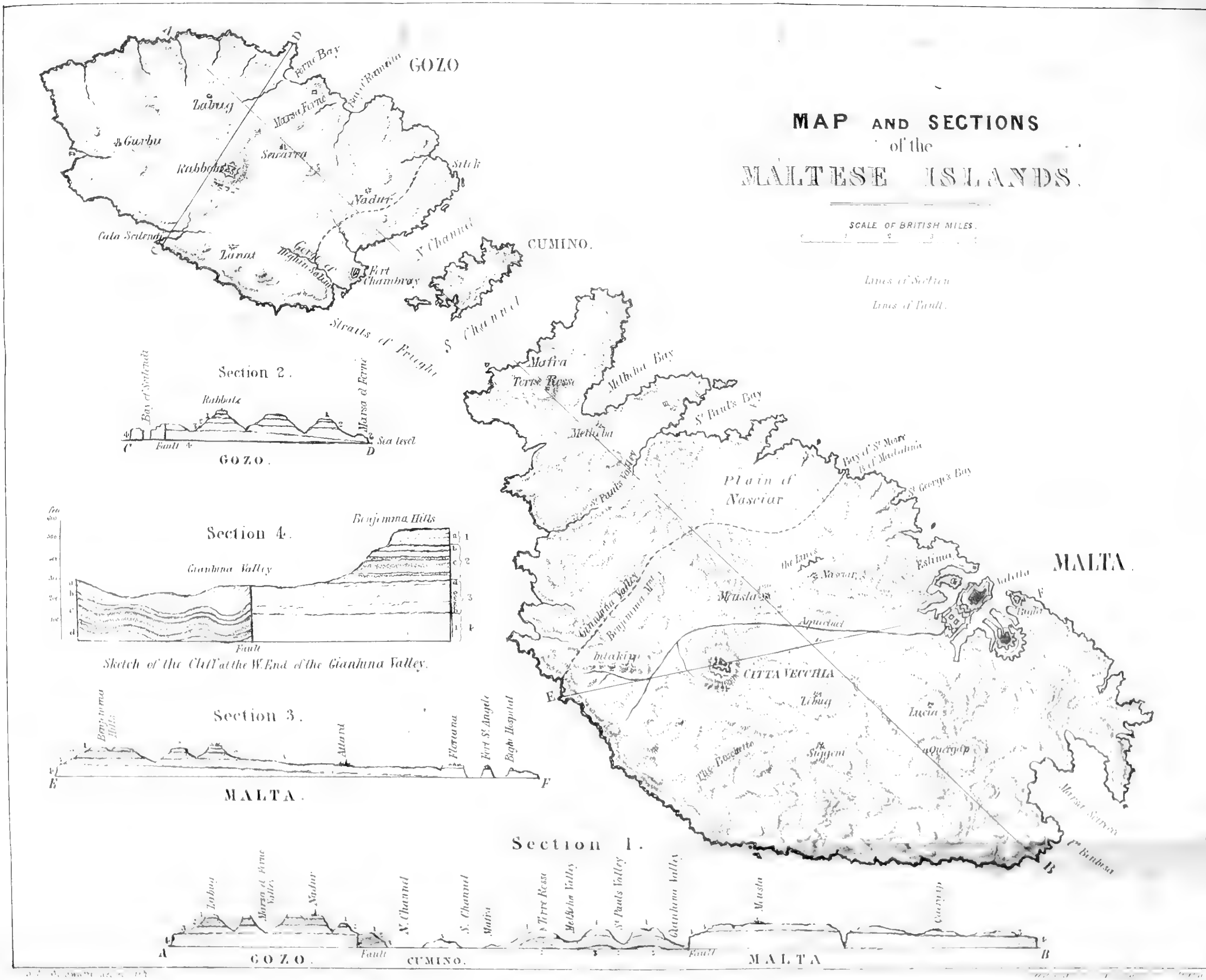
4th *Division.*—Great protozoic group; all the older fossiliferous slates of North and South Wales; Coniston limestone; lower part of the "Silurian system" of Mr. Murchison; oldest fossiliferous slates of Scotland and Ireland, and of various parts of the continent, &c.

It is stated that the great difficulty is to draw clear and consistent lines of demarcation between these great primary divisions. They pass into one another, and interchange some fossil species, especially near their limits. Were it not for the magnificent sections of the old red sandstone in the British Isles, and also in the north-eastern parts of Europe (as now shown by Mr. Murchison and his fellow labourers), the author asserts, that the second and third divisions would probably be confounded and eventually pass under one common name (including Upper Silurian and Devonian). In Belgium and the Rhenish provinces the demarcation between them is quite arbitrary. We there find Goniatites and long-winged Spirifers and other organic types (first supposed to characterize the "Devonian system") abundant in the Silurian rocks: and there is nothing in the physical structure of those countries to suggest the separation of these two divisions. By help of the British sections, combined with new facts brought to light in Russia and America, the second division must however maintain its place.

Between the third and fourth divisions there appears to be a much better marked separation, both physically and zoologically, than between the others. These two divisions (at least in North Wales) differ in structure, interchange hardly any fossil species, and through large districts are unconformable. Hence they belong to two *systems*, and not to *one*, if the word *system* be used in a definite sense, and be applied to the successive divisions (such as the Devonian). To avoid incongruity of language, the author uses the word *system* in a general sense; and under the name *Palæozoic System* describes the whole series of formations comprehended under the four divisions above described. In this great descending series the "Silurian system" (in the sense in which the words were first used) stands in the place of the third, and the upper part of the fourth primary division.



MAP AND SECTIONS
of the
LTESE ISLANDS.
SCALE OF BRITISH MILES.
0 1 2 3 4 5
Lines of Section
Lines of Fault.
B. of Madalina
St George's Bay
Eslima
Nasciar
Valetta
MALTA.


MAP AND SECTIONS
of the
MALTESE ISLANDS.
SCALE OF BRITISH MILES.
GOZO
CUMINO.
MALTA.
Section 2.
Rabbato
GOZO.
Section 4.
Benjemma Hills
Gianluna Valley
Fault
Sketch of the Cliff at the W. End of the Gianluna Valley.
Section 3.
MALTA.
Section 1.
GOZO.
Fault
CUMINO.
MALTA
Plain of Nasciar
CITTA VECCHIA
St. Paul's Bay
Mellicha Bay
Marsa Scirocco
Straits of Freghi
N. Channel
S. Channel

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY OF LONDON.

Vol. IV. Part II. 1843—1844. No. 97.

Nov. 1, 1843.—"On the Geology of the Maltese Islands." By Lieut. Thomas Spratt, R.N., of H.M. surveying vessel Beacon, F.G.S.

The axis of the chain of the Maltese Islands runs from south-east to north-west, and is about twenty-nine miles long. Malta, the southernmost of the group, is nearly seventeen miles long; and its greatest breadth, measured transversely to the axis, is nearly nine miles. Gozo, the northernmost island, is nearly nine miles long, and its greatest transverse breadth is a little more than five miles.

The mineral deposits of which these islands consist, are all stratified, and disposed in parallel layers. They seldom deviate much from the horizontal position; but the prevailing dip, which is very gentle, varies from north-east to east by north; and consequently the prevailing strike of the deposits coincides nearly in direction with the axis of the chain.

None of the deposits are wholly devoid of organic remains; and some of the softer strata contain them in great abundance and in a state of excellent preservation. Many of these fossils are characteristic of certain strata, and all are of marine origin.

Of the strata of these islands the author forms four groups, which, taken in their descending order, are the following:—

1. Coral limestone.
2. Yellow sandstone and blue clay.
3. Freestone.
4. Semi-crystalline limestone.

No. 1.

The "Coral Limestone" (A) consists of a reddish-brown or whitish calcareous rock, which is mostly of a compact, hard, and almost flinty texture. It contains cretaceous nodules, and is sometimes interstratified with soft calcareous sandstone. Its organic remains are particularly abundant in the cliffs abutting on the different bays on the north-west coast of the island of Malta. In the cliff at the west end of the Gianhina Valley, on the south-west coast of the island, the coral limestone is nearly 100 feet thick; but on the different hills which, in other parts of the island of Malta and in Gozo, are capped by this deposit, it now presents a thickness only of from twenty to sixty feet. Near Casal Garbo, towards the north-western angle of Gozo, the only remains of the coral limestone which origiginally formed a continuous upper crust over that part of the island, are detached masses of this deposit, lying on the surface of denuded freestone. Similar masses are seen in other parts of the island. Some of these fragments at Casal Garbo are variegated with yellow and white, and are used for ornamental work under the name of "Gozo Marble."

No. 2.

Next to the coral limestone occur two beds, which the author groups together under the name of "*Yellow Sandstone and Blue Clay.*" The upper of these two beds (B), which is about twenty feet thick, consists of yellow sand or sandstone, with greenish-black particles intermixed. It abounds in organic remains, many of which differ from those of the coral limestone. One of its most characteristic fossils is a small, very thin Nummulite, which sometimes is in such quantity that it forms a third part of the bed to which it belongs. It occurs most abundantly in the cliffs of the Bay of Ramella, on the north-west coast of Gozo. These shells usually lie with their flat sides parallel to the plane of stratification. Associated with the Nummulites are sometimes layers of oysters. Wherever a section of the yellow sand is visible, the teeth and bones of species of shark may be obtained. These are very abundant in Malta, in the cliffs of the north-west coast, and in Gozo; in the eastern hills, and in the cliff beneath Fort Chambray, towards the south-eastern corner of the island. (See catalogue, p. 230.) The yellow sand contains also the bones and teeth of Cetacea; but these are comparatively rare. The lower of the two beds (C) consists of blue clay or marl, from 100 to 120 feet thick. It contains two or three thick layers of a lighter colour than the rest, but is not much disposed to separate into thin layers of stratification. Imbedded in it are crystals of gypsum, and occasionally nodules of sulphur. The clay contains a few organic remains. The Testacea are mostly species of Mitra, &c. A Nautilus is found, but rarely, under Fort Chambray. With the shells has been found the bone of a small Sepia. The fossils of the clay generally serve as nuclei to irregular nodules of iron pyrites, and the substance of the fossils is also frequently converted into hydrated peroxide of iron.

No. 3.

To the blue clay succeed five beds, of which the author forms one group, denominated by him "Freestone."

The clay passes into a white calcareous sandstone (D) from twenty to thirty feet thick; and below this is a bluish-grey or fawn-coloured marl (E) about twenty feet thick. These two deposits contain several species of microscopic chambered shells.

Next are found from twenty to thirty feet of a pale yellow or white calcareous freestone (F) separable into thin strata. It contains nodules of flint, and the fossils of this bed are found in a silicified state on the north-west side of Bengemma hills. This stone is sometimes used for building, but it exfoliates by exposure to the weather, and more particularly when acted on by the sea. It contains a Scalaria and other forms.

Below the upper bed of freestone is a bed, from two to eight feet thick, of calcareous sandstone (G), of a pale chocolate colour and flinty hardness, which consists almost wholly of the casts of organic remains (see Mr. Forbes's catalogue), and mixed with the casts are shapeless nodules of the sandstone of the same colour and texture. This deposit preserves its peculiar character wherever the freestone group of beds is found. It is best exhibited in the island of Gozo, in the Bay of Marsa el Forno on the north-west coast, and at the base of the cliffs under Fort Chambray, when it forms rocky ledges two or three hundred yards broad, extending along the coast, and rising only a foot or two above the sea-level.

The lowest bed of the group is a yellowish-white calcareous freestone (H), from forty to fifty feet thick. This is the stone which is commonly used for building in the two islands. From the facility with which it may be cut by the hatchet, or formed by the lathe, this stone, both in the rough state, in the state of slabs, and when turned into pillars, balustrades, vases, and other architectural ornaments, is used extensively in all the public and private edifices of Malta and Gozo, and is an article of considerable export to all parts of the Mediterranean. A fossil turtle was found in this bed, near Casal Luca, south of the city of Valetta.

No. 4.

The lowest of the four deposits of the Maltese Islands is a yellowish-white semi-crystalline limestone (I) of very considerable thickness, since nearly 400 feet of it in perpendicular depth are visible on the north-west coast of the island of Gozo. From its durable properties it is extensively quarried for building in various parts of the island of Malta, more especially to the west of the city, near the village of Musta, and on the denuded flat to the west of Valetta. The author has made a detailed examination of only about twenty or thirty feet of the uppermost strata of this deposit. Owing to the hardness of the rock it is difficult to detach from it perfect specimens of the fossils.

Malta is divided into two parts by a great fault, which cuts the island transversely to the axis of the chain, and to the north-west lets down the strata about 300 feet. Gozo also is divided, a little way inland from the strait which separates it from Malta, by a fault running also transversely to the axis of the chain, and producing to the south-east nearly the same amount of depression in the strata which is occasioned, in the opposite direction, by the fault of Malta. The joint effect of these two disturbances is, to let down the deposits, in the space between the two faults, to the depth above-mentioned, that being about half the height above the sea-level of the most elevated points in each of the two islands. In the sunken tract lie the Straits of Frieghi which separate Malta from Gozo, and midway between the two principal islands, the small island of Comino.

The Maltese fault is clearly displayed by a vertical section in the sea-cliff, on the south-west coast of the island, near the west end of the Gianhina valley. (See Section 4.) From the coast the fault passes beneath the northern face of the Ben-gemma hills, along the line of that valley, its course being indicated by the different levels at which the respective strata crop out on its opposite sides. It crosses the plain of Nasciar, and meets the sea on the north-eastern coast between the two bays of Maddalena and St. Marco. (See Map.)

The Gozo fault, emerging from the gorge of Highin Selim, which enters the Straits of Frieghi near the south-west corner of the island, passes to the north of Fort Chambray, and to the south of Casal Nadur; and it meets the sea on the north-eastern coast in the Bay of Silek. (See Map and Section 2.)

In Malta, to the south of the great fault, the strata dip gently east by north, so that at Marsa Scirocco, on the south-eastern, and at Valetta, on the north-eastern coast, the semi-crystalline limestone is submerged. It becomes visible at the water's edge, to the north-west of Valetta, near Scliema; and further north, near St. George's Bay, it is quarried for building. It rises considerably above the sea-level near Cape Benhisa, the extreme south-eastern point of the longitudinal line of section. (See Section 1.) In the whole breadth of the island the level of the strata is depressed in the line of dip about 200 feet. The semi-crystalline limestone and the superincumbent freestone stretch across the island to the south of the fault from coast to coast. The hard and durable quality of the limestone, which constitutes the lower stage of the inaccessible cliffs that encircle the island to the south-west and south, account for the straight and unindented configuration of that part of the coast.

The eastern side of the island to the south of the fault, as far west as a line drawn through Casal Siggieni and Citta Vecchia, consists wholly of this lower limestone and its superincumbent freestone, the newer deposits, that is to say, the coral limestone, the yellow sandstone, the blue clay, and even some of the upper strata of the freestone, having been swept off by denuding agents. This denuded district is almost a flat; and though naturally sterile, it has been rendered productive by spreading over the rocky surface an artificial soil, and carefully supporting the same by terraces.

On the western side of the island to the south of the fault, the coral limestone, the yellow sandstone, and the blue clay, have escaped the denuding action; and owing partly to their presence, and partly to the freestone and the subjacent limestone standing at a higher level on the western side of the island south of the fault than they do on the eastern, the western side is considerably the loftiest. The above newer deposits form a chain of table-topped hills, called the Ben-gemma hills, which rise considerably above the rest of the island, their highest point, which is to the north-west of Citta Vecchia, being 600 feet above the sea.

Gozo, to the north of its great fault, in respect of the character and arrangement of its deposits, and of their fossil contents, is an exact counterpart to the southern part of the island of Malta. In Gozo, however, the deposits are somewhat more developed, and their fossils are more various and abundant. In Gozo, north of the fault, the strata dip gently to the north-east, in consequence of which, on the north-western coast, the semi-crystalline limestone is submerged; whereas, along the whole of the south-western coast it presents a straight and unindented line of precipitous cliffs, rising, in some parts, perpendicularly 400 feet above the sea, and descending as abruptly, and apparently to as great a depth beneath the waves. This is the deepest section of the limestone that is to be seen anywhere in the Maltese Islands.

In Gozo, to the north of the fault, the coral limestone, the yellow sandstone, and the blue clay have not been so much degraded as they have in the south-eastern part of the island of Malta. On the south-western side of Gozo, however, there is a considerable tract from which these upper deposits have been entirely swept away. Throughout the remainder of the island, north of the fault, it is these deposits which form the crests of a number of detached flat-topped hills, rising from 130 to 200 feet above the valleys, these valleys being excavated down to the level of the inferior deposits. The highest level above the sea which any of these crests attain, is about 640 feet. All these table-hills have steep, escarped sides, and present perfect sections of the newer series of deposits. Their number and abruptness gives a more diversified and picturesque character to the island of Gozo than belongs to the scenery of the island of Malta.

It remains to speak of that portion of the two islands which lies between the two faults. To the north of the fault in Malta, it is only the coral limestone, the yellow sandstone, and the blue clay that are visible, with the exception of some of the upper strata of the freestone deposit, which appear in some places on the western coast just above the sea-level. (See Sections I. and IV.) In whatever parts of the sunken tract the softer strata of the above-mentioned newer deposits are exposed to the sea, the coast becomes indented with bays and inlets. It is by this action, partly, that the two deep bays of St. Paul and Melleha, in the north-eastern corner of the island of Malta, have been formed; but these bays, and also the two valleys that open into these bays respectively, owe their origin principally to undulations in the strata, the valleys following the course of the troughs in the strata occasioned by the undulations in question.

Most of the valleys in the Maltese Islands follow the course of the dip of the strata. Among the Ben-gemma hills lie the valleys of Boschetto and Entahkleb, which are noted for their picturesque scenery, and also for their fertility. Their fertility is owing to the springs which break out at the outcrop of the blue clay, in consequence of its retaining the moisture which falls on the porous substance of the superincumbent coral limestone and yellow sandstone. From one of the springs in the valley of Entahkleb the water is conducted by an aqueduct to Valetta. There are no springs in Malta or Gozo, but when there is clay to retain the water.

The longitudinal gorges of Siggieni in Malta, and of Highin Selim in Gozo, are exceptions to the ordinary direction of the valleys in these islands; but these hollows appear to be owing to natural rents in the substance of the hard semi-crystalline limestone. On the precipitous sides of these gorges, and at different levels, horizontal markings are seen, which appear to be the effects of the sea, acting at different epochs of the progressive elevation of the land. Better evidence, however, of these epochs is afforded by the succession of natural terraces which line the face of every hill in these islands, wherever the strata were of such a nature as to yield readily to the action of the waves.

"Note on the Fossils found by Lieut. Spratt in the several beds of the Tertiary Formation of Malta and Gozo." By Prof. E. Forbes, Curator G. Soc.

Bed A. *Spondylus quinquecostatus*, Deshayes, identical with the Greek species. *Ostrea Boblayei*, Desh., *Ostrea Virleti*, Desh., a variety. *Pecten Pandora*, Desh., *P. squamulosus*, Desh., *P. burdigalensis*, and *P. Beaudanti* ? *Clavagella* ?

Casts of *Cytherea* ? and *Arca*.

Terebratula ampulla, and *T. bipartita*, Brocchi. *Orthis detruncata* (*Terebratula*, sp.), Gmelin, identical with the existing species.

Echinus, sp. *Cidaris*, sp. *Nucleolites*, sp. *Brissus*, 2 sp., and *Spatangus*, sp.

Eschara monilifera. *Escharina*, sp.

Nullipora.

Remains of *Crustacea*.

Bed B. *Ostrea Virleti*, *O. navicularis*, Desh. ? and another species. *Pecten cristatus*, Bronn ?, *P. squamulosus*, *P. burdigalensis*, and two other species.

Casts of *Thracia* ? *Isocardia* ? *Arca*, *Venus*, 2 species, and *Tellina*.

Scalaria retusa, Brocchi.

Casts of *Cypræa*, *Conus*, 2 species, *Oliva*, *Natica*, *Turritella*, *Turbo* ? *Pleurotoma*, *Pyrula*, *Phorus*, and *Trochus*.

Clypeaster altus and *marginatus*; *Brissus*, 3 species.

Lenticulites complanatus.

Cellepora mamillata, *Myriapoda*, sp. *Retepora*, sp.

Cetacean remains (according to Prof. Owen, of more than one species of *Delphinus*, and the bones apparently of a *Manatee*).

Fish-teeth (determined by Sir Philip Grey Egerton), *Corax aduncus*, *Carcharias megalodon*, and *C. productus*, *Oxyrhina xiphodon*, *O. hastilis* ? *O. Mantelli* ? *Hemipristis serra*, and *H. paucidens*, with other *Squalidæ*.

Bed C. *Sepia*, sp. *Nautilus zigzag*, identical with the London clay fossil.

Scalaria, sp. *Pleurotoma*, sp.

Cast of *Mitra*, *Rostellaria* and *Columbella*.

Pecten burdigalensis, *Ostrea*, sp.

Cardita. *Lucina*.

Spatangus, sp.

Caryophyllia, sp. *Cellepora mamillata*, *Fungia* ?

Bed D. *Vaginula depressa*, Daudin.

Cristellaria, sp. *Nodosaria*, sp.

Fossils common to Beds C, D, E, F, G.

Ostrea navicularis, *Pecten cristatus*. Casts of *Conus*, *Natica*, and *Cypræa*, *Spatangus*, and 2 species of *Brissus*.

Bed F. Two species of *Brissus*, and a *Nucleolite*.

Beds G. and H. *Pecten burdigalensis*, *Scalaria*, sp.

Scutella subrotunda, *Spatangus*, sp., and two species of *Brissus*.

Bed H. *Nautilus*, sp.
Beds H. and I. *Pecten.*
Casts of *Lucina, Solarium, Conus, Phorus, Natica*, and *Cypræa.*
Balanus (*Lepas*, sp.) *stellaris*, Brocchi ?
Scutella subrotunda, Clypeaster, sp. Two species of *Brissus, Nucleolites, Cidaris.*

Mem. The species of *Brissus* found in the lowest beds are identical with those found in bed B. Such is also the case with the *Pectens.*

"Report on the collections of Tertiary Fossils from Malta and Gozo." Presented by Lieut. Spratt, J. W. Collings, Esq., and Miss Attersol. (Read March 20, 1844.) By the Curator.

The Maltese collection includes between eighty and ninety species of animal remains, belonging to the classes *Vertebrata, Mollusca, Crustacea* and *Cirrhipeda, Foraminifera, Echinodermata* and *Zoophyta.* Many of these are in a very perfect state, others are casts.

The Vertebrata consist of the remains of Cetacea and of fishes, chiefly sharks. The former have been examined by Prof. Owen, and the latter by Sir Philip Egerton. They are considered by those naturalists as tertiary, probably miocene.

A great part of the collection consists of Molluscous remains. Of these three are Cephalopoda, viz. a Sepia and 2 species of Nautilus, one of which is the *Nautilus zigzag*, identical with the London clay fossil. One is a Pteropod, the *Vaginula depressa* of Daudin.

Of Pectinibranchous Mollusca there are numerous species, but mostly in the state of casts. Among the perfect shells of this order are three species of *Scalaria*, including the *Scalaria retusa* of Brocchi, a miocene fossil. The casts belong to the genera *Conus, Cypræa, Natica, Oliva, Turritella, Turbo, Pleurotoma, Pyrula, Phorus* and *Trochus.*

Of Brachiopodous Mollusca there are 4 species belonging to the genus *Terebratula.* Three of these are known species, viz. *Terebratula ampulla* and *bipartita* of Brocchi, fossils of the subapennine beds, and *Terebratula detruncata* of Gmelin (*Orthis* Phillippi), a small species still existing in the Mediterranean Sea.

Of Lamellibranchiate Mollusca there are 17 perfect species and numerous casts belonging to the genera *Thracia, Isocardia, Arca, Venus, Cytherea, Lucina* and *Tellina.* Among the perfect species are 3 species of oyster, which have been described by Deshayes in the Geology of the Morea, viz. *Ostrea Boblayei, O. Virleti*, and *O. navicularis.* Also *Spondylus quinque-costatus, Pecten pandora*, and *P. squamulosus*, figured in the same work. *Pecten cristatus* of the Italian beds, *Pecten burdigalensis, P. scabrellus* ?, and *P. Beaudanti*, are also present in this collection. The remainder of the species of this genus, which appear to be very characteristic of the Maltese formation, I have been unable to name, from want of materials for comparison. Besides the above-named shells, there are perfect specimens of a *Lucina*, a *Cardita*, and a *Clavagella.*

The remains of Crustacea and Cirrhipoda consist of a few fragments and a good specimen of a *Balanus*, apparently the species figured by Brocchi under the name of *Lepas stellaris*. Also a species of *Pollicipes* presented by Mr. Greenough.

The *Foraminifera* include the *Lenticulites complanatus* (which appears to be found in those beds in vast numbers), and species of *Nodosaria* and *Cristellaria*.

The *Echinodermata* in this collection are numerous, and of remarkable beauty. They include all the Maltese species figured in the work of Scilla, besides several apparently undescribed. They belong to the genera *Cidaris* (1 species), *Echinus* (1 species), *Nucleolites* (3 species), *Galerites* (1 species), *Spatangus* (3 or 4 species), *Brissus* (3 species), *Clypeaster* (4 species), and *Scutella* (1 species). Among the species of the last 2 genera are *Clypeaster altus*, *marginatus*, *Tarbellianus* and *scutellatus*, and *Scutella subrotunda*, several of which are found in miocene beds in the South of France, and in Italy.

The Zoophyta include species of *Fungia*, *Caryophyllia*, *Cellepora*, *Escharina*, *Eschara*, and *Retepora*. They have been submitted to Mr. Lonsdale, who has recognized among them *Cellepora mamillata*, and *Eschara monilifera*, both French miocene fossils.

There is no reason to believe that the fossils in this collection came from more than one tertiary formation.

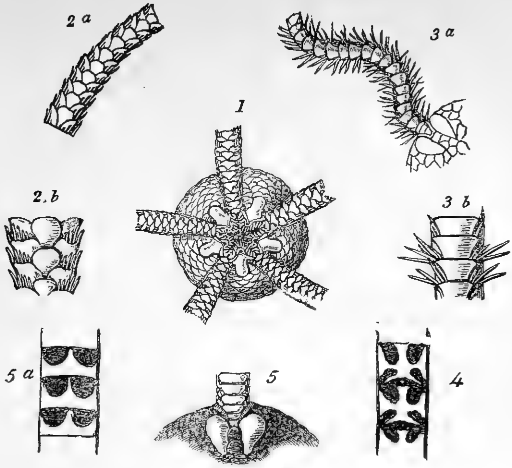
As far as can be judged from the examination I have made of them, they belong to a tertiary formation of a later date than the London clay and Paris basin, and older than the Sicilian and other pliocene strata. Certain beds in the South of France and North of Italy, which have been referred to the miocene period, appear to agree in age with the Maltese beds, though they may possibly be older than the Touraine faluns and the English crag.

"On the Fossil Remains of Starfishes of the order *Ophiuridæ*, found in Britain." By Prof. E. Forbes. Communicated by R. I. Murchison, Esq., President of the Royal Geographical Society.

In Mr. Morris's catalogue of British fossils (p. 55), four species of *Ophiura* are enumerated: viz. *Ophiura Egertoni* of Broderip*, from the inferior oolite; *O. Milleri* of Phillips, from the marlstone, at Staithes; an unnamed species, from the London clay, recorded by Mr. Wetherell in the Geological Proceedings; and a species from the upper chalk, also unnamed, in the cabinet of Mr. Fitch. In the ninth volume of the Magazine of Natural History (p. 437), Mr. Williamson figures and describes a fossil *Ophiura* under the name of *O. loricata*, from the marlstone at Staithes; and in a paper read before the Geological Society during the session 1842–43, Professor Sedgwick has recorded an *Ophiura* in the Cambrian slates of North Wales.

Of such of the above species as have already received names, the first two will now fall under the genus *Ophioderma* of Muller and Troschel†, as *Ophioderma Egertoni*, and *Ophioderma Milleri*; since they present the peculiar forms of ovarian shields, and the superior genital openings distinctive of that genus. *Ophiura loricata* of Williamson appears to be the upper surface of *Ophioderma Milleri*.

* For references to the works in which this and the other species mentioned are described, see table. † Wiegman's Archives, 1840.



1. *Ophiura Murravii*, inferior surface (n.s.).
2. *Ophiura serrata*. *a.* part of arm, n.s. *b.* joints of arm magnified.
3. *Amphiura Pratti*. *a.* part of disk and arm, n.s. *b.* joints of arm magnified.
4. Section of arm of *Ophioderma Egertoni*.
5. *Ophioderma tenuibrachiata*, part of disk and arm. *a.* Section of arm.

The following Ophiurites are either new, or hitherto uncharacterized as British :

1. *Ophioderma tenuibrachiata*, F.—The disc is similar to that of *O. Egertoni*, but the rays are much longer in proportion, and less tapering. They have a more flexible aspect than those of the *O. Egertoni*, and present in their section, a different form of the central ossicula ; for these, instead of being trilobate, are oblong with a triangular central anterior lobe. Discovered in the lias at Bridport by Dr. Murray of Scarborough and communicated by Mr. Bowerbank. Mus. Murray.

2. *Amphiura Pratti*, F.—The specimen presents the under surface of the animal, the disc, which was probably soft or cartilaginous, having disappeared, though its limits are well-marked by the forms of the ossicula composing the bases of the arms, which were inserted into it. There are traces of a few smooth, imbricated scales on the intermediate plates beneath. The arms are nearly six times as long as the diameter of the disc, and are slender and flexible, but not tapering. The inferior ray-scales are quadrangular, with oblique sides. Each lateral ray-plate bears a row of slender, conic, diverging, smooth spines, which are about as long as the breadth of the ray. There is also a very small spine at the inferior angle of each.

This curious star-fish, which presents most of the characters of the genus *Amphiura* (Linnean Transactions, vol. xix. pt. ii. p. 150), was discovered by Mr. Pratt in the Oxford clay. Mus. Geol. Soc.

3. *Ophiura Murravii*, F.—The disc is large in proportion to the arms, and appears to have been covered by large scales. The ovarian plates are scutiform and rather small, projecting on the disc ;

and the converging ossicula, at their bases, are comparatively large and broad. The rays are short, broad and tapering. The inferior ray-plates are very small and triangular. The lateral cnes encroach on those below, and unite with them beneath. Of the spines, which were probably numerous and small, some obscure traces only remain. This is a true *Ophiura*. It was discovered by Dr. Murray of Scarborough, in the marlstone at Staithes. Mus. Murray.

4. *Ophiura serrata*, Roemer, Kret. Geb. tab. vi. f. 23.—The inferior ray-plates are petaloid, rounded above, tapering and subtruncate below. The lateral ray-plates do not touch, and they bear upon their upper margins strong conic spines, which do not quite equal the plates in length, and appear to have been six or seven in a row. The species appears to have borne a close resemblance to the recent *Ophiura albida* of the European seas. It appears to be identical with the *Ophiura serrata*, described by Roemer as occurring in the chalk-marl of Northern Germany. The fragment of an arm in white chalk is preserved in the Geological Society's Museum, to which it was presented by Mr. Tennant. It is possible that Mr. Fitch's Ophiurite belongs to this species. I have seen several loose ossicula of *Ophiura serrata* from the chalk.

5. In Sir Philip Egerton's collection, there is an Ophiurite from the Oxford clay, which may possibly be distinct from any of those described. The spines are very short, slender and acute; the rays are long. It appears to belong to the genus *Amphiura*, but the remains are too imperfect to warrant the constitution of a species until better specimens are procured.

The following table exhibits all the instances of fossil Ophiuridæ known to the author, arranged in ascending chronological order. From it it will be seen that this tribe of animals is present in the earliest fossiliferous formations, as well as in those of the several systems up to the newest strata. The generic forms do not appear to have materially varied from those now existing.

Table of Fossil Ophiuridæ.

Genus.	Species.	Country.	Formation.	Reference.
Ophiura?	*Salteri*, Sedgwick	Wales	Cambrian slates	Sedgw. G. P. iv. pt. 1. p. 220
(*Acroura*, Ag.)	*prisca* (*Ophiura*, sp.), Munst.	Germany	Muschelkalk	Goldf. t. lxii. f. 6.
Aspidura, Ag.	*loricata* (*Ophiura*, sp.), Munst.	Germany	Muschelkalk	Goldf. t. lxii. f. 7.
Ophioderma, M. & T.	*tenuibrachiata*, Forb.	England	Lias	
Ophioderma, M. & T.	*Milleri*, Phill.	England	Lias	Phil. Geol. Y. i. t. 13. f. 30
Ophiura, Lam.	*Murravii*, Forb.	England	Marlstone	
Ophioderma, M. & T.	*Egertoni* (*Ophiura*, sp.), Brod.	England	Inf. oolite	Brod. G.T. 2. ser. v. t. 12. f. 5, 6.
Amphiura, Forb.	*Pratti*, Forb.	England	Oxford clay	
Amphiura?	sp.	England	Oxford clay	
Ophiura, Lam.?	*speciosa*, Munster	Germany	Solenhofen slate.	Goldf. t. lxii. f. 4.
Ophiura, Lam.?	*carinata*, Munster	Germany	Solenhofen slate.	Goldf. t. lxii. f. 5.
Ophiura, Lam.	*Cunliffei*, Forb. MSS.	S. India	Greensand	(in Mus. G. Soc.)
Ophiura, Lam.?	*granulosa*, Roemer	Hanover	Lower chalk	Roemer, K. G. t. vi. f. 22.
Ophiura, Lam.	*serrata*, Roemer	Hanover / England	Lower chalk / White chalk	Roemer, K. G. t. vi. f. 23.
Ophiura, Lam.?	sp. nov.	England	London clay	Wetherell, G. P. i. p. 417
Ophiura, Lam.	*libanotica*, Koenig	Syria	Miocene?	Koenig, Ic. Sect. p. 2. f. 26

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY OF LONDON.

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Nov. 15, 1843.—G. T. Vigne, Esq. of Woodford, Essex, was elected a Fellow of this Society.

"On some Fossil Remains of Anoplotherium and Giraffe, from the Sewalik Hills, in the north of India." By H. Falconer, M.D., F.G.S., and Capt. P. T. Cautley, of the Bengal Artillery, F.G.S.

In continuation of their former researches on the fossil remains of the Sewalik Hills, the authors, in their present communication, establish, on the clear evidence of anatomical comparison, certain discoveries which, in previous publications, they had either merely announced, or had supported by proofs professedly left incomplete. They now demonstrate that there occur in the remarkable tertiary deposits of the Sewalik range, together with the osseous remains of various other vertebrate animals, bones belonging to the two genera, Anoplotherium and Giraffe: the former genus determined by Cuvier from parts of skeletons dug out from the gypsum beds of Paris; the latter genus known only as one of man's contemporaries, until, in the year 1838, the authors gave reason for believing its occurrence in the fossil state.

The specimens now figured and described form part of the collection which was made by the authors on the spot, and is now deposited in the British Museum. They were found, together with remains of Sivatherium, Camel, Antelope, Crocodile, and other animals, in the Sewalik range to the west of the river Jumna.

The bones are found imbedded either in clay or in sandstone. When clay is the matrix, they remain white; and, except in being deprived more or less completely of their animal matter, they have undergone little alteration. The bones in this state the authors have elsewhere designated as the "soft fossil." When sandstone is the matrix, the animal matter has completely disappeared, and the bone is thoroughly mineralized and rendered nearly crystalline by the infiltration of siliceous or ferruginous matter, and acquires a corresponding hardness, or tinge of iron, with increased specific gravity. The matrix in contact with the bone is rendered compact and crystalline in texture. The remains in this state have been designated by the authors as the "hard fossil."

The remains of Anoplotherium and of the larger species of Giraffe, described in the present communication, belong to the "soft fossil;" those of the smaller species of giraffe to the "hard fossil."

Anoplotherium.—The occurrence, in the Sewalik deposits, of bones belonging to this genus, was announced by the authors in their 'Synopsis of the fossil genera from the upper deposits of the Sewalik hills,' published in the 4th volume of the Journal of the Asiatic Society of Bengal, in the year 1835; and the same fact was afterwards referred to in the 6th volume, p. 358, of that journal. In these communications the species was not described, but was named provisionally, *A. posterogenium.* In a communication made to the Geological Society in the year 1836, descriptive of a quadrumanous fossil remain, and published in the 5th volume of the 2nd series of their Transactions, the same species was mentioned under the name of *A. Sivalense,* a term which the authors propose to retain, in accordance with the principle they adopted in the cases of the horse, camel, hippopotamus, &c., of connecting the most remarkable new species of each fossil Sewalik genus with the formation itself.

In their present communication the authors purposely abstain from entering on the anatomical characters of this new species further in detail than is barely sufficient for its determination; and they therefore confine their notice to two fine fragments of one head, one fragment (Pl. II. fig. 1.) belonging to the left upper jaw; the other fragment (Pl. II. fig. 2.) to the right upper jaw.

By a happy chance the teeth are beautifully preserved. The age of the individual, which was just adult, was the best that could be desired to show the marks characteristic of the genus; for the teeth had attained their full development, though the two rear molars had hardly come into use.

Pl. II. fig. 1. p is a horizontal view of the left upper jaw, comprising the six back molars. These teeth were subjected to a rigid comparison with a cast from the jaw of *Anoplotherium commune,* figured by Cuvier in the 3rd volume of the 'Ossemens Fossiles,' (pl. 46. fig. 2), and also with casts from the corresponding molars of *Chalicotherium Goldfussi,* figured by Kaup in the 2nd livraison of his 'Ossemens Fossiles,' (pl. 6. fig. 3–5 and 8–10), between the teeth of which two extinct quadrupeds those of the Sewalik fossil are intermediate in size. In general form and in the principal distinctive marks they agree closely with the teeth of the typical European species of Anoplotherium, as described by Cuvier; but they differ from those types in some particulars requiring special notice: they are closely allied to the teeth of the Chalicotherium of Kaup.

The three rear molars considerably exceed, in all their dimensions, the corresponding teeth of *A. commune*; and the two rear molars also differ from the corresponding teeth of *A. commune* in the following respect, that their width is greater than their length. This proportional compression lengthwise belongs to the last two premolars of the Sewalik fossil, and it holds also with the back molars of the Chalicotherium. The outer surface presents, both vertically and horizontally, the usual double chevron, or W-form of Anoplotherium, with the three salient vertical bulges swelling up from the base to the crown; but with this difference from Anoplotherium, that the surface of the re-entering angles is more inclined inwards. The latter point is one of agreement with Chalicotherium, in which the outer ridge of the crown is so inflected as to be brought into the middle of the plane of the tooth. The interspaces forming these re-entering angles are more unequal than in *A. commune*, the anterior one being much the broader. The posterior one in the last molar is placed very obliquely, sloping backwards and inwards. In these respects also the fossil agrees closely with Chalicotherium. The vertical bulges, more especially the rear one of the last molar, are slightly notched near the apex into a lobule of the enamel, but much less so than in Chalicotherium. In consequence of the progress of wear being more advanced in the two other back molars, they show no indications of this notch.

From the great inflexion of the outer surface, the longitudinal ridge of the crown is strongly zigzaged. The apex of the anterior re-entering angle gives off a transverse ridge, which is much inclined downwards, and joins on with the base of the isolated conical cusp (a, a', a'') in the anterior and inner corner of the tooth, a cusp characteristic of Anoplotherium. In the Sewalik species, as in Chalicotherium, this cusp is much larger, more pointed, surrounded by deeper hollows, and more in relief than it is in *A. commune.* It is even more developed than in Chalicotherium. The apex of the posterior re-entering angle gives off a like transverse ridge which sweeps round into the posterior side, and forms in the germ a sort of three-sided pyramid, connected by a low ridge with the cusp. The anterior border of the crown is formed of a similar low ridge, sweeping round to the inner side of the cusp, upon which it terminates near the middle of the cusp. This ridge is less developed than in *A. commune.*

The penultimate and antepenultimate are so like the last molar, that the authors deem it sufficient to refer to the figures. The penultimate is the largest of the three, and the antepenultimate considerably the smallest. There is in all the three molars a strong development of the cusp; though, from the different stages of wearing, it shows differently in the several teeth. In the back tooth it is intact and has a sharp edge; in the penultimate the point is just worn off into a slight oblique facet; in the antepenultimate it is ground low down into a circular depressed disc, surrounded by a ring of enamel.

The other teeth in the specimen (Pl. II. fig. 1.) are the last three false molars. What was the entire number of this series, whether it extended to four, as in *A. commune,* or was limited to three, the specimen affords no certain indication. If there was a fourth tooth (which is most probable), it must have been in a rudimentary or reduced state, as in the rhinoceros, and must have been disconnected from the rest of the series by being placed somewhat forwards in a diasteme; for no indication is obtained, from the appearance of the anterior tooth, or from remains of any alveolus, that there was another tooth close in front of the sixth. These three premolars, taken in succession from rear to front, diminish rapidly in size; and in the aggregate are much shorter than the same three teeth in *A. commune,* the joint length in the Sewalik fossil being 1·8 inch, whereas in the smaller jaw of *A. commune* it is 2·3 inches. In the latter, as is the case in the ruminants, the anterior premolars are narrow and elongated; in the Sewalik fossil they are short and wide. This general condensation of the premolars adds to the probability of the existence of a vacant diasteme. All the premolars exhibit, in a well-developed form, the characteristic cusp. The posterior two have their outer surface flat or slightly convex; and they contract inwards towards the cusp in a subcuneiform shape, the cusp and inner side being bounded by a low basal ridge.

The antepenultimate premolar of the Sewalik fossil is somewhat different from the two others, being much smaller, and contracting upwards into a trenchant edge. The cusp is connected by a transverse ridge with the main ridge of the crown, and the basal ridge is reduced to a small mammilla in front of the cusp.

Pl. II. fig. 2. represents the outside of the right upper jaw, comprising the four back molars, and is an exact counterpart, so far as it goes, of the left upper jaw.

There is little else shown by this specimen than what regards the teeth. The muzzle appears to have fined off rather abruptly in front of the malar protuberances, and the orbit to have been advanced more forward on the face, and to have been more depressed below the brow than in *A. commune**. The upper orifice of the suborbitary canal is seen opening behind the anterior angle of the orbit, the floor of which appears to have extended behind the post-orbitary processes.

The dimensions, as compared with those of *A. commune*, and *Chalicotherium Goldfussi*, are as follow:—

	A. Sivalense.	*A. commune.*	*Ch. Goldfussi.*
	Inches.	Inches.	Inches.
Length of the series of 6 molars	5·5	5·5	
Ditto 3 true molars	3·7	3·2	
Ditto 3 premolars.........	1·8	2·3	
Length of the last true molar	1·3	1·2	1·8
Width of ditto	1·5	1·2	1·94
Length of the penultimate true molar......	1·4	1·2	
Width of ditto	1·55	1·1	
Length of the antepenultimate true molar.	1·1	1·	
Width of ditto	1·1	1·1	
Length of the last premolar.................	0·75	0·65	
Width of ditto	0·88	0·75	
Length of the penultimate premolar	0·70	0·90	
Width of ditto	0·80	0·62	
Length of the antepenultimate premolar..	0·55	0·75	
Width of ditto	0·55	0·50	
Height of the last molar	1·1	0·65	0·87

These measurements show the Sewalik species to have been larger than *A. commune*, and smaller than *Ch. Goldfussi*. One of the most

* See Ossemens Fossiles, tom. 3. tab. 57. fig. 1.

striking points in which it differs from the two latter terms of comparison, is in the dimensions of its back molar, which, with the same amount of wear, is about half an inch higher than in *A. commune,* and in this respect considerably exceeds even the longer and wider tooth of the Chalicotherium.

	Length.	Width.	Height.
A. Sivalense	1·3	1·5	1·1
A. commune	1·2	1·2	0·65
Ch. Goldfussi	1·8	1·94	0·87

On the whole, the Sewalik species appears to be most closely allied to the *Chalicotherium Goldfussi.* The existence of a vacant diasteme in front of the anterior tooth would constitute a difference from the Anoplotherian type of some importance. The characters generally show a return from the ruminant tendencies of the Cuvierian species back to a more pachydermatous type, and a closer affinity with the rhinoceros, between which and *A. commune* it may ultimately prove to be an intermediate form. Until the evidence for separation is conclusive, the authors suggest leaving it with the genus Anoplotherium. The *A. commune* was determined by Cuvier to be of the size of a small ass; the *A. Sivalense* would rank in dimensions between a horse and the small Sumatran Rhinoceros.

Remarks on Chalicotherium.—Kaup appears to have founded this genus, as distinct from Anoplotherium, on real or supposed differences, 1st, in the rear molars; 2nd, in the incisors; 3rd, in the canine. The difference in the rear molars consists in the size of the lobule of the enamel into which the vertical bulges, near the apex, are notched; this character indicates, as he conceives, an affinity with the Tapir and Lophiodon. But this lobule, even if constant, does not appear to the authors of sufficient importance to constitute the basis of a generic distinction. The general form of the rear molars of both the upper and lower jaws is only an enlarged and less rectangular representation of those of Anoplotherium. Moreover, in the direction of the ridges of the crown, and in the insulation of the conical cusp, the accordance between Chalicotherium and Anoplotherium is complete. As to the second distinction, drawn from the supposed form of the incisors, the detached tooth which he figures and describes as a lower incisor (Oss. Foss. livraison ii. p. 30. pl. 7.), judging from the figures and from a cast which the authors have examined, very closely resembles, both in form and in the development of the crown, the penultimate premolar of the *A. Sivalense.* The channeled sides and the bifid extremity of the fang, indicating two confluent fang roots, and the complicated form of the crown with three mammillæ on the inside, appear to the authors strongly to militate against regarding the tooth as an incisor. They therefore consider this tooth as an upper premolar (and probably as the penultimate one) of the right side.

As to the third distinction, drawn from the canine teeth, judging from a cast of the detached fragment which Kaup describes and figures as the canine of *Ch. Goldfussi,* the authors consider that determination as problematical. It seems to them to bear a resemblance in form rather to the lower incisor of an animal allied to Rhinoceros. They advance these doubts with the utmost deference to the distinguished author.

Remarks on the Genus Anoplotherium.—The true Anoplotheria of Cuvier (of which *A. commune* may be regarded as the type), together with the *A. Sivalense* and the *Chalicotherium* (Anoplotherium ?) *Goldfussi*, are allied, by their dentition, to Rhinoceros. The Dichobunes, *A. Leporinum, A. murinum* and *A. obliquum*, Cuvier arranges with considerable doubt, and provisionally only, among the Anoplotheria. He considers it not impossible that the two latter species were small *ruminants*. The *A. cervinum* of Professor Owen (Geol. Trans. 2nd ser. vol. vi. p. 45), obtained by Mr. Pratt from Binstead in the Isle of Wight (Idem. vol. iii. p. 451), is admitted on all hands to be exceedingly like a musk deer. Such heterogeneous materials are too much for the limits of any one genus. Cuvier imagined the separation of the two metacarpal bones to be a character limited to the Anoplotheria exclusively. He has also regarded the union of the metacarpal bones as holding without exception in all the ruminants; and this law with respect to ruminants, though empirical, he regards as equally certain with any conclusion in physics or morals, and as a surer mark than all those of Zadig (Disc. Prel. p. 49).

The authors, having had an opportunity of examining the skeleton of an African ruminant, the *Moschus aquaticus* of Ogilby, described in the Proceedings of the Zoological Society by that gentleman from a living specimen, found it wanting in the above supposed essential character of the ruminants, and possessing the above supposed distinctive character of Anoplotherian Pachyderms. Its metacarpals are distinct along their whole length; its fore leg, from the carpus downwards, is undistinguishable from that of the peccary; and its succentorial toes are as much developed as in the last-mentioned animal.

The deviation from the ordinary ruminant type, indicated by the foot of this Moschus, is borne out by a series of modifications in the construction of the head and in the bones of the extremities and trunk, all tending in the direction of the pachyderms.

The authors believe the present to be the first announcement of the existence of such an anomaly in any living ruminant: they had previously ascertained the occurrence of the same structure in a fossil ruminant from the Sewalik hills. As the Dorcatherium of Kaup breaks down the empirical distinction between the ruminants and pachyderms, as regards the number of the teeth, so does the *Moschus aquaticus* as regards the structure of the feet.

Giraffe.—In the 7th volume of the Journal of the Asiatic Society of Bengal (pp. 658–660) is a communication dated "Northern Doab, July 15, 1838," and intituled, "Note on a Fossil Ruminant Genus allied to Giraffidæ, in the Sewalik hills, by Capt. P. T. Cautley." The specimen referred to in that paper was the third cervical vertebra of a ruminant, which, for the reasons therein assigned, was supposed to have been a giraffe. At that time the authors of the present communication had not access either to drawings of the osteology or to a skeleton of the existing giraffe: but the grounds for referring the vertebra to that genus were, that it belonged to a ruminant with a columnar neck, the type of the ruminants being preserved, though very attenuated in its proportions: that the animal was very distinct from any of the camel tribe: that it was in the giraffe that there existed such a form most aberrant from the mean in respect of its great elongation. That the bone belonged to a giraffe was put forth at the time as only a probable inference, and chiefly to serve as an index to future inquiries.

The authors, having since the former period obtained additional specimens, and had access to the fullest means of comparison, are now able to place on the record of determined Sewalik fossils, one very marked species of giraffe, and also indications of a second species, which, so far as the scanty materials go, appears to come near to that of Africa.

The first specimen to which they refer is the identical vertebra noticed by Capt. Cautley in 1838. (See Pl. III. fig. 1–5.) It is an almost perfect cervical vertebra. It were needless to enter on the characters which prove it to have belonged to a ruminant. Its elongated form shows that it belonged to one with a columnar neck; that is to say, either to one of the camel and Auchenia tribe, or to a giraffe, or to some distinct and unknown type. The fossil differs from the vertebra of a camel, 1st, in the position of the vertebrary foramina (a, a'); 2nd, in the obsolete form of the upper transverse processes. According to the masterly analysis of the Macrauchenia by Professor Owen, the Camelidæ and Macrauchenia differ from all other known mammalia in the following peculiarity; that the transverse processes of the six inferior cervical vertebræ are without perforations for the vertebrary arteries, which enter the vertebrary canal along with the spinal chord, then penetrate the superior vertebrary laminæ, and emerge on the canal again close under the anterior oblique processes. This structure appears on the cervical vertebræ of the Sewalik fossil camel. In the vertebra now under consideration, on the contrary, the foramina (a, a') maintain their ordinary position, that is, they perforate the transverse processes, and appear on the surface of the body of the vertebra.

Since the bone therefore does not belong to a camel, is it the bone of a giraffe? There is preserved in the museum of the Zoological Society the skeleton of a young Nubian giraffe which died at the Society's gardens. When its third cervical vertebra is placed in apposition with the fossil, the two are found to agree in every general character, though they disagree in some of their proportions, and in certain minor peculiarities. In this young and immature giraffe the length of the third cervical vertebra is 7½ inches; what, then, is the length of this bone in the adult Nubian giraffe? The authors, from their not having had under their examination this vertebra of an adult animal, have been unable to ascertain this point directly; but they are able to infer it, from the length of a detached bone preserved in the museum of the Royal College of Surgeons of London, which is the second cervical vertebra of a giraffe, nearly, but not quite full-grown*. The length of this bone is $11\frac{1}{2}$ inches. Now in the skeleton of the young giraffe belonging to the Zoological Society the 2nd and 3rd cervical vertebræ are exactly of the same length. The authors infer, therefore, that in an animal nearly full-grown, such as was that to which the detached bone at the College of Surgeons belonged, the length of the 3rd cervical vertebra is $11\frac{1}{2}$ inches; and consequently, that the length of the same bone in an animal which has reached full maturity, is about 12 inches†.

That the fossil vertebra belonged to an adult which had long attained its full size, is shown by the complete synostosis of the upper and lower articulating surfaces, by the strong relief of the ridges and the depth of the muscular depressions. But the length of this bone is only a little more than eight inches. As the other dimensions of the fossil and recent vertebræ that the authors placed in apposition, are nearly in proportion to their respective lengths, it follows that this fossil species of giraffe was one-third shorter in the neck than an adult of the existing Nubian variety.

But it was not only in size that the two giraffes differed; they differed also in their proportions. In the young giraffe at the Zoological Society the vertebra, which is $7\frac{1}{2}$ inches long, has a vertical diameter of 3·8 inches; whereas in the fossil species the vertebra, which is 8 inches long, instead of having a vertical diameter exceeding 4 inches (as it ought, if its breadth were proportional to its length), has a vertical diameter of only 3·6 inches. This goes to prove that in this fossil giraffe the neck was one-tenth more slender in proportion to its length than the neck is in the existing species.

The inferior surface of the body of the vertebra is more curved longitudinally in the fossil than it is in the recent bone; the height of the arc in the former case being to the height in the latter as 3 is to 2.

On the under surface of the fossil vertebra a very distinct longitudinal ridge (*b*) runs down the middle, and this ridge is wanting in the recent bone; but this difference, probably, is chiefly owing to difference of age.

In the fossil vertebra the upper articulating head (*c*) is very convex; for with a transverse diameter of 1·4 inch it has a vertical height of 1 inch: laterally it is a good deal compressed. (See Pl. III. fig. 4.)

The posterior articulating surface (*d*) forms a perfectly circular cup, two inches in diameter; and this diameter, in the immature Nubian giraffe, is one-tenth greater, although the vertebra is one-sixteenth shorter. This affords a further proof of the comparative slenderness of neck in this fossil species.

In regard to the apophyses, the inferior transverse processes (*i, i*) are sent off downwards and outwards from the lower part of the

* This appears from the detached state of the upper and lower articulating heads of the bone.

† The height of the skeleton of the young giraffe in the museum of the Zoological Society is $10\frac{1}{2}$ feet; that of a full-grown Nubian giraffe is 16 feet.

anterior end, exactly as in the recent species, and they are developed to nearly the same amount of projection. There is, however, this considerable difference, that whereas in the recent species they do not run half-way down the body of the vertebra, in the fossil they are decurrent along the whole of its length in well-marked laminar ridges, which are confluent with the nearly obsolete ridges of the upper transverse processes, the united mass near the posterior end being dilated into two thick alæform expansions (*e*, *e*).

In the fossil, as in the recent bone, the superior transverse processes are seen only in a rudimentary state; in the former, however, they run forwards across the body with less obliquity, and consequently make the canals for the vertebrary arteries twice as long as they are in the recent bone. In the fossil the orifices (*a*, *a'*) of these canals divide the length of the vertebra into three nearly equal portions; whereas in the recent bone the orifices are both included within its anterior half.

The anterior oblique processes (*f*, *f*) have the same general form and direction both in the fossil and recent species; but in the former they are considerably stouter and larger, and their interspace is less. The articular surfaces are convex, and are defined exactly as in the recent species.

The posterior oblique processes (*g*, *g*) of the fossil differ in form very little from those of the recent bone; in the fossil, however, the articular surfaces are considerably larger; and the ridges in which they are continued along the side of the upper vertebrary arch, are much less convergent than in the recent bone; so that in the latter this part is somewhat heart-shaped; whereas in the fossil it is nearly oblong, and "looks squarer," so to speak.

The spinous process (*h*) in the fossil is the same thin triangular lamina that is seen in the recent species; and it differs only in having its most prominent point lower down on the arch.

The spinal canal is very much of the same form and dimensions in both the fossil and the recent vertebra. At this point some of the matrix remains attached to the fossil bone, and prevents any very precise measurement.

As a minor point of agreement between the fossil and recent bones, it may be noted that, in both, the foramen (*k*) for the small nutritious artery on the inferior side of the body of the vertebra is on the right. In the other cervical vertebræ of the recent skeleton, this solitary foramen is on the left.

From the above comparisons it appears that the fossil vertebra, while it is very distinct from that of a camel, fulfils all the conditions required for a strict identification with that of a giraffe; that its peculiarities are not of greater than specific importance; and consequently do not warrant its being referred to a distinct and unknown type among the ruminants.

The following are the dimensions, in detail, of the third vertebra in the adult Sewalik fossil and in the immature Nubian Giraffe, $10\frac{1}{2}$ feet high, in the museum of the Zoological Society:—

	Sewalik Fossil. Inches.	Nubian Recent. Inches.
Length between the ends of the oblique processes	8·1	7·5
Length of the body of the vertebra between the articulating heads	7·8	
Greatest width at the posterior end of the body, between the transverse processes	3·1	2·8
Least width at the middle of the body, between the upper transverse processes	1·65	1·6
Width between the outer margins of the upper oblique processes	2·65	2·55
Width of sinus between the upper oblique processes	1·1	1·2
Width between outer edges of posterior oblique processes	2·5	2·3
Least width of spinal arch between the ridges connecting the upper and lower oblique processes	1·25	1·0
Vertical diameter, posterior end of vertebra	3·6	3·8
Vertical diameter, anterior end, between the inferior border articulating head and upper margin spinal canal	2·6	2·7
Antero-posterior diameter articulating head	1·9	1·55
Transverse diameter articulating head at the middle	1·4	1·5
Greatest diameter articulating head	1·4	1·8
Vertical height articulating head	1·0	
Length of articulating surface, lower oblique process	1·6	1·2
Width of ditto	1·0	0·8
Length of articulating surface, upper oblique process	1·2	0·85
Width of ditto	0·8	0·7
Vertical diameter, spinal marrow, posterior end	1·25	
Vertical diameter, articulating cup, posterior end	2·0	2·2
Transverse diameter...... ditto........... ditto	2·0	2·3
Diameter upper transverse processes	0·8	0·7

Hence the authors conclude that there belonged to the Sewalik fauna a true well-marked species of giraffe closely resembling the existing species in form, but one-third less in height, and with a neck proportionately more slender; and for this small species they propose the name *Camelopardalis Sivalensis*.

Second Fossil Species of Giraffe.—The fossil specimens next to be described have been in the possession of the authors ever since 1836. They are fragments from the upper and lower jaws of another fossil species of giraffe, in which the teeth are so exactly of the same size and form with those of the existing species, and so perfectly resemble them in every respect, that it requires the calipers to establish any difference between them.

The largest specimen (Pl. II. fig. 3 *a*. 3 *b*.) is a fragment of a left upper jaw containing the two rear molars. The back part of the maxillary, beyond the teeth, is attached, and clearly proves that they belonged to a full-grown animal. These teeth were compared with the teeth, in the same stage of wearing, contained in the head of an adult female giraffe belonging to the museum of the College of Surgeons, and the fossil and recent teeth were found to agree together in the most minute particulars. The following are the corresponding dimensions of the fossil and recent teeth:—

	Fossil. Inches.	Recent. Inches.
Joint length of the two back molars, upper jaw	2·5	2·55
Greatest width of last molar	1·4	1·3
Ditto ditto of penultimate molar	1·45	1·35

The second specimen (Pl. II. fig. 4.) is the rear molar of the right upper jaw, corresponding exactly in size and form with that of the left side, but if anything, rather more worn, and belonging therefore, probably, to a different individual. The agreement extends down to the small cone of enamel at the base of the hollow between the barrels on the inside. Its dimensions are:—

Length	1·2 inch.
Width	1·4

The third specimen (Pl. II. fig. 5 *a*. 5 *b*.) is a fragment of the left lower jaw, containing the last molar. It has precisely the form and proportions of the corresponding tooth in the left lower jaw of the female head referred to, and the same development of its third barrel or heel, which is always found in this tooth in ruminants. Its dimensions are:—

Length	1·7 inch.
Greatest width	1·0

The fourth specimen (Pl. II. fig. 6.) is the last false molar of the left lower jaw, detached. It agrees closely with the corresponding tooth in the recent female head above referred to. This tooth is thicker in proportion to its length in the giraffe than in other ruminants, and this constitutes one of the most distinctive characters of the giraffe's premolars. The anterior semibarrel appears a trifle longer than the corresponding tooth of the recent animal; but this is owing to a difference of wear, and is not borne out by measurement. The dimensions are:—

	Fossil.	Recent.
Length	1·0 inch.	1·0 inch.
Breadth	0·9	0·86

The authors are possessed of the same tooth of the right lower jaw, detached; but have not thought it necessary to figure it.

The fifth specimen (Pl. II. fig. 7.) is the penultimate false molar of the right upper jaw. It is of the same size and form with the corresponding tooth in the recent female head, with this difference, that it has three tubercles at the inside of the base. On a sixth specimen of the first false molar of the right upper jaw, which is not represented among the figures, there are three similar tubercles similarly placed. It would require an extensive comparison of recent heads to determine what value attaches to this peculiarity; whether the tubercles are constantly absent from the teeth of the recent species, or appear occasionally as a variation on those of individuals. The dimensions of the penultimate false molar of the upper jaw are:—

	Fossil.	Recent.
Length	1·0 inch.	0·95 inch.
Breadth	1·12	1·12

There is a peculiar, finely reticular, striated and rugose surface to the enamel of the teeth of certain quadrupeds, the appearance of which the authors compare to that of a fine net, forcibly extended, so as to bring the sides of the meshes together. This texture they formerly described as existing on the surface of the molars of the Sivatherium. It is found also on the teeth of the recent giraffe, and is more or less conspicuous on those of the hippopotamus. It is not observed in the camel, the moose deer, or the larger bovine ruminants; or if ever present, it is but faintly developed. This texture is well marked on the enamel of the teeth of this second species of giraffe. A magnified representation of it is given in Pl. II. fig. 3 *c*.

The series of teeth last described, excepting the fifth and sixth specimens, are all but undistinguishable from those of the Nubian giraffe; and the authors have sought in vain for any distinctive character by which to discriminate them. There is no good evidence to show that this fossil species and the living are even different; but in putting the case thus, the authors are far from advancing that the species are identical. The materials are far too scanty to warrant a conjecture to that extent.

Since the neck of the *C. Sivalensis* was one-third too short and slender to sustain the head that would have suited the teeth last described, the authors consider it a necessary consequence that these teeth belonged to a distinct species. Had the difference been less considerable, they might have hesitated regarding this conclusion; but the difference between 8 inches and 12 inches in the length of the same cervical vertebra of two adult animals of the same genus, admits, in their opinion, of no other construction than distinctness of species. For the present, until sufficient materials shall be obtained to determine the relationship between the African giraffe and the second Sewalik species, in reference to their supposed resemblance, the authors propose to mark the latter by the provisional name of *Camelopardalis affinis*.

General Remarks.—In a former communication to the Society, (Geol. Trans. 2nd ser. vol. v. p. 503) the authors noticed the remarkable mixture of extinct and recent forms which constituted the ancient fauna of Northern India. An extinct testudinate form, *Colossochelys Atlas*, as enormous in reference to other known Chelonians as the Saurians of the lias and the oolite are to their existing analogues, is there associated with one or more of the same species of crocodile that now inhabit the rivers of India. The evidence respecting one of these species of crocodile, resting as it does on numerous remains of individuals of all ages, is considered by the authors as nearly conclusive of the identity of the fossil with its recent analogue. These reptiles occur together with extinct species of such very modern types as the monkey, the camel, the antelope, and (as has now been shown) the giraffe: and these are met by species of the extinct genera Sivatherium and Anoplotherium. As regards the geographical distribution of the true Anoplotheria, those hitherto discovered have been confined, as the authors believe, to Europe; and as regards their geological distribution, to the older and middle tertiaries. In India this genus continued down to the period when existing Indian crocodiles and probably some other recent forms had become inhabitants of that region.

It might be expected that in a deposit containing Anoplotherium, Palæotherian remains also would sooner or later be discovered. However, among the very large collection of fossil bones from the tertiary sub-Himalayan range, made by the authors during ten years in that part of India, they have never found a single fragment of a head or tooth which they were able to refer to Palæotherium. This is merely a negative result, and only proves the rarity of that form*.

Although there occur among the Sewalik fossils abundant remains of almost every large pachydermatous genus, such as the elephant, mastodon, rhinoceros, hippopotamus, sus, horse, &c., yet no remain has been found referrible to the Tapir, a fact the more remarkable, inasmuch as one of the only two existing species of that genus is now confined to the larger Indian islands and a part of the adjoining continent.

The finding of the giraffe as a fossil, furnishes another link to the rapidly increasing chain which (as the discoveries of year after year evince) will sooner or later connect extinct with existing forms in a continuous series. The bovine, antelope, and antlered ruminants have numerous representatives, both recent and fossil. The camel tribe comprises a considerable fossil group, represented in India by the *Camelus Sivalensis,* and is closely approached to in America by extinct Pachydermatous Macrauchenia. The giraffe has hitherto been confined, like the human race, to a single species, and has occupied an isolated position in the order to which it belongs. It is now as closely represented by its fossil analogues as the camel; and it may be expected that, when the ossiferous beds of Asia and Africa are better known, other intermediate forms will be found, filling up the wide interval which now separates the giraffe from the antlered ruminants, its nearest allies in the order according to Cuvier and Owen†.

The giraffe throws a new light on the original physical characters of Northern India; for whatever may be urged in regard to the possible range of its vegetable food, it is very clear that, like the existing species, it must have inhabited an open country, and had broad plains to roam over. In a densely forest-clad tract, like that

* Mr. M'Clelland in his paper on *Hexaprotodon* (Journ. Asiatic Society of Bengal, vol. vii. p. 1046) casually mentions a species of Palæotherium as occurring among the Sewalik fossils. But he does not describe or figure the specimen. Messrs. Baker and Durand in their remarks appended to their catalogue of the Dadoopor collection (Idem, vol. v. p. 836), mention four specimens containing teeth of the upper and lower jaws belonging to what they provisionally designate "Cuvierian genera:" in regard to one of which, having the upper and lower jaws in contact, they state that, "although it affords some analogies both to the Palæotherium and Anoplotherium, its essential peculiarities are sufficiently remarkable to cause it to be separated from either genus." Till these specimens are either figured or described, the point must remain undecided in regard to Palæotherium being represented in the Sewalik fauna.

† M. G. de St. Hilaire, in his zeal for the mutability of species, imagined that he had detected in the Sivatherium the primeval type which time and necessity had fined down into the giraffe. Anatomical proofs were all against this inference; but if a shadow of doubt remained, it must yield to the fact, that in the Sewalik fauna the Giraffe and the Sivatherium were contemporaries.

which now skirts the foot of the Himalayahs, it would soon have been exterminated by the large feline feræ, by the hyænas, and large predaceous bears which are known to have been members of the old Sewalik fauna.

Postscript.—Since the above remarks were submitted to the Society, M. Duvernoy's paper, embodying two communications read to the Academy of Sciences on the 19th May and 27th November last, has appeared in the January Number of the 'Annales des Sciences Naturelles.' These notices were published in the 'Comptes Rendus,' but were unknown to the authors at the time. M. Duvernoy describes the lower jaw of a fossil giraffe found in the bottom of a well, lying on the surface of a yellow clay, along with fragments of pottery and domestic utensils, in the court of an ancient donjon of the 14th century in the town of Isoodun, Département de l'Indre. Considerable doubt remains as to the bed and source whence the fossil was derived. M. Duvernoy attributes the jaw to a distinct species of giraffe, which he names *Camelopardalis Biturigum.* Professor Owen, from the examination of a cast, confirms the result, expressing his conviction "that in the more essential characters the Isoodun fossil closely approaches the genus Giraffe, but differs strikingly from the (*single*) existing species of the south and east of Africa, and that the deviations tend towards the subgenus Elk."

M. Duvernoy also mentions the discovery of a tooth in the molasse near Neufchatel, by M. Nicolet, determined by M. Agassiz to be the outer incisor of a fossil giraffe.—(*Duvernoy, Annales des Sciences Naturelles,* No. for January 1844.)

References to the Figures in the Plates.

Plate II. Fig. 1. *Anoplotherium Sivalense*; left upper jaw with the teeth seen from above; (*a a′ a″*) the conical cusp.
2. Ditto; upper jaw, right side, with the four back molars and part of the orbit.
3 *a.* *Camelopardalis affinis*; the last two upper molars; left side seen vertically.
3 *b.* Ditto, ditto; horizontal view of the crown.
3 *c.* Rugous reticulated surface of the enamel, magnified to twice the natural size.
4. Last upper molar of ditto, right side.
5 *a.* and *b.* Last molar of ditto; lower jaw, left side.
6. Last false molar of ditto; lower jaw, left side.
7. Second false molar; upper jaw, right side.

Plate III. Figs. 1–5. *Camelopardalis Sivalensis*; third cervical vertebra.
a a′. Orifices of the arterial canals.
b. Longitudinal ridge, underside of the body.
c c. Upper articulating head.
d. Lower articulating surface.
e e. Alæform expansions of the transverse processes.

f f. Superior oblique processes.
g g. Inferior ditto ditto.
h h. Spinous processes.
i i. Inferior transverse process.
k. Foramen of the nutritious artery.

N. B. The figures in both plates are drawn to the natural size, excepting fig. 3 *c*. of Plate II.

Fig: 3 a.

Fig: 3 b.

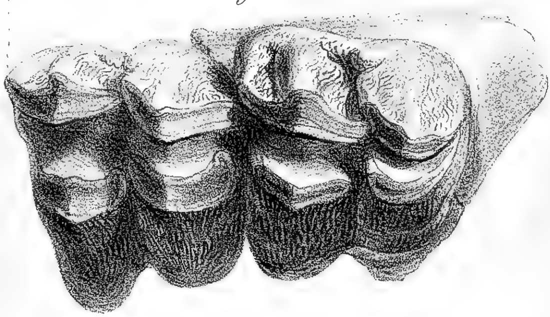

Fig: 5 b.

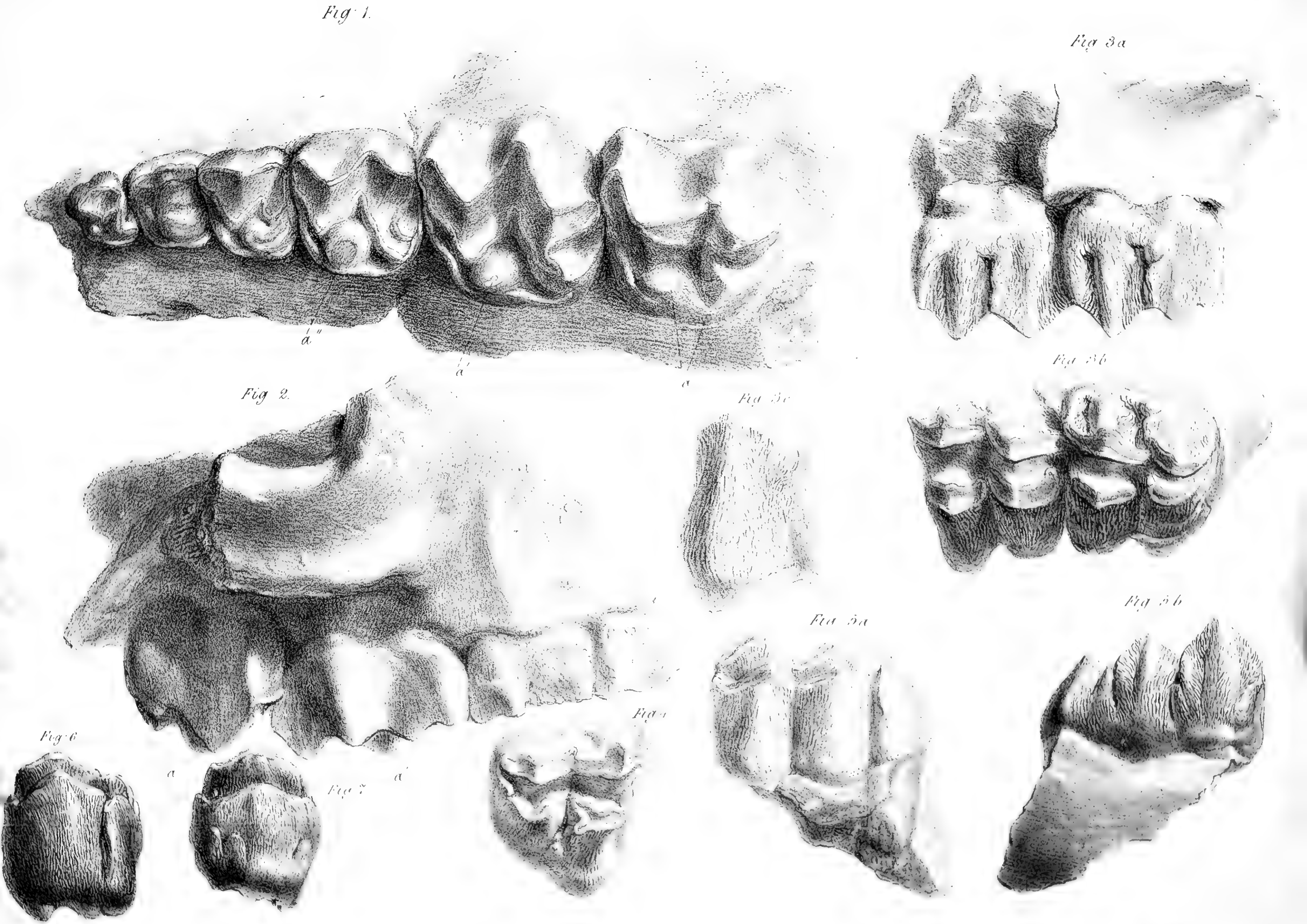

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Fig 1-2. Anoplotherium Sivalense
Fig 3-7 Camelopardalis affinis


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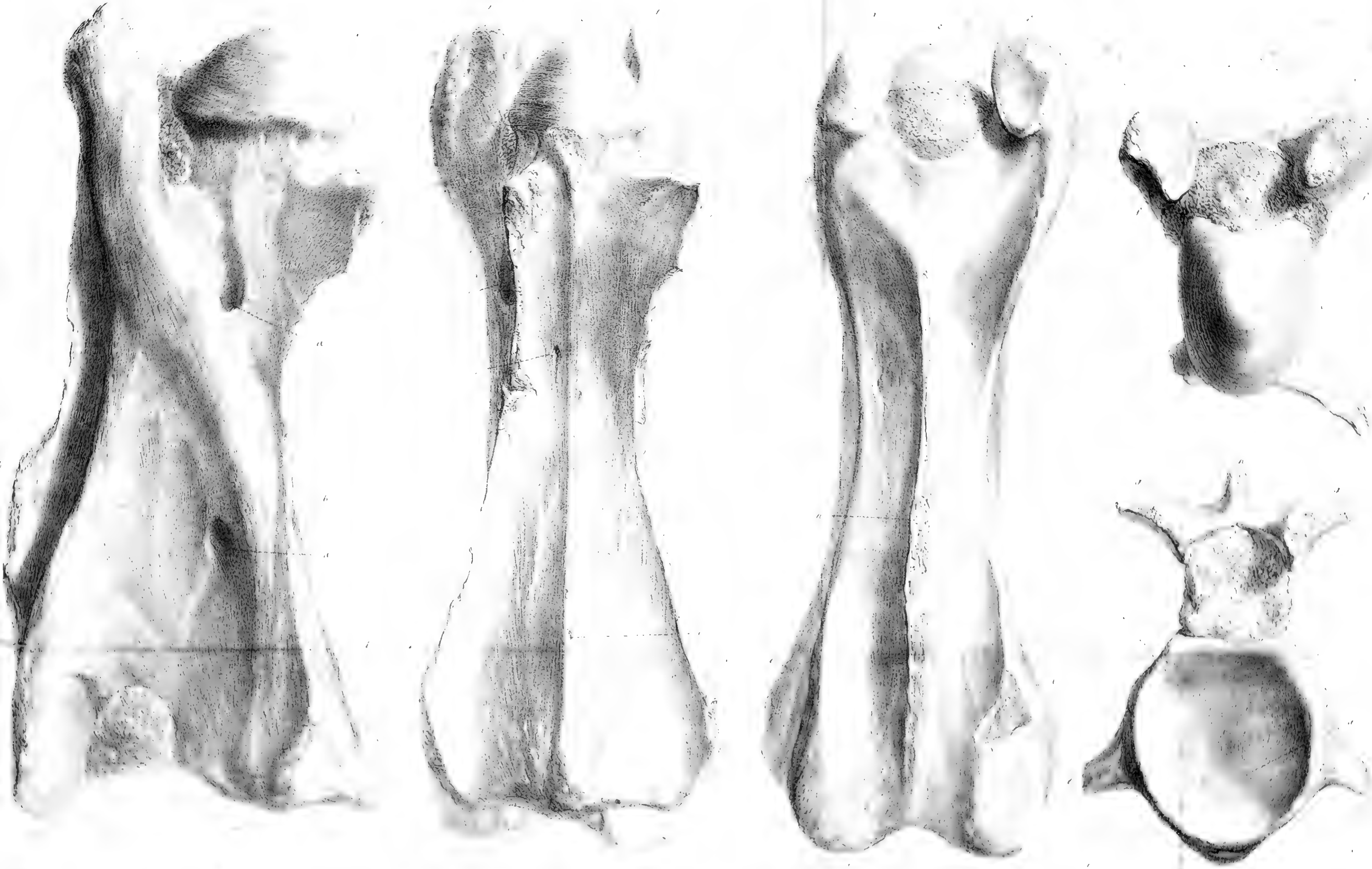


Camelopardalis Sivalensis.
Third cervical Vertebra

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY OF LONDON.

VOL. IV. PART II. 1843—1844. No. 99.

NOVEMBER 29, 1843.

Joseph Travis Clay, Esq., and Francis W. Jennings, Esq., were elected Fellows of this Society.

The following communication, a part of which had been read at the previous meeting, was concluded:—

On the OLDER PALÆOZOIC (*Protozoic*) ROCKS OF NORTH WALES. By the Rev. A. SEDGWICK, M.A., F.R.S., Woodwardian Professor of Geology and Fellow of Trinity College in the University of Cambridge.

§ 1. *Introduction.*

IN a paper read before the Geological Society in June, 1843, and intituled, "An Outline of the Geological Structure of North Wales,"* the author gave a description of those stratified rocks in the northern counties of the principality which are of anterior date to the mountain limestone. Those rocks he separated into the following three principal groups:—

1. Chlorite-slate and mica-slate. These form a band along the north-western side of the promontory of Carnarvonshire from Porth Dilleyn to Bardsea island.

2. Greywacke and roofing slate, often containing calcareous bands, and alternating with Plutonic rocks of cotemporaneous formation: and these rocks the author terms, in his present paper, the *Protozoic*, group. They extend in an east and west direction, from the borders of Shropshire to the western coast of Carnarvonshire; and their north-western boundary, from the confines of Shropshire to Yspytty Evan, coincides nearly with the Holyhead road; and from Yspytty Evan to Conway, with the Conway river.

3. An overlying and sometimes unconformable deposit of flag-

* Proceedings of the Geological Society, vol. iv. p. 212.

tone, &c., coterminous along the Holyhead road and Conway rivers with the last-mentioned principal group; but bounded towards the north-west by an overlying range of mountain limestone.

The present paper communicates the results of new researches which, in the company and with the assistance of his friend, Mr. J. W. Salter, the author made, during the summer of 1843, in the eastern portion of his former field of observation: his remarks on the present occasion being directed principally to the geological position and organic remains of the fossiliferous slates which lie to the east of the great Porphyry range of the Arenigs.

During these excursions, besides correcting the north-western boundary line of the rocks belonging to the second principal group, the author determined their southern boundary. That boundary follows a very sinuous course from the mountain limestone of Llanymynech hill, on the east, to the Dyfi near Mallwydd, on the west; whence it runs in a south-western direction, down the right or northern bank of that river for several miles. The boundary line of the protozoic rocks, both in the north and in the south, was laid down by the author and his companion on the Ordnance Map, from which they have been transferred to the small map annexed to the present Abstract.

The author has also materially improved the details of the sections which he formerly exhibited to the Society, and has greatly extended his lists of fossils. For the determining of these fossils, for the lists of them appended to this abstract, and for the general observations* which an examination of these lists has given rise to, he expresses himself indebted to Messrs. J. C. Sowerby and J. W. Salter, of whom the latter examined most of the localities where the fossils were obtained.

§ 2. *On the Calcareous Slates and Limestone of Glyn Dyffws on the Holyhead road, West of Corwen and of Rhiwlas, North East of Bala.*

In an endeavour to determine the position of the limestone of Glyn Dyffws, a series of calcareous and fossiliferous slates was traced from Cader Dinmael, on the north, through Glyn Dyffws and Pen-y-Cerrig, southward, to the hills on the left bank of the Merddwr brook, near Llwyn Onn. Here the strike was interrupted by enormous dislocations.

Calcareous slates, passing into limestone, again appear, to the south and west, at Llwyn Jolyn, Craigian-buchan-isaf, Llwyn-y-ci, and again, on the same line of strike, in the high grounds of the Rhiwlas estate N.E. of Bala, and lastly, about a mile above Bala, in the bed of the river Tryweryn. A part of this limestone band has been noticed by Mr. Sharpe.†

* In this Abstract the observations of Messrs. Sowerby and Salter are annexed to Professor Sedgwick's description of the geological position of the fossils; and, for distinction's sake, are printed in smaller type.

† Proceedings of the Geological Society, vol. iv. p. 10.

The above calcareous rocks, which may be termed those of Glyn Dyffws and Rhiwlas, might be supposed, from their proximity and almost uniform strike, to belong to one deposit; but no proof of such a connection is obtained by the evidence of sections, the interval between the above two series of localities being much disturbed and broken. Moreover, the fossils of the Rhiwlas beds, considered as a whole, appear to differ from those of Glyn Dyffws, which agree with those of the limestone band, known by the name of the "Bala limestone," on the eastern side of the lake. It is clear that the Rhiwlas limestone lies far below that of Bala; for the strike of the former passes a mile to the west of the western shore of the lake; and in that line of strike calcareous beds are found, though not in the form of limestone, agreeing, in respect of their organic remains, with the Rhiwlas series.

The fossils of Glyn Dyffws and Rhiwlas will be treated of in describing the first line of section.

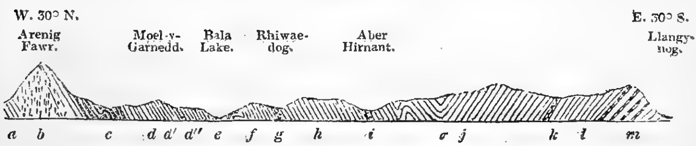
Fossiliferous bands, which occasionally pass into limestone, are also found at several places a little to the north-west of the localities which afford the Rhiwlas limestone. Those places are, 1. the valley above Pentre Cwmda; 2. a spot east of the mountain road between Garw fynydd and Moel Emoel; and 3. Eglws Anne in the forks of the Nant-y-Coegnant. Unless there be an inversion of the beds in all that district (and of such an inversion the author could perceive no indications) these last-mentioned calcareous bands must lie considerably below the Rhiwlas limestone.*

§ 3. *Transverse Sections across the Southern End of the Berwyn Chain.*†

Section I.

Arenig Fawr to the Tanat River at Llangynog.

Horizontal base 15 miles.



* At a still lower level, apparently, lie the non-fossiliferous bands of limestone, which occur at the following places:—

1. To the S.W. of Arenig Fawr, in the upper branches of the Lliw.
2. Near Hengwrt Uchaf, on the road from Dolgelly to Bala; the limestone forming three bands, which were at one time worked for lime.
3. On the east flank of Cader Idris.
4. On the road from Dolgelly to Dinas Mowddy.

These non-fossiliferous bands are all crystalline; and appear to have been much altered by igneous rocks.

† The lines of section, with their numbers attached, are laid down on the Map, which accompanies this Abstract.

1. Immediately to the west of Arenig Fawr slates occur (*a*), dipping eastward. They contain *Asaphus Buchii*, and a few other fossils.

2. Next occur the Porphyries of Arenig (*b*), which are regarded by the author as old eruptive or recomposed trappean rocks, of cotemporaneous date with the slates with which they are associated. They form, therefore, no determinate base for the protozoic rocks of North Wales.

3. Upon the Porphyries rests a thick deposit of dark earthy slates (*c*) dipping eastward, and extending in that direction about a mile. Towards the upper limit of this bed numerous fossils occur; viz. *Asaphus Powisii*, *Trinucleus Caractaci*, *Leptæna sericea*, Encrinital stems, &c.

4. Immediately over the preceding is a still thicker bed of grey slate (*d*, *d′*, *d″*), which, including the very fossiliferous band, *d′*, supposed to be the equivalent of the Rhiwlas limestone, extends to the western shore of Bala lake. Measured in a direction transverse to the strike, the horizontal distance to the lake exceeds two miles; and as the dip, with one very limited exception, is steadily towards the east, and at a very considerable angle, the thickness of this bed must be great. The whole of the bed is fossiliferous. Near Moel-y-Garnedd were found an Asterias, *Orthis flabellulum*, Encrinital stems, &c. Further eastward are the very fossiliferous slates, the supposed equivalent of the Rhiwlas limestone; and close to the margin of the lake, still higher, fossil bands appear.

The total thickness of these fossiliferous beds west of Bala lake, without including the masses of interbedded Porphyry, is estimated by the author at not less than 2000 feet.

[The series of the Rhiwlas limestone, and of the fossiliferous beds west of Bala lake, is characterised by an abundance of Orthoceratites, and by *Asaphus Buchii*, *Illænus Bowmanni* (a new species), and other Trilobites. To these add *Asterias primæva*. Notwithstanding the considerable number of species of Brachiopoda contained in the list of fossils of the Protozoic rocks of North Wales (*vide* List I.), the number of such remains in the Rhiwlas series is very small.]

4. The breadth of the lake is supposed to be occupied by a group of hard quartzose slates (*e*); since further to the south such slates are seen to rest on the beds associated with the Rhiwlas limestone. Their thickness is not less than six or seven hundred feet.

5. The first group on the east side of the lake consists of a series of hard grey slates (*f*), which contain some highly fossiliferous bands. Some of these are much contorted on the line of strike but their aggregate thickness is computed at not less than 500 feet.

6. Next occurs the Bala limestone (*g*), a complex group about 100 feet thick, containing two bands of impure limestone, one only of which, about 12 feet thick, is worked for lime. In one place it contains a bed of schaalstein.

[The Bala limestone and the Glyn Dyffws beds are marked by multitudes of Orthides, particularly *O. Actoniæ* and *O. Vespertilio*, besides *Leptæna tenuistriata*, and, in some places, an abundance of *Asaphus tyrannus* and *A. Powisii*. They contain few species of coral, but specimens are very abundant, and these belong principally to the genus *Favosites*. (The *Chætetes petropolitana* is also very common.) The *Ophiura Salteri* has been found both in the Bala limestone and at Cader Dinmael. The series, moreover, furnishes two or three species of Cypricardia, a genus not previously found in Lower Silurian rocks.]

7. Next comes a series of slates (*h*), of very varied colour and texture, which alternate with bands of greywacke. As these beds dip steadily towards the east at a very high angle, and are more than a mile broad, their thickness must be very great.

8. The Hirnant limestone (*i*) follows, and has a remarkable pisolitic structure; but, as a limestone, it is very impure. This group is of considerable thickness. The beds are highly inclined, and dip to the east, a few degrees south. The group was traced by the author from Aber Hirnant southwards, in the direction of the strike, to Bwlch-y-Groes*, and was laid down on the Ordnance Map.

[The Hirnant limestone is characterised by its containing only a few species of Orthis; in which respect it differs in a remarkable degree from the limestone of Bala. Of those which it does contain, two or three (which are new species†, and very flat) are found in great abundance. It abounds in a new plaited Terebratula, and in Encrinital stems; but contains only a few corals].

9. With the same easterly dip, and at a high angle of elevation, follows a very thick group of slate rocks (*j*). Some are dark and earthy, others grey and siliceous, others glassy and chloritic. They alternate with a few bands of cotemporaneous Porphyry.

[Over the preceding, near the synclinal of the South Berwyns, fossils, resembling those of the Bala limestone, appear here and there, but in no great abundance; and the peculiar species of the Hirnant limestone are lost. These beds seem to possess scarcely any Conchifera or Gasteropoda, and not any Orthoceratites. The fossils belong principally to Brachiopoda, and *Leptæna sericea* is abundant, but so also is *Trinucleus Caractaci*. Some of the sandy beds contain Encrinital stems, but corals are very rare.]

10. More than a mile to the east of the Hirnant limestone is a synclinal line (σ), beyond which the beds dip towards the west. The lower beds, which were found to the westward, are therefore again brought to the surface, and the Bala limestone (*k*) reappears in two places near the top of the descent leading to Llangynog. Both these places are on the eastern side of the watershed of the

* It has been stated by Mr. Sharpe, in a paper read before the Geological Society (see "Proceedings of the Geological Society," vol. iv. p. 13.), that the line of the Bala limestone, as laid down in Mr. Murchison's map of the Silurian formations, is composed of the Bala and the Hirnant limestones. The Bala limestone, along its whole line of strike, and its several quarries, were examined by Professor Sedgwick in the year 1832; and were laid down by him in colours on Evans's half-inch map of North Wales. The Hirnant limestone was seen by him in the same year, and recognised as a distinct bed. He supposed it to be continued to the east side of Bwlch-y-Groes, but did not mark its course upon any map. Mr. Murchison, in representing the course of the Bala limestone, merely transferred Professor Sedgwick's coloured representation to his own map; and in this transfer from a map in which the physical features of a country are very ill represented, to another map in which they are well represented, it is possible that some errors may have been committed. But for these errors Professor Sedgwick states that he is not responsible.

† Some of these resemble the new species which were found at Cyrn-y-brain, N. of Llangollen.

Berwyns; and, consequently, on this line of traverse, the Bala limestone dips under the Berwyns, as Mr. Murchison * has correctly stated. Further northwards that is not the case.

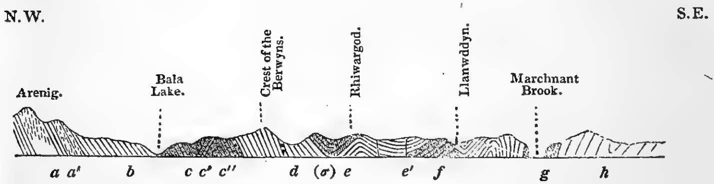
[The series of fossils on the line from Llanwddyn to the head of the Pennant valley, and thence to the top of the pass west of Langynog, is the exact counterpart of the list from the limestones of Bala and Glyn Dyffws.]

11. The limestone is followed in descending order, 1st. by fossiliferous slates (*l*); 2dly, by slates without fossils alternating with beds of Porphyry (*m*). These are supposed to represent a part of the series between the Bala limestone and Arenig at the western end of the section; and they are cut off, near Llangynog, by a complicated series of faults. The author here takes occasion to remark on the very great aggregate thickness of the fossiliferous beds which are traversed by the line of section just described; although, on the one hand, the section has no determinate base, and, on the other, does not reach to the highest of the protozoic rocks; since it is impossible to tell how many hundred feet may be wanting to connect the highest beds which are traversed in this section, with the base of the Denbighshire flagstones.

Section II.

The Arenigs to Llanwddyn.

Horizontal base 20 miles.



This section, like the former, commences on the west side of Bala lake, and with a ridge of porphyry ($a\ a'$); but the porphyry appears at a higher geological level than in the former section. The section passes through the grey slates (*b*) on the west side of the lake, and on the east side, through the Bala limestones ($c\ c'\ c''$), which, on this line, are very much contorted. It then traverses the strike of the Hirnant limestone (*d*), and exhibits in great perfection the beds (*e*), above that limestone. The synclinal axis (σ) lies here considerably to the east of the mountain crest; and, to the west of that axis, the same beds are again repeated; but they are now much faulted and broken (e'). The beds (*f*), supposed to represent the Bala limestone, reappear in the hills near the village of Llanwddyn; from whence they may be followed northwards in the direction of their strike, through the head of the Pennant valley, and thence to the top of the pass

* See "Proceedings of the Geological Society," vol. iv. part i. p. 11.

between Llangynog and Bala, dipping westward beneath the chain of the southern Berwyns.

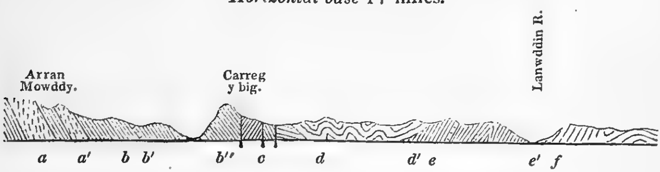
Below the village of Llanwddyn there continues a prevailing westerly dip; but the derangements are enormous, and, at the great bend in the Fyrnwy river, the lower Silurian rocks (*g*) are seen resting upon the upper (*h*) in a reversed position.

In this section, as in the former, the protozoic series is of great thickness.

SECTION III.

ARRAN MOWDDY to LLANLIHANGEL.

Direction of the Section, W. 10° N. to E. 10° S.
Horizontal base 17 miles.



This section commences with cotemporaneous porphyries (*a a′*); but they break out at a still higher geological level than in Section II. The porphyry is succeeded by grey slates (*b b″*) containing the Bala series (*b′*), which may be followed southward in the direction of the strike, down the western bank of the Dyfi. The beds dip east by south, except to the extent of a faulted interval (*c*) on the east side of Carreg-y-big. We have in this line of section a great thickness of the fossiliferous portions of the protozoic series, but not the whole thickness; since these beds are succeeded in the line of section by a trough of overlying and unconformable Upper Silurian rocks, *dd′*. These rocks accord with the type, not of the Denbigh or Montgomery flagstones, but of the coarse-grained greywacké and flagstone which form the base of the upper system near Cernioge.

Beyond this trough, the older beds (*e e′*) again rise out, but with a reversed or northwesterly dip, and at a very high angle of inclination. At the east end of this, as of the former section, the Upper Silurians (*f*) pass under the Lower (*e*), owing to inversion.

In following the fossiliferous beds of the southern Berwyns to the neighbourhood of Mallwydd, the author found those beds overlaid by Upper Silurian rocks of the Cernioge type; a fact which had previously been noticed by Mr. Sharpe. Mr. Sharpe, however, considers that these Upper Silurians rest *conformably* on the Lower, and that the entire upper part of the Lower system is here displayed.* The author considers that the upper system wraps round the southern end of the Berwyns *unconformably;* and that the upper part of the lower system is incomplete.†

* Proceedings of the Geological Society, vol. iv. p. 13.

† The errors committed in certain parts of Mr. Murchison's map, in the neighbourhood of Mallwydd, by spreading the Cambrian colour over an area

§ 4. *On the Structure of the Berwyn Chain.*

1. This chain is considered as commencing, on the south, in the ridges above Mallwyd, to the east of the river Dyfi, and as stretching from thence in a north-westerly direction to the hills which overhang the Dee below Corwen.

2. If a line be drawn from the summit of the mountain pass between Llangynog and Bala to the great bend in the valley of the Dee between Llandrillo and Bala, the south-western portion of the chain, extending as far to the north-east as that line, constitutes a great trough. The subordinate groups of this southern portion of the chain are made up of the fossiliferous rocks of Bala; but its crests consist of beds far above the Bala limestone. On the eastern side of the trough the beds are partly vertical, and partly inverted; and on the south eastern extremity of the chain, for several miles along the boundary between these disturbed rocks of the lower system and the co-terminous upper Silurians, the inversion affects also the upper system of rocks.*

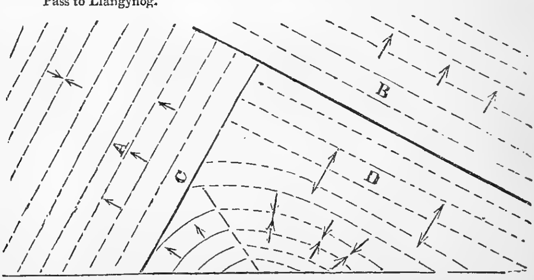
3. A longitudinal fault, with a great upcast to the west, ranges, on the eastern side of the chain, from the vertical and inverted beds above-mentioned to the northern end of Cader Ferwyn; in consequence of which, the Berwyn chain, for the distance of more than 4 miles north of the Llangynog pass, is no longer in a trough of rocks belonging to the Bala series; but the crest of the chain consists of rocks which are lower than the Bala limestone, but not lower than the fossiliferous slates on the east of Bala lake.

4. The strike of the higher ridges of the Berwyn chain varies from N. and S. to N. E. and S. W.; but N. N. E. and S. S. W. is about the mean strike.

which is actually covered by Upper Silurian rocks, has been pointed out by Mr. Sharpe. The same observation may be applied to a district extending along the south end of the Berwyns as far as the tributaries of the Severn. Professor Sedgwick observes, that since he had never either examined, or professed to have examined, this part of North Wales until the year 1843, he does not hold himself responsible for the colouring adopted in that part of the map in question.

* The following diagram has been prepared by the author, in illustration of his views respecting the structure of the North Berwyns.

Part of the Berwyns, N. of Pass to Llangynog.



A. System of the North Berwyns. C. Line of fault, North Berwyns.
B. Line of fault, North end of the Berwyns. D. Llanrhiadr, anticlinal.

5. The beds, on the two opposite sides of the great upcast fault, are in a most anomalous position. On the west side, they strike about N. by E.; but on the east side, nearly E. and W.

6. At Bwlch Maengwynnedd, above a mile north of Cader Ferwyn, is another great fault or flexure. To the north of that point all the beds, to the further extremity of the chain, dip either N., or N. by E., and strike either E. and W., or E. by S., and W. by N. This strike is continued towards the east, as far as the mountain limestone on the confines of Shropshire; and, towards the west, to the hills north-west of Llandrillo, on the left bank of the Dee, between that river and the brook, Nant Ffrauan.

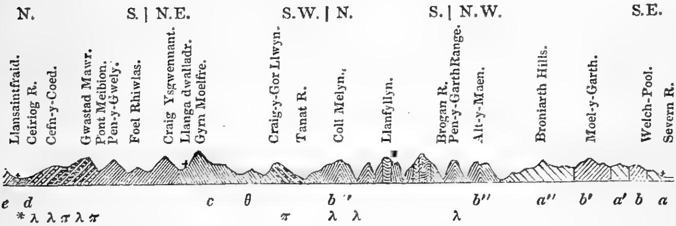
This position of the strata on the eastern side of the Berwyn chain gives a regular ascending section from the lower series to the upper, in advancing towards the Dee from south to north, along a meridian passing to the east of Llangynog.

§ 5. *Sections East of the Berwyns.*

Section IV.

Welch-pool on the Severn to Llansaintfraid on the Ceiriog.

Mean Direction of the line of Section, S. to N.
Horizontal base 24 miles.



1. At the southern extremity of Section IV., we have the Upper Silurian flagstone of the Severn (a), which formation, after two intervening portions of lower Silurian rocks (b b'), re-appears in the Broniarth hills (a'').

2. Then occurs a great undulating series of Caradoc sandstone (b'', b'''), with innumerable fossils; but among these the author discovered no trace of *Asaphus Buchii*, nor of some of the other characteristic species of the lower rocks in the Bala sections. These beds extend as far as the Tanat river, where the strike is nearly east and west.

3. From beneath the Caradoc sandstone, there rises, north of the

* Those points where, either in the author's sections or coloured copy of the Ordnance Map, calcareous beds are marked as occurring, are denoted by the letter λ; those points where porphyry is marked as occurring, are denoted by the letter π.

Section IV. a.

Craig-y-glyn, three miles and a half to the west of the line of Section IV. at the point marked θ.

Horizontal base $2\frac{1}{4}$ miles.

Tanat, a series of slates (θ), not differing in their mineralogical character from the slates of the higher Berwyns; and in these, at a great depth as measured from the Caradoc sandstone, are found calcareous bands, full of fossils, among which are *Asaphus Buchii*, &c. The Craig-y-Glyn limestone (*vide* Section IV. a.), which appears to the north of Llanrhaiadr, at the distance of nearly four miles to the west of the line of Section IV., the author regards as belonging to these bands.

[The Craig-y-Glyn limestone has most of the species of the Rhiwlas limestone; but the abundance of *Asaphus Buchii*, of *Orthis compressa*, of a new species of Orthis, and of Encrinital stems, give it a peculiar character.]

4. Still lower in the series are similar slates; but they are without fossils, and, after several breaks or undulations, the beds, about two miles further to the north, are found to have acquired a steady northern dip.

5. South of Pont Meibion, on the Ceiriog, fossils again appear, conforming to the types of the lower portion of the protozoic group.

[The lower part of the series near Pont Meibion may be only a repetition of the Craig-y-Glyn series, with a reversed dip. But the higher part of the series, which ranges over the crest of the Berwyns by Bwlch Llandrillo, contains only Bellerophons, particularly a new species, *B. nodosus*, found also at Soadley, in Shropshire, by Mr. Salter. At Bwlch Llandrillo, a new Orthis, *O. cambriensis*, which is also found in the Bala series, is abundant; and to this may be added many other species of Orthis, which that series contains.]

6. Then follows, in the ascending section, a great series of beds full of fossils, and these beds alternate with bands of cotemporaneous porphyry, schaalstein, &c.

7. Lastly, there is a well-defined thick group, whose width, measured transversely to the strike, is about a mile. It is composed of calcareous slates, and contains two bands of limestone, both of which have been worked for lime. It passes upwards into pale-coloured earthy slates (*d*), and these seem to pass, without a break, into the overlying Denbigh flagstone (*e*), which just appears on the southern bank of the Ceiriog, and extends northward from that river towards the vale of the Dee. The fossils both of paragraphs 5 and 6, are entered in the list of the Ceiriog fossils.

[The Llansaintfraid series, including the slates and two bands of limestone, lies above the porphyries of the Teirw river, and, consequently, far above the fossiliferous beds of Pont Meibion. It is distinct from any other part of the series, with the exception, perhaps, of the beds on the western bank of the Fyrnwy river, above Meifod. (*Vide* Section VI.) It is loaded with shells of the Wenlock limestone; among which are *Orthis sinuata* and *O. inflata; Spirifer crispus, Terebratula crispata, Atrypa affinis,* and *Euomphalus funatus.* It also contains nine or ten Wenlock corals, such as *Catenipora*, &c. Among the Orthides is a new species, which is found also at Coniston. Several of the corals belong to new species. Besides the above, are several well-known Caradoc sandstone species of shells.

In addition to the above positive characters, the group is distinguished by the following negative one — that it contains apparently none of the species which are characteristic of the lower parts of the Protozoic series, such as *Asaphus Buchii, Agnostus pisiformis, Illænus Bowmanni, Spirifer crucialis*, &c.

This group, then, seems to form a kind of passage between the lower and upper systems.

To judge from the fossils only, the Coniston limestone appears to be intermediate between the Llansaintfraid and the Bala limestones.]

On the evidence of this Section and of the lists of fossils which belong to it, the author concludes: —

1. That the highest or Llansaintfraid group cannot be identified with any of the groups in Sections I., II., and III.; and that if it ever be brought into comparison with any group in those Sections, it must be with the highest group, namely, with that which is found near the crest of the southern Berwyns; and, therefore, that it lies far above the Bala limestone.

2. That the rocks from Pont Meibion southwards, and those of Craig-y-Glyn, may be brought into comparison with the lower parts of the Bala series, to the west of the lake, and with the slates east and west of Arenig, which contain *Asaphus Buchii.*

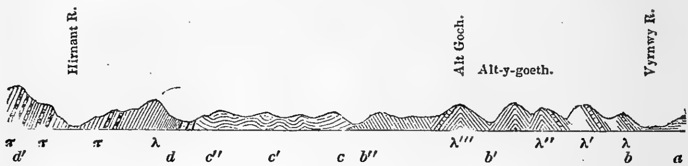
The preceding conclusions the author proposes, subject to the modifications which they must necessarily undergo, when his sections and lists of fossils come to be compared with those obtained by the gentlemen employed on the Ordnance Geological Survey, from an examination of the mountains of South Wales west of the district surveyed by Mr. Murchison.*

* The sections of Cumberland and Westmoreland are not of a nature, in the author's opinion, to throw light on questions having reference to minute points in the classification of the different members of the Protozoic series of rocks, for, in those countries, the Lower Silurian rocks, containing fossils, are of comparatively small thickness, and have a well-defined base, which the author has formerly described. See "Proceedings of the Geol. Soc." vol. iii. p 551. They exhibit no traces of the lower beds such as occur in North Wales, containing *Asaphus Buchii*, &c.; and they disappear when the Porphyries begin. The Coniston limestone appears to be very little lower than the limestones of the Ceiriog, and is therefore probably higher in the series than the Bala limestone. In North Wales, on the contrary, the fossiliferous series has no well-defined base, since fossiliferous beds of vast thickness, extending far below the Bala limestone, there alternate with porphyries.

SECTION V.

The VYRNWY RIVER, 1 mile S.W. of Meifod, to HIRNANT, about 2 miles S. of Llangynog.

Mean Direction of the line of Section, S. 40° E. to N. 40° W.
Horizontal base $10\frac{1}{2}$ miles.

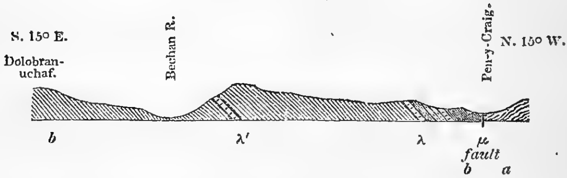


This section commences with the upper Silurian rocks (a), which extend southward from the Vyrnwy river to the Severn. It is followed by rocks of the lower series (b, b', b''), containing calcareous bands (λ, λ', λ'', λ'''). The lower fossiliferous bands near Meifod agree generally in their fossil species with the limestone of Bala, and with the fossiliferous beds on the line of the Teirw river occurring below, and associated with the porphyries, as described in Section IV. The line of section afterwards again cuts the overlying upper Silurian rocks (c, c', c''), a little within the line of their northern boundary. The lower system appears to the south of Llangynog, alternating with beds of cotemporaneous porphyry.

SECTION VI.

PEN-Y-CRAIG, 3 miles S.W. of Meifod, ACROSS THE BECHAN RIVER to DOLOBRANUCHAF.

Horizontal base $1\frac{3}{4}$ miles.



At Pen-y-Craig, south of Mathyrafal, just at the base of the overlying upper Silurian flagstone (a), there is a higher fossiliferous group (μ) than any which has yet been described. The upper part of this passage group consists of calcareous shale, and the lower part of conglomerate, sandstone, and limestone. Further to the north we have the lower series of the ordinary type in the neighbourhood of Meifod, with two calcareous and fossiliferous bands.

[Note on the Fossils of the Limestone of Pen-y-Craig.—*Leptæna tenuistriata*, which was abundant in the lower fossiliferous group (λ), is not seen in the limestone. Corals are very abundant, and are nearly the same with those of the upper limestone bands on the Ceiriog (*vide* Section IV.), but are very different from the corals of the lower group of the Meifod country. There are very great numbers of *Turbinolopsis bina*, of *Favosites polymorpha* and *F. alveolaris*, of *Cyathophyllum*, and *Stromatopora*.

On the Fossils of the *calcareous shale* of Pen-y-Craig.—In the very remarkable list of fossils (List I. column 13.) obtained from this shale, we have *Terebratula marginalis*, a Wenlock shell, associated with *Leptæna duplicata*, *Atrypa undata*, *A. globosa*, and *Orthis lata*, shells which have been considered as characteristic of the Llandeilo flags.]

From a review of all the preceding facts, the author concludes that the Protozoic series of North Wales is of enormous thickness; that it has no defined base, the fossils disappearing in the descending section, not suddenly, as in Cumberland and Westmoreland, but gradually; that many species are found in every subordinate group from the top to the bottom; and that some species, especially certain Trilobites, characterise the lower group.

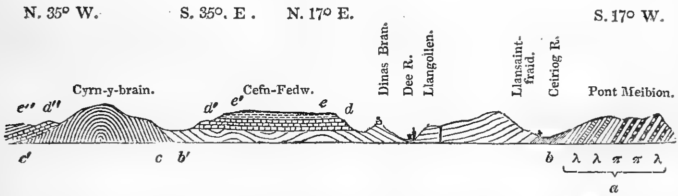
§ 6. *Upper Silurian Rocks of Llangollen, Cernioge, &c.*

The geological structure of this part of North Wales the author illustrates by three sections, which he exhibited to the Geological Society on a former occasion; but which, with the help of Mr. Salter, he is now able to present in a more accurate shape.

Section VII.

Llansaintfraid Glyn Ceiriog, across the valley of the Dee, to Cyrn-y-brain, near the head of the vale of the Clwyd.

Horizontal base 12 miles.



This Section may be considered as a continuation, northwards, of Section IV. To render clear the position of the upper Silurian flagstones of the Dee (*b b′*), lying as they do in a trough which is bounded, both to the north and to the south, by a mass of palæozoic rocks (*a* and *c c′*), a portion (*a*) of the older series of rocks, which lie to the south, and were before represented in Section IV., is here repeated. On the northern side of the trough, at Cyrn-y-brain, the existence of a mass of older rocks (*c c′*), which was before suspected by the author, has been ascertained; with the help of Mr. Salter, its extent has been laid down upon the Ordnance Map; and it has been inserted in the section.

In his paper, read in June, 1843, the author described the occurrence, in the valleys of Llansaintfraid Glyn Ceiriog, of a peculiar mass of dark roofing slate (*b*), containing (though not abundantly) *Graptolites ludensis*, a fossil which occurs throughout the whole of the upper series. He was then in doubt whether to refer this slate to the protozoic or Upper Silurian rocks; but he now regards it as the lowest of the Upper Silurian rocks in the Llangollen district. On the southern flank of Cyrn-y-Brain, that is, on the northern edge of the Llangollen trough, this slate reappears.

To the north of the Llansaintfraid valley, on the present line of section, is a great thickness of Denbighshire flagstone, which the author, now as before, separates into three subdivisions.* The lower of these consists of flagstone, passing into bands which are hard and quartzose, or into earthy semi-indurated shale. The middle subdivision resembles the lower, but is more indurated. The upper flags consist of softer beds, which are more or less slaty, and contain only a few fossils; but these are surrounded by other beds, harder and more quartzose, which are very fossiliferous. An example of these fossiliferous beds occurs at the summit of Castell Dinas Bran.

All the above subdivisions of the Denbigh flags contain impressions of Orthocerata. The lower and middle subdivisions afford numerous compressed traces of the fossil, determined by Professor E. Forbes to be a Creseis; and associated with the Creseis are found *Graptolites ludensis*, and sometimes *Leptæna lata*. The middle and the upper subdivisions, of which the latter has been considered by Mr. Bowman (Trans. Manchester Geol. Soc. vol. i. p. 203.) as non-fossiliferous, yield *Cardiola interrupta* and *Terebratula Wilsoni*, although rarely. In the upper subdivision, at Castell Dinas Bran, *Terebratula navicula* and *T. semisulcata* are very abundant. (For the other fossils of Castell Dinas Bran, see Proc. Geol. Soc., vol. iv. p. 221.). From the abundance of the Creseis which, taken as a whole, the Denbigh flags contain, the name of "Creseis flagstone" might serve as a good local name to give to this group.

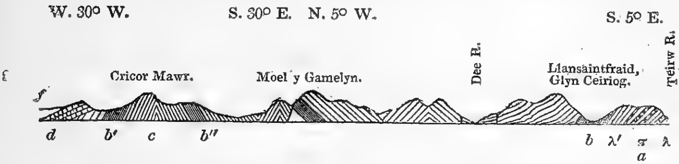
These upper Silurian rocks are overlaid by unconformable and nearly horizontal beds of mountain limestone (*d d′*); and these are crowned at Cefn Fedw by a capping of millstone grit (*e e′*). At the north-western base of Cefn Fedw, the upper Silurian rocks (*b′*) again appear, and are succeeded by the palæozoic mass of Cyrn-y-Brain, full of Caradoc sandstone fossils. On the north-western flank of this mass the mountain limestone, crowned by millstone grit, again appears, and in an inclined position.

* Mr. Bowman has separated this part of the Upper Silurian rocks of North Wales into subdivisions, which he has compared with those of the entire Ludlow series of Mr. Murchison: to these views of Mr. Bowman the author signifies his dissent.

Section VIII.

From the Teirw River, across the valley of the Dee, to Cricor Mawr, near the head of the Vale of the Clwyd.

Mean direction of the line of section, S. 20° E. to N. 20° W.
Horizontal base $11\frac{1}{2}$ miles.

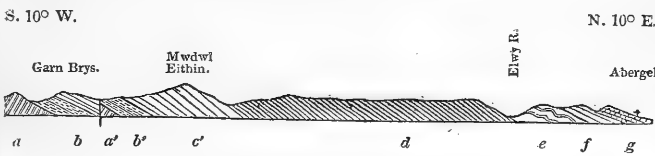


This Section is nearly the counterpart of Section VII., and runs nearly parallel to it: it passes the Dee about 3 miles W. of Llangollen. At the southern extremity, on the Teirw river, we have the limestones (λ λ′), and porphyries (π) of the Palæozoic series (*a*). Then follows a trough containing the dark roofing slate and the flags (*b b*′), of the upper Silurian series. Towards the northern extremity of the trough, a mass of the older rocks (*c*), abounding, like the similar mass of Cyrn-y-brain, in fossils of the Caradoc sandstone, breaks out at Cricor Mawr. This mass is covered, on its north-western flank, by upper Silurian rocks; and these are overlaid by mountain limestone (*d*), a range of which bounding the vale of Clwydd on the S. E. runs from the point represented in the Section, beyond Abergele. The mountain limestone is followed by new red sandstone (*f*).

Section IX.

From Garn Brys, S. W. of Cernioge, to Abergele.

Horizontal base 20 miles.



In this Section, we have, near Cernioge, first, the rocks of the older series (*a*), abounding with fossils of the Caradoc sandstone; and secondly, lying unconformably on the preceding, are the conglomerates and sandstones (*b*) which there constitute the base of the upper Silurian series. These conglomerates, &c., the author compares to the coarse greywacké and flagstone which constitute the unconformable base of the upper series at the south-eastern extremity of the Berwyns. These coarse mechanical rocks do not appear in any distinct form in the country traversed by the two former lines of section. The conglomerates pass into sandstones (*c*′) of a finer structure, which alternate with bands of dark coarse slate, having occasionally true slaty cleavage; and these slates the author compares with the dark roofing slates which form the base of the upper series in the Llangollen district.

In this part of the Section, the author interpolates a fault, by overlooking which, he was led, when he first exhibited this Section, to estimate the conglomerates and sandstones at too great a thickness. To the north of this fault, the finer sandstones (c') are repeated.

To the sandstones succeeds a thick mass of Denbighshire flagstone (*d*), generally agreeing with that of the Llangollen district; and this is followed by the coarse greywacké and slate of Bronhaulog (*e*); whereupon the author takes occasion to remark that, in North Wales, slates arising from transverse cleavage extend to a higher geological level than they do in Westmoreland, and to a still higher level in Devonshire than they do in North Wales; and, consequently, that such cleavage does not define the age of any rock, but serves only, like other peculiarities of structure, to mark the existence of certain physical conditions.

At the end of the Section occurs a thick mass (*f*) in which are a number of beds like those of the lower groups, but often passing into rotten slate or mudstone. The last bed (*g*) in this Section is mountain limestone.

On the fossils of these Upper Silurian rocks, as a whole, it may be remarked, that they agree very nearly with those from the upper Silurian rocks of Mr. Murchison; but that the distribution of species is somewhat different. Thus, in the list of fossils from the Lower Flags (*vide* list of fossils from Plas Madoc, Proc. Geol. Soc., vol. iv. p.221.), species are found which were once supposed to be characteristic of the tilestone of Shropshire, a bed above the upper Ludlow mudstone. This may be accounted for by the circumstance, that both the tilestones and the Plas Madoc beds belong to an arenaceous deposit; and hence, though widely separated by intervening slates and flagstones, they have in common some species not found in the intermediate beds.

P BY MESSRS. J. W. SALTER AND J. DE CARLE SOWERBY.

elonging to those Columns are to be found in Column 4. [ED.]

	ending Order. See Sec. IV.			Ascending Order. See Sec. VI.		Extracted from the next List of Fossils.	Observations.
		11.	12.	13.	14.	15.	
		Pont-y-Meibion to Bwlch Llandrillo.	Glyn-Ceiriog.	Pen-y-Craig Limestone.	Pen-y-Craig Calcareous Shale.	Of the foregoing Species the following are found also in the Upper Silurian rocks of N. Wales.	
Agr							
Illæ		+					
Par							
Tri							
		+	+				
Asa							
			+				
		+?					
		+	+				
		+					
		+				+	
Caly							
		+					
						+	
			+				
Ent							
					+		
Nau							
Litu							
			+				
Phr							
			+				
Orth							
			+				
Bell							
		+ +	+				
		+ +					
Con							
Pleu							
Mur							

Many undescribed	- - -				
annulatus	- -				+
scalaris	- - -				
Tentaculites ornatus	- - -				
Verticillipora abnormis ?	- - -				+
alveolaris	- - -				
spongites	- - -				+
Favosites polymorpha	- -				+
Chætetes petropolitana	- -				+
Catenipora escharoides	- -				
Porites pyriformis	- - -				
(u. s.)	- -				

TABLE I. — FOSSILS OF THE OLDER PALÆOZOIC (PROTOZOIC) ROCKS IN NORTH WALES. DRAWN UP BY MESSRS. J. W. SALTER AND J. DE CARLE SOWERBY.

NOTE. — *Columns 1. 2. and 3. are added to this List on the authority of Professor Sedgwick's paper: other Fossils belonging to those Columns are to be found in Column 4.* [ED.]

NAMES OF GENERA AND SPECIES.	Localities taken in the Ascending Order. See Section I.								In the Descending Order, from Col. 8. See Sec. I.	In the Ascending Order. See Sec. IV.			Ascending Order. See Sec. VI.		Extracted from the next List of Fossils.	OBSERVATIONS.
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	
	Slates West of Arenig Fawr.	Dark earthy Slates E. of Arenig Fawr.	Gray Slates E. of Arenig Fawr.	Rhiwlas and Moel-y-Garnedd, W. of Bala Lake.	Cader-Dinmael and Glyn-Diffwys.	Rhiwaedog, E. of Bala Lake, to Bwlch-y-Groes, &c.	Aber Hirnant to Llan-Mowddy.	Pass to Llangynog and Rhiwargor.	From Llangynog to Pennant and Llanwddyn.	Craig-y-Glyn.	Pont-y-Meibion to Bwlch Llandrillo.	Glyn-Ceiriog.	Pen-y-Craig Limestone.	Pen-y-Craig Calcareous Shale.	Of the foregoing Species the following are found also in the Upper Silurian rocks of N. Wales.	
Crustacea.																
Agnostus pisiformis				+		+		+	+ +		+					
Illænus Bowmani (n.s.)				+					+ +							
Paradoxides (n.s.?)				+												
Trinucleus Caractaci		+		+	+	+		+ +?	+	+	+	+				
fimbriatus					+			+	+			+				
Asaphus Buchii	+			+	+?					+ + +	+?					
tyrannus				+	+	+			+	+ + +	+	+				
Powisii		+			+	+		+	+		+					
caudatus										+	+				+	
(n.s.)						+			+	+	+					
Calymene Blumenbachii									+						+	
(n s.)					+	+		+				+				
n.s.? with granulated head				+												
Entomostracites punctatus														+		
Mollusca. — Cephalopoda.																
Nautilus primævus						+						+				
Lituites cornu arietis												+				
Phragmoceras? (n.s.?)				+												
Orthoceras, smooth and distant septa				+		+										
smooth and close septa				+												
smooth and conical												+				
Heteropoda.																
Bellerophon bilobatus				+					+	+	+ +	+				
nodosus											+ +					
Pteropoda.																
Conularia quadrisulcata						+										
Gasteropoda.																
Pleurotomaria (n.s. angular)				+		+					+			+		
Murchisonia (de Vern.)																
(n.s.? large)												+				
Turbo Pryceæ						+										
Littorina striatella						+								+		
Euomphalus funatus												+				
(n.s.)												+				
Conchifera.																
Arca Eastnori?											+					
Nucula? (n.s.)							+		+ +							
Cypricardia (n.s.)				+	+	+										
(n.s.)					+											
(n.s.)					+											
Brachiopoda.																
Lingula (n.s.?)						+								+		
Terebratula decemplicata				+	+											
tripartita						+		+				+				
crispata												+				
marginalis* (imbricata)													+	+ +		Wenlock Limestone.
(n.s.)							+									
(n.s.)							+									
(n.s.)													+	+		
Atrypa affinis								+				+	+	+	+	

* The names marked with an asterisk are names substituted for those given in the Silurian system, in consequence of the examination of a collection from Sweden, in the possession of Mr. Murchison.

TABLE I.—FOSSILS OF THE OLDER PALÆOZOIC (PROTOZOIC) ROCKS IN NORTH WALES—(*continued*).

NAMES OF GENERA AND SPECIES.	Localities taken in the Ascending Order. See Section I.								In the Descending Order, from Col. 8. See Sec. I.	In the Ascending Order. See Sec. IV.			Ascending Order. See Sec. VI.		Extracted from the next List of Fossils.	OBSERVATIONS.
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	
	Slates West of Arenig Fawr.	Dark earthy Slates E. of Arenig Fawr.	Grey Slates E. of Arenig Fawr.	Rhiwlas and Moel-y-Garnedd, W. of Bala Lake.	Cader-Dinmael and Glyn-Diffwys.	Rhiwaedog E. of Bala Lake, to Bwlch-y-Groes, &c.	Aber Hirnant to Llan-Mowddy.	Pass to Llangy-nog and Rhi-wargor.	From Llangynog to Pennant and Llanwddyn.	Craig-y-Glyn.	Pont-y-Meibion to Bwlch Llan-drillo.	Glyn-Ceiriog.	Pen-y Craig Limestone.	Pen-y Craig Calcareous Shale.	Of the foregoing Species the following are found also in the Upper Silurian rocks of N. Wales.	
Atrypa undata - - -														+ + +		Llandillo Flags.
globosa - - -														+		Llandillo Flags.
(3 new species) - -												+				
(2 or 3 new species) - -														+		
Spirifer crucialis - - -				+	+	+ +		+	+							
Cyrtæna* (radiatus) - -				+		+										
crispus - - -												+				
Orthis elegantula* (canalis) - -				+	+	+	+	+	+	+	+	+	+	+		
testudinaria - - -				+	+	+	+	+	+	+	+	+	+	+ ?		
alternata - - -				+	+	+		+	+	+	+	+		+		
Vespertilio - - -				+	+	+		+	+		+	+				
Actoniæ - - -				+	+	+		+	+			+				
flabellulum - - -			+	+	+	+			+		+	+				
Cambriensis (n. s.) - -				+	+	+			+		+ +					
virgata - - -					+	+			+			+				
compressa - - -										+ + +						
sinuata - - -												+				
inflata (n. s.) - - -												+ +				
lata - - - -														+		Llandillo Flags.
(2 new species) - -												+				
(n. s.) - - -										+ +						
(n. s.) - - -										+						
(3 new species) - -							+									
Leptæna sericea - - -		+		+	+	+		+ +	+	+	+	+				
tenuistriata (rugosa *Dalm.*) -					+	+		+	+	+		+				
duplicata - - -														+ +		Llandillo Flags.
transversalis - - -												+		+ +		
depressa - - -													+	+	+	
(n. s.) - - -					+	+			+							
(n. s.) - - -				+												
(n. s.) - - -												+		+		
(n. s.) - - -												+				
Orbicula (n. s. large) - -						+										
Radiaria.																
Ophiura Salteri - - -					+	+										
Asterias primæva - - -			+													
Encrinites (stems) - - -		+	+	+ + +		+	+	+	+	+ +		+		+		
(pelvis) - - -				+												
Pentacrinites? - - -										+						
Polyparia.																
Stromatopora (n. s.) - -													+ +			
Retepora (with large meshes) - -												+ +				
(n. s.) - - -												+				
Fenestella? (branched) - -												+ +		+		
(n. s.) - - -												+		+		
Turbinolopsis bina - - -												+	+ +	+ +		
(n. s.?) - -												+				
Cyathophyllum dianthus - -												+				
(n. s.) - -												+	+ +	+		
Porites pyriformis - - -												+ +		+ + +		
Catenipora escharoides - -												+ +		+ +		
Chætetes petropolitana - -					+	+		+	+		+					
Favosites polymorpha - -					+	+						+	+ +			
spongites - - -					+	+	?	+				+				
alveolaris - - -												+	+ +	+ + +		
Verticillipora abnormis? - -					+							+				
Tentaculites ornatus - - -												+				
scalaris - - -												+				
annulatus - - -					+	+							+	+		
Many undescribed - - -																

NAMES OF (	See Sec. IV. …to …lan-…	See Sec. IV. 12. Glyn-Ceiriog.	Ascending Order. See Sec. VI. 13. Pen-y-Craig Limestone.	Ascending Order. See Sec. VI. 14. Pen-y-Craig Calcareous Shale.	Extracted from the next List of Fossils. 15. Of the foregoing Species the following are found also in the Upper Silurian rocks of N. Wales.	OBSERVATIONS.
Atrypa undat:				+ + +		Llandillo Flags.
globos				+		Llandillo Flags.
(3 nev		+				
(2 or :				+		
Spirifer crucia						
Cyrtæ						
crispu		+				
Orthis elegant		+	+	+		
testudi		+	+	+ ?		
alterna		+		+		
Vesper		+				
Actoni		+				
flabellu		+				
Cambr.						
virgata		+				
compre						
sinuata		+				
inflata		+ +				
lata				+		Llandillo Flags.
(2 new		+				
(n. s.)						
(n. s.)						
(3 new						
Leptæna seric		+				
tenui		+				
dupli				+ +		Llandillo Flags.
trans		+		+ +		
depre			+	+	+	
(n. s.						
(n. s.						
(n. s.		+		+		
(n. s.		+				
Orbicula (n. s						
Ophiura Salte						
Asterias prim						
Encrinites (st		+		+		
(p						
Pentacrinites						
Stromatopora			+ +			
Retepora (wi		+ +				
(n. s		+				
Fenestella? (l		+ +		+		
(		+		+		
Turbinolopsis		+	+ +	+ +		
		+				
Cyathophyllu		+				
(n. s.)		+	+ +	+		

TABLE II.

Fossils of the Denbigh Flagstone and Sandstone Series, found in various Parts of North Wales.

[Drawn up by Messrs. J. W. SALTER and J. DE CARLE SOWERBY.]

Crustacea.

Calymene Blumenbachii.
Downingiæ.
one or two new species.
Asaphus caudatus.
longicaudatus.
Cawdori.
(subcaudatus).

Annelida.

Serpulites longissimus.

Cephalopoda.

Lituites Ibex.
Orthoceras striatum.
articulatum.
virgatum.
annulatum.
* Creseis tenue † (Vahl).
(primæva).
* a conical species.

Heteropoda.

Bellerophon carinatus.
globatus.
trilobatus.
n. s.

Gasteropoda.

Turritella obsoleta.
conica.
Natica parva.
Trochus helicites.

Conchifera.

* Avicula (fragments).
Nucula.
Cucullæa antiqua.
a large n. s.
* Cardiola interrupta.
* Cardium?
Cypricardia (several imperfect).

Brachiopoda.

Terebratula navicula.
† semisulcata.
(lacunosa. Sil. Sys. p. 5.)
Nucula.
Wilsoni.
bidentata.
Orthis lunata.
orbicularis.
two or three new species.
Spirifer ptychodes.
interlineatus.
Atrypa affinis.
two or three new species.
Leptæna lata.
‡ euglypha.
depressa.
Orbicula rugata?

Radiata.

Crinoidal remains abundant.
* Actinocrinites (n. s. highly ornamented. — Llangollen).

Polyparia.

Stromatopora.
Fenestella.
Cyathophyllum (several species).
Favosites (several species, one very slender).
* Graptolites ludensis.

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* Denotes the species characteristic of the Denbigh flagstone series.

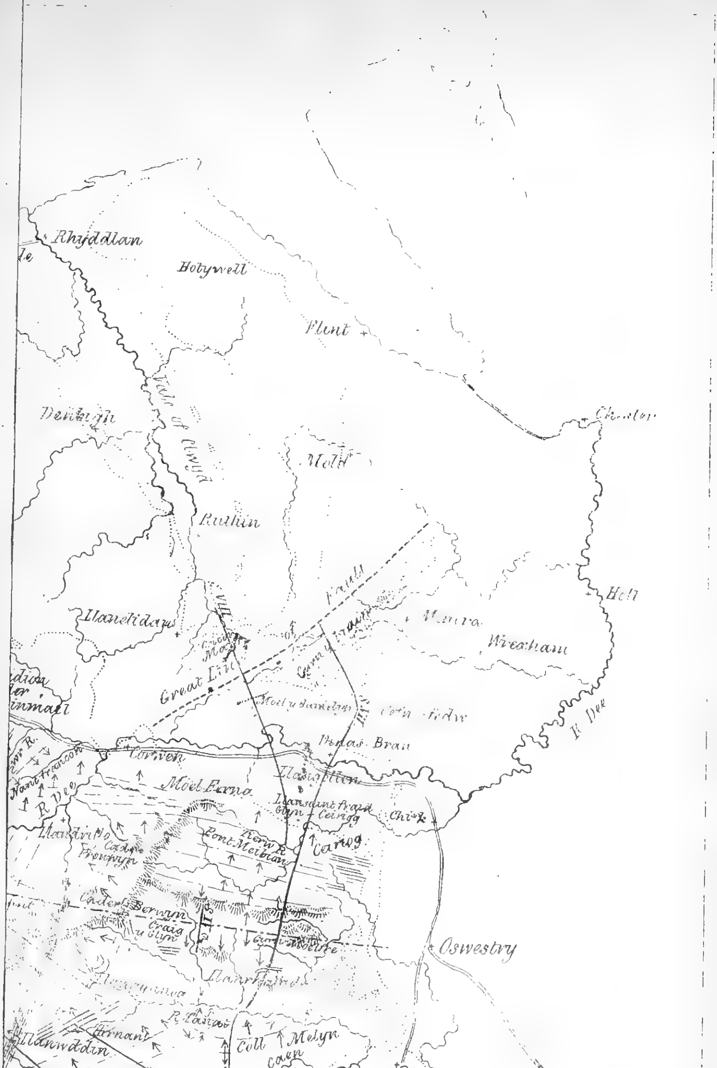
† Names substituted for those given in the Silurian system, in consequence of the examination of a collection from Sweden, in the possession of Mr. Murchison.

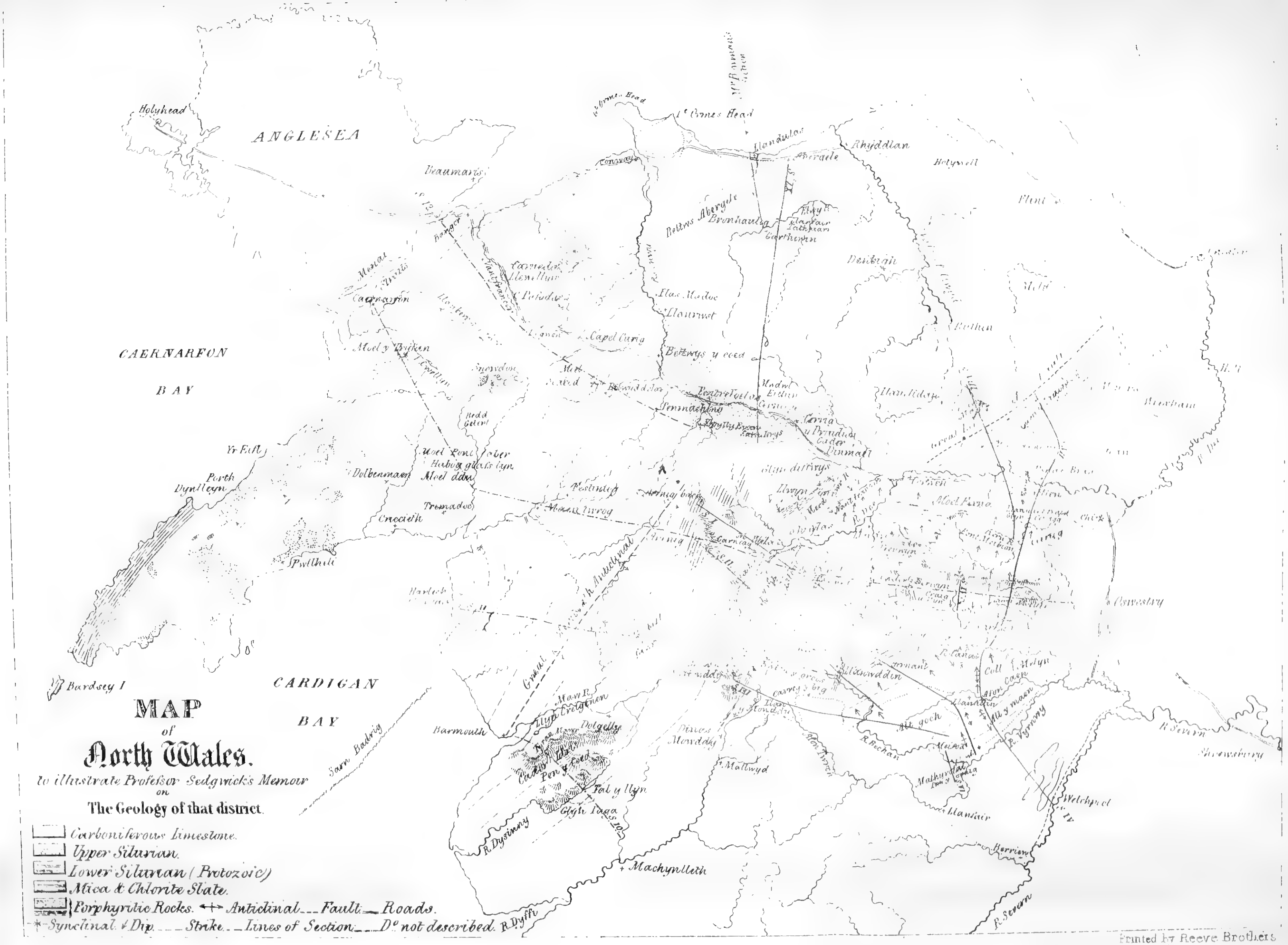
‡ Denotes the species which have hitherto been found only in the more calcareous beds at Plas-Madoc, Llanrwst.

TABLE III.

TABULAR VIEW of the PROTOZOIC ROCKS OF NORTH WALES, in the ascending Order.

West of the Berwyns.	Chlorite Slate. (*From Porth Dinlleyn to Bardsea Island, in the S. W. of Carnarvonshire.*)	Slate and porphyries. (No fossils yet discovered.)	Slate and porphyry, with crystalline limestone and a few fossils, e.g. Asaphus Buchii. (*W. of Arenig Fawr.*)	Porphyries, with a few bands of slate. (*Arenig Fawr.*)	Slate with bands of limestone, and many fossils: Asaphus Buchii. (*Rhiwlas, &c.*)	Slate, with a few trappean bands, and a band of limestone, a calcareous slate. (*Glyn Dyffwys east side of Bala Lake.*)	Slate, and band of limestone. (*Hirnant river.*)	Slates, with a few fossils. (*Crest of the Southern Berwyns, and east of the Crest.*)		
East side of the South Berwyns.			Soft earthy slates.		Soft earthy slates, with arenaceous bands, and a thick mass of calcareous slate. (*Craig-y-Glyn.*)	Coarse sandstones and earthy slates; the lower part with the fossils of the Bala limestone. (*Tyrnwy R., above Meifod.*)			Coarse sandstone, with a band of limestone and calcareous shale. (*Pen-y-Craig, S. W. of Meifod.*)	Upper Silurian.
East side of the North Berwyns.			Soft earthy slates.			Earthy slates, with arenaceous bands and fossils. (*Pont-Meibion, Bwlch Llandrillo.*)	Coarse slate and porphyries. (*Teirw River, falling into the Ceiriog.*)	Calcareous slates, with bands of limestone. (*Glyn Ceiriog.*)		Upper Silurian.


Rhyddlan
Holywell
Flint
Chester
Denbigh
Vale of Clwyd
Mold
Ruthin
Fault
Holt
Llanelidan
Wrexham
Corwen
Moel Ferna
Dinas Bran
R. Dee
R Dee
Oswestry
Craig y Glyn
Coll
Melyn
Caen
Llanwddin



Printed by Reeve Brothers

December 13, 1843.

The Rev. Thomas Image, M.A., was elected a Fellow of this Society.

The following communications were read :—

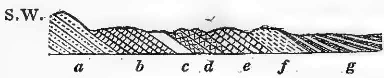
1. *On the* Geology *of* Cape Breton. By Richard Brown, Esq.*

In a letter to Mr. Lyell, dated Sydney Mines, Cape Breton, Oct. 20. 1843, the author stated—

"I have made a survey of some forty miles of coast on the eastern side of our coal-field; and have since devoted a few days to the examination of the shores of the Island of Boularderie, which is four miles wide, and twenty-six miles long, and exhibits natural sections on both sides from end to end. Nothing can be more definite than the position of the masses of gypsum in this island. I have examined them this summer in four different places, scores of miles apart, and find the following, with little variation, to be a section of the accompanying strata:

Section I. (Ideal).

General sequence of the Coal Measures and Gypsiferous Formations near Sydney, Cape Breton.



† *g.* Coal measures.
f. Coarse sandstone with coal plants —Shale.
e. Limestone in thin beds—Fossils.
d. Gypsum.
c. Soft red shale.
b. Coarse concretionary limestone and shales.
a. Coarse conglomerate, highly inclined.

"Wherever I have had an opportunity of making observations, they have confirmed your views as to the relative age of the gypsum."

Subjoined is the *Memoir* received from Mr. Brown.

The following is a sketch of the north-western end of the Sydney coal-field. On the W. side of Sydney Harbour, the coal-measures can be traced transversely, without interruption, for 5200 yards, dipping to the N. E. at an angle of 7°, which gives a thickness of 1900 feet. The coal-measures, generally speaking, are very free from faults.

* This paper and the next (Mr. Dawson's on Nova Scotia) are both illustrated by the map of Nova Scotia appended; but the map was originally prepared by Dr. A. Gesner to illustrate the paper of which a notice has already appeared in the "Proceedings," vol. iv. p. 186. One portion of the map is repeated, and coloured according to Mr. Brown's survey.

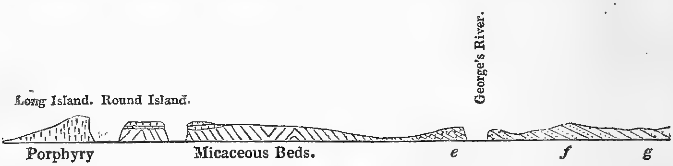
† These references are continued throughout the paper in the other Sections.

The coal-measures are underlaid by a series of sandstone beds, with some beds of shale. The thickness of the sandstone, in some places, exceeds 2000 feet; but to the west of the Little Entrance it is much thinner; and, finally, when it approaches the granite ridge that lies between the Great Entrance and St. Anne's Harbour, it has thinned out. The sandstones, with their superincumbent coal-measures, are very uniform in their dip to the north-east.

Next to the sandstone is the limestone; and this accompanies the sandstone very uniformly, along the whole course of its outcrop, from the southern branch of Sydney Harbour to the Granite ridge west of the Great Entrance. On both branches of Sydney Harbour, and at George's River, the limestone dips distinctly beneath the sandstone. The shore, from George's River to Long Island, gives the following Section,

SECTION II.

LONG ISLAND to the COAL MEASURES East of GEORGE'S RIVER.



First we have the limestone (*e*); then a low, flat space of half a mile, where the stratification cannot be observed; then beds of a red and brown micaceous slaty rock, dipping at high angles in various directions between south and west.

The base of Round Island is of the same kind of rock; but the Isle is capped with a limestone which, to judge from its fossils, is quite different from the limestone * above described beneath the sandstone. Long Island, on its eastern side, is 200 feet high, and very precipitous; but, in a westerly direction, it slopes gradually to the water. It is composed principally of Porphyritic rocks.

On the opposite side of the channel, the shore exhibits the following section:—

SECTION III.

First, the sandstone (*f*) which underlies the coal-measures, and can be traced to within a few hundred yards of Roe's Point.

At Roe's Point the limestone (containing here *Productus Lyelli*) shows itself, having an easterly dip. This limestone, both in its local position, dip, and general appearance, corresponds with the limestone on the other side of the channel, at George's River;

* This limestone contains *Terebratula elongata*, and a *Modiola.*

and these circumstances lead to the supposition that in both instances it dips under the sandstone. Between Roe's Point and Campbell's Cove, on the western shore of the Island of Boularderie, the strata are very much broken and disturbed by faults. It would be difficult to describe these disturbances by words; but the Section will give the most distinct idea of them. Gypsum appears along this line in two places, which are shown in the Section.

First, to the N. W. of Roe's Point, we have solitary pinnacles of gypsum appearing on the beach. Next, three beds of limestone, with two of sandstone interposed, these beds all dipping in an opposite direction to those at Roe's Point. The middle bed of limestone contains *Productus spinosus*. The third and upper of these limestones is cut off by a vertical fault, which is succeeded by a flat arch of limestone, resting upon sandstone. This again is cut off by a vertical fault, which is succeeded by a horizontal bed of limestone.

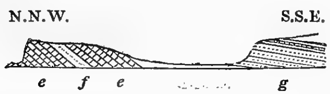
This is followed by a level space; and beyond that we have a series of beds dipping in the same direction with those of Roe's Point.

1. A thin bed of limestone.
2. A bed of sandstone.
3. A thick bed of coarse limestone.
4. Gypsum, 18 feet thick.
5. Rich marl, 6 feet.
6. Green sandstone, with veins of gypsum, 2 feet.
7. Red marl, with grains of gypsum, 12 feet.

This is followed by a level space, when no beds are seen, and beyond that we have limestone, dipping in the same direction with the gypsiferous marls.

Section IV.

Campbell's Cove, near Lime Point.



Proceeding from Campbell's Cove along the shore of the Island of Boularderie in a south-westerly direction, we have similar limestones, lying in a horizontal position, for the space of two miles, until we arrive at Lime Point, where a small cove exhibits three beds of limestone with two interposed beds of sandstone dipping to the S. S. E., and apparently underlying the sandstone with coal-plants; but separated from it by a space which affords no section. The lowest of the three beds of limestone contains *Spirifer glaber* (Lyell); the middle bed contains shells.

The writer mentions in his letter to Mr. Lyell that, "on the eastern side of the Sydney coal-field, he has found below the coal-seams, in every instance, beds of fire-clay, containing the long fibrous leaves of *Stigmaria*, matted together.

"In the black bituminous Shale, which lies about twenty yards above the Main Coal at Sydney, he has found the scales of different kinds of fishes, as hard and bright as enamel; one tooth, and a number of Coprolites; also the *Cypris* in great abundance, and a *Modiola*."

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2. *On the* Lower Carboniferous Rocks, *or* Gypsiferous Formation *of* Nova Scotia. By John William Dawson, Esq., of Pictou, Nova Scotia.*

The coal formation of the eastern part of Nova Scotia consists of a great thickness of sandstones, shales, and conglomerates, of various reddish and grey colours, the former being most prevalent. The lower part of the series is distinguished by the presence of limestones with marine shells and gypsum. Its central portion is characterised by a greater prevalence of grey and dark colours, and by containing an abundance of vegetable fossils and beds of bituminous coal. The upper portion of these productive coal measures appears to pass into a thick deposit of reddish sandstones and shales, containing few fossils, either animal or vegetable. To examine the structure and relations of the lower, or gypsiferous part of this series, is the object of the present paper: it will, however, be proper in the first place to notice the general disposition of the rocks of the Carboniferous system, in the region more particularly observed, which extends along the shores of the Gulf of St. Lawrence, from Tatmagouche to Antigonish Harbour.

The coast section between these points cuts at acute angles across two great coal troughs, the one beginning at Pictou, and thence stretching to the west along the northern shore of the Basin of Mines; the other beginning at Antigonish, and thence extending westward to the Stewiacke and Shubenacadie Rivers. These two troughs are separated by a hilly range composed of igneous rocks and of disturbed lower-carboniferous and Silurian strata. This range beginning at Cape St. George extends westward to the East River of Pictou; and beyond this it is continued along the outcrops of the oldest carboniferous rocks in the direction of Truro.

The southern boundary of the Antigonish trough is formed by the region of Palæozoic, metamorphic, and Plutonic rocks which occupy the southern side of the province. A chain of hills, similar in structure to the range of Cape St. George, but of greater elevation, separates the Pictou trough from a region belonging to the coal strata which extends beyond Tatmagouche in a northerly direction.

The chain in question commences at the New Annan Hills, and extends westward through the Cobequid Mountains † to the Bay of

* See the map of Nova Scotia.

† Dr. Gesner, many years since, described the Cobequid chain as forming a ridge separating the coal-formation of the north side of the Basin of Mines from that of Cumberland county. Mr. Logan first noticed the existence of a trough of carboniferous strata between Antigonish and Windsor.

SECTION I.

TATMAGOUCHE to TRURO, 24 miles.

d. Horizontal red sandstone.

c. Red and grey sandstones and shale, with concretionary limestone, containing copper ore, *lignite, Endogenites,* and *footmarks of birds;* dip near the hills, 30°; at Tatmagouche only 10°.

b. Sandstone and coal—*coal-plants.*

a. Limestone, dark slate, shale, and grits, with shells and encrinites—Intruding bands of granite, syenite, amygdaloid, &c.

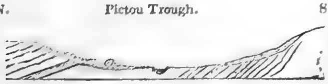
Fundy. To the eastward it does not reach the coast of Northumberland Strait, though its underground continuation in that direction is indicated by an Anticlinal line which traverses the newer members of the coal formation that lap round the eastern extremity of the Annan Hills.

These trough-shaped arrangements of the strata are subject to many irregularities. The hilly region of Mount Thom is placed nearly transverse to the Pictou trough. In consequence of the separating ridges and anticlinal lines having been elevated, either during the carboniferous period, or at a still later epoch, the carboniferous strata are traversed by numerous faults and minor lines of disturbance, the prevailing direction of which is from east to west. In spite of these disturbances, however, the strata in the troughs have a general synclinal arrangement which can be traced in the hilly regions, such as that of Mount Thom. This will be seen by examining the accompanying map.

East River.

SECTION II.

Valley of the eastern branch of EAST RIVER.



c. Hard sandstone.

b. Gypsiferous formation, with beds of limestone and gypsum alternating, and drifts overlying.

a. Silurian slate.

The gypsiferous formation appears in several places on the south side of the Pictou coal trough. In noticing its appearance at these points, I may begin by stating some facts respecting the section on the East River of Pictou in addition to those already described by Mr. Lyell. The members of the gypsiferous formation seen in that section consist of hard, brownish-red shales and sandstones (*c*), with beds of marine limestone and masses of gypsum (*b*). These latter are seen in the valley of the river between the sandstones and the Silurian strata (*a*); but there are no good sections to be found in the neighbourhood. With the view of ascertaining their true relations, I examined two gypsum rocks, within three miles of that seen by Mr. Lyell. The first of these consisted of white granular gypsum, containing, like most similar beds in this province, minute disseminated grains of carbonate of lime, and having, in one part, large rounded masses of anhydrous gypsum, enclosed in the common species, an appearance which I have not elsewhere observed. No other rock was seen in connection with this bed, which appeared to be upwards of 100 feet thick, and to have a strike corresponding with that of the nearest visible sandstones and limestones. The other bed examined was on Lime Brook, a tributary of the East River. Here there is no good section, but the gypsum may be seen in connection with soft sandstones mostly white, and having limestones both below and above, separated, however, by intervals without section, which have probably once been occupied by soft sandstones removed by denudation. The limestone, underlying the gypsum at Lime Brook, is without fossils, and rests unconformably on the edges of slates with Silurian fossils, angular fragments of the slate being included in its lower portion. The limestone above the gypsum is of a lighter colour, and more pure than any other limestone on the East River, and is also distinguished by containing a species of coral, not found in the other beds. These limestones are seen at several other points, apparently resting on the older slates; and in some places appear to be penetrated by fissures containing hæmatite and other ores of iron, peroxide of manganese, and sulphate of barytes.*

The limestones and gypsums thus resting on the Silurian strata at the East River are separated from the productive coal measures by hard reddish sandstones and shales, apparently of great thickness, and containing (especially in their lower part) beds of marine limestone. Where they approach the coal measures, however, the sandstones are very much disturbed, and for this reason I was anxious to obtain some additional evidence of the actual superposition of the coal measures. I therefore examined the section shown by the Middle River, and found there a series of beds dipping in the same direction with those at the Albion mines, though at a higher angle, and beginning at about 5000 feet below the main coal at the Albion mines. The uppermost of these rocks is a thick bed of hard grey sandstone; underlying this are alternations of grey and reddish sandstones and shales, containing in one place a bed of bituminous shale, with *Calamites* above, and cylindrical leaves or roots, perhaps of *Stigmaria*, below. Beneath these are several hundred feet of red and variegated sandstone, with shale and conglomerate. Here there is a break in the section,

* The balls of hæmatite scattered over the country, near the gypsums of the East River, have been derived from these fissures in the gypsiferous rocks; and their abundance is an additional evidence of the denudation which these rocks have suffered.

and these rocks are succeeded, farther up the river, by disturbed sandstones and limestones, which I was unable to examine, but which I believe to correspond with those of the East River.

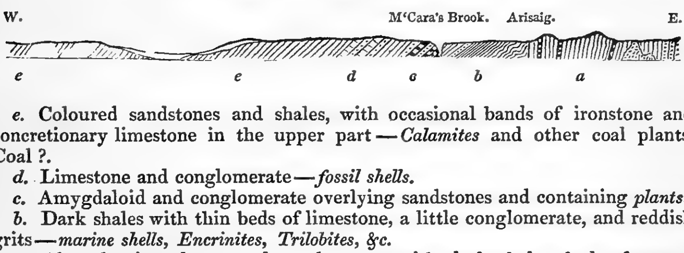
From these observations, in connection with those formerly made by Mr. Logan and Mr. Lyell, it is apparent that the lowest members of the Carboniferous series seen on the East River consist of limestones, gypsum, and soft sandstones, above which are hard reddish sandstones and shales, with limestone; and lastly, red and grey sandstone, shells, and conglomerate, with carboniferous plants, and probably these beds pass into the productive coal measures.

On the south side of the West River of Pictou, limestones, having the same fossils with those found on the East River, are seen in several places, and are associated with reddish sandstones, hard grey shales, and white and purple sandstones. Farther westward, near the Salmon River, there are sandstones, limestones, and gypsum, identical in fossils and mineral character with those of the East River, and like them connected with productive coal measures, which they appear to underlie. Still farther westward, the gypsiferous formations of Onslow and the De Bert River probably form a continuation of the Pictou lower carboniferous deposits, being, like them, succeeded to the northward by the middle and newer members of the coal formation.*

Merigonish.

Section III.

Merigonish to Malignant Cove, 20 miles.



e. Coloured sandstones and shales, with occasional bands of ironstone and concretionary limestone in the upper part—*Calamites* and other coal plants. Coal ?.

d. Limestone and conglomerate—*fossil shells.*

c. Amygdaloid and conglomerate overlying sandstones and containing *plants.*

b. Dark shales with thin beds of limestone, a little conglomerate, and reddish grits—*marine shells, Encrinites, Trilobites, &c.*

a. Altered red sandstone and conglomerate with dark shales, beds of amygdaloid, and intruding masses of greenstone.

Eastward of the East River, the band of carboniferous rocks included between the shores of the gulf and the hills to the southward, shows a series of beds, amounting to 10,000 or 12,000 feet in thickness, and dipping to the north-west at an angle of 20 degrees. The upper part of this section, beginning at the entrance of Meri-

* The salt springs of the West River rise from lower carboniferous rocks, those of Salmon River from the productive coal measures. In both instances they rise from vertical strata on lines of fault.

gonish harbour, shows grey and brownish-red sandstones and shales, buff-coloured sandstones, impure iron-stone, and coarse concretionary limestone, these beds containing Calamites, coniferous wood, and one or two small beds of coal. This part of the section is, however, very imperfect, though, wherever the rocks can be seen, there is a perfect conformity of dip. Their general aspect and fossils correspond with those of the middle part of the coal-formation, and they occupy about six miles of the coast section.

Eastward of the rocks last described, the section is better, and shows a great thickness of brownish-red sandstones and shales, with some grey beds, in which I could not find any fossils, except some carbonised fragments of plants. These strata occupy about three miles of the section, and are underlaid by reddish conglomerates, containing two beds of dark grey limestone, having an aggregate thickness of about 80 feet. These limestones contain numerous fossils, among which are *Productus Martini*, *Spirifer glabra*, and other shells, all common to these beds and the limestones of the East River. These conglomerates and limestones are succeeded by a few hundred feet of thinly stratified, reddish and grey sandstones, with a few fragments of fossil plants in bad preservation. Beneath these, red conglomerates again appear, associated with amygdaloidal trap. The latter is of a grey colour and earthy aspect, and has its cells filled with white carbonate of lime. It constitutes two conformable beds, whose lower sides are more compact than their upper. Their upper surfaces are also partially broken up and intermixed with conglomerate. At this point the carboniferous rocks are cut off on the coast section; some hard brownish grits, however, seen in a neighbouring brook, called M'Cara's brook, probably underlie the rocks last mentioned.

The section between M'Cara's brook and Arisaig is occupied by dark shales and thin layers of limestone, with a few beds of reddish shale and conglomerate. These rocks dip S. W., but become much fractured as they approach Arisaig. They contain numerous fossils, including species of the genera *Tentaculites*, *Graptolites*, *Trilobites*, *Orthoceratites*, *Modiola*, *Productus* and *Conularia*, and remains of *Encrinites*. Though mostly Silurian, a few of these species appear to be the same with those of the slates of the East River. Rocks having the appearance and fossils of the latter are, however, found a short distance inland, to the southward of the shales.

There can be little doubt that, in the sandstones, limestones, and conglomerates of this section, we have the representatives of at least a part of the Gypsiferous formation of the East River, and, resting conformably upon these, an equivalent of the coal-measures.

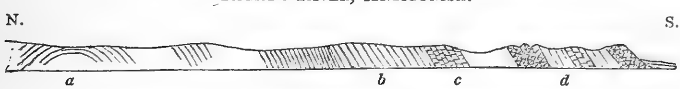
Arisaig.

At Arisaig, 15 miles from Merigonish harbour, we enter on the disturbed district, separating the coal-trough of Pictou from that of Antigonish. From Arisaig to Malignant Cove, the shore displays hard brownish-red quartzose and jaspery rocks, with thick beds of hard grey shales, red conglomerates, and coarse purplish grits. Associated with these, are beds of amygdaloid, which are evidently interstratified with the accompanying rocks, and are probably, like those of M'Cara's brook, of contemporaneous origin. The whole of these beds are vertical, and are, without doubt, lower carboniferous rocks (perhaps a little lower in the series than those last seen at M'Cara's brook), but in a much altered condition. Beyond Malignant Cove, syenitic greenstone is seen on the shore, and, is said to appear in different places as far as Cape St. George. Eastward and southward of Malignant Cove, the hills, in many places, show masses of compact felspar and other igneous rocks, accompanied by altered and disturbed grits. After passing this disturbed region, we enter on the Gypsiferous rocks of the northern side of Antigonish harbour, having a general dip to the southward. Of these rocks, I examined two interesting sections.

Antigonish.

SECTION IV.

RIGHT'S RIVER, ANTIGONISH.



d. Gypsiferous beds—gypsum, limestone, and sandstone.
c. Limestone.
b. Red conglomerate and coarse red sandstone, dark sandstone and shale.
a. Dark and grey sandstones and shales, reddish sandstone: —*plants.*

The first of these sections is that represented above, and is seen extending about five miles. Near the mouth of this river, at the head of Antigonish harbour, is a thick bed of white gypsum, dipping to the south-west. Succeeding this, in descending order, after a small interval (which appears to have been occupied by sandstones, now nearly removed by denudation), is a bed of dark-coloured limestone, in which, at different points where it appears, I found *Productus Martini* with other shells also occurring on the East River; and *Productus Lyelli*, a shell not yet met with in the East River limestones, but very characteristic of the gypsiferous formation in other parts of the province. Below this limestone there is another break, also showing traces of sandstones and a bed of gypsum, and then a thick bed of dark limestone, partly laminated and partly brecciated without fossils, and containing in its fissures thin plates of copper ore. Beneath this limestone is a great thickness of reddish conglomerate, composed of pebbles of igneous and metamorphic rocks, and varying in texture from a very coarse conglomerate to a coarse-grained sandstone. In one place it contains a few beds of dark sandstones and shales. These are succeeded by red, grey, and dark sandstone and dark shales, in a disturbed condition, but probably underlying the conglomerate; they contain a few fossil plants. This section on Right's River includes a thickness of probably 8000 feet.

Section V.

Ogden's Lake to South Lake, near Antigonish (4 miles).

d. Grey sandstone, and red conglomerate.
c. Soft red sandstones and clays; *lignite, calamites,* &c.
a. Altered dark sandstones and shales; intruded greenstone.
b. Grey and soft red sandstones and shales.
e. Limestone.
f. Gypsum.

Another section, near the mouth of Antigonish harbour, displays a series somewhat similar. At the north side of the outlet of Ogden's Lake, about eight miles from Antigonish, is a bed of gypsum, probably nearly 200 feet in thickness. Its upper part is composed of white granular gypsum, in thick laminæ, and with disseminated particles of carbonate of lime. Beneath this is a considerable thickness of foliated red gypsum, in its lower part alternating with layers of a grey argillaceous non-crystalline limestone, on which it rests, and which is penetrated by small veins of white fibrous gypsum in its upper portion, while below it becomes brecciated, and then laminated. It is probably 100 feet thick, and appears to contain no fossils. These great beds of gypsum and limestone dip to the S. S. E. at an angle of 25°, and rest unconformably on soft red sandstones and shales, with some grey sandstones and reddish conglomerate, dipping nearly in the same direction, but at an angle of 50°. Following this underlying series in the descending direction, it becomes more highly inclined, and is finally vertical, resting against a mass of altered and contorted dark shales and sandstones, with veins of greenstone containing much epidote. This part of the section is connected with a ridge of igneous rocks running in an east and west direction, and which a few miles farther inland attains a considerable elevation. It consists of a reddish syenite, quartz, compact felspar, and greenstone. After passing these disturbed rocks, there is a break in the section, which is next occupied by thick beds of brownish-red sandstone and clay, supporting a thin bed of conglomerate and some thick beds of grey sandstone, containing *Calamites, Sternbergia, Endogenites, Carpolites,* and pieces of lignite. The relations of these beds to the other parts of the section I could not determine. They dip to the north-east, and probably belong, either to the upper part of the gypsiferous formation, or to some newer member of the coal series.

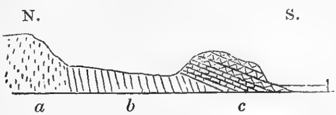
These sections differ from that of the East River of Pictou, chiefly in the presence of large masses of sandstone and conglomerate beneath the limestones, and in the non-appearance of the thick series of sandstones above the gypsum, so conspicuous in the Pictou sections.

Shubenacadie.

Having thus described the Lower Carboniferous rocks, as they appear in some of the best sections near the Gulf of St. Lawrence, it may be interesting to compare their arrangement and lithological character with those of the Gypsiferous formations of the central part of the province, formerly supposed to be newer than the coal-formation, but referred by Mr. Lyell, principally on the ground of its fossils, to the lower part of the Carboniferous system. The rocks seen on the estuary of the Shubenacadie furnish a good specimen of these deposits for the purpose of comparison. The sections on this estuary show several extensive masses of stratified deposits, differing considerably in their mineral character, and separated by faults in such a manner that their true relations do not appear. Most of these masses consist of Red sandstones and marls, with beds of gypsum and limestone. These, when compared with the corresponding rocks in the Pictou and Antigonish sections, appear to differ only in their apparently greater mass, and especially in the thickness of the deposits of red sandstone and marl. The upper bed of gypsum on Right's River is succeeded by a level tract affording no section; and from the two sections, representing the outline of the surface near the gypsum of Ogden's lake and the East River, it will be seen that the present outline of the surface is caused by a great removal of the softer beds.

SECTION VI.

Near OGDEN'S LAKE, ANTIGONISH (showing denudation).



c. Gypsum and limestone.
b. Grey and soft red sandstones.
a. Syenite and greenstone.

One of the most remarkable rocks on the banks of the Shubenacadie is a great bed of compact and laminated non-fossiliferous limestone, near the mouth of the estuary. This bed has its upper surface broken up into a kind of breccia, and supports a great thickness of soft red sandstone and conglomerate, with beds of gypsum. It is also traversed by fissures filled with hæmatite and ores of manganese. It rests upon a great thickness of hard, brownish grits and shales, which appear in different places on the road from Shubenacadie to Truro. The horizontal red sandstone of Truro rests on the edges of these grits, which, near Truro, become either vertical or dip rapidly to the north-east, and perhaps also underlie some of the gypsiferous rocks of the Onslow hills. From a consideration of all these circumstances, it appears probable that these hard grits are the equivalents of the lower grits and conglomerates of Antigonish; and that the bed of limestone which they support is a representative of the lower limestone at Antigonish and Pictou. To the lower grits I would also refer the mass of dark red sandstones and shales at Eagle's Nest, three miles from the mouth of the estuary of the Shubenacadie. The mass of contorted dark sandstones and shales at Five-mile River resembles some parts of the productive coal formation more nearly than any of the lower carboniferous rocks: and the horizontal red sandstone, a few miles farther up, is analogous to many of the beds both above and below the gypsum at Antigonish and Pictou.

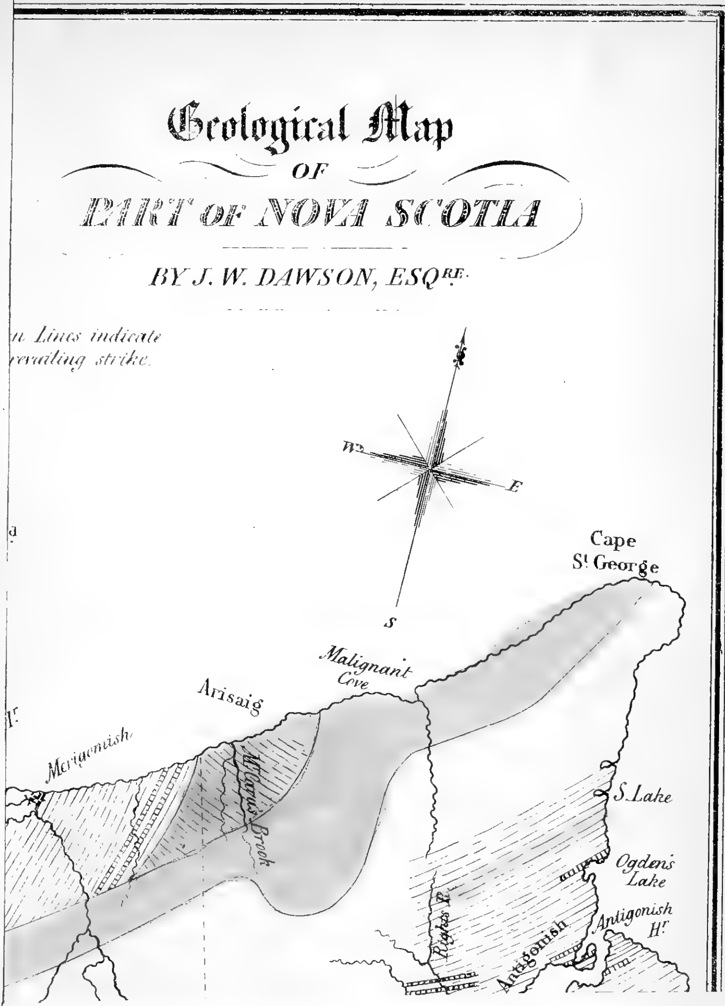
From a comparison of the appearances of the lower carboniferous rocks in the various sections which I have examined, I have drawn out the following table, which, I think, exhibits very nearly their general arrangement. It commences with the productive coal measures.

Lower Carboniferous or Gypsiferous Formation.

Rocks.	Fossils.	Where seen.
1. Brownish-red, mottled and grey sandstones; brownish-red shales; some conglomerates; the beds containing small quantities of copper ores.	Endogenites, Calamites, Lepidodendron.	Merigonish, East River, Middle R., Shubenacadie?
2. Brownish-red hard sandstones and shales, often rippled; some grey sandstones, conglomerates, and limestones; copper ores in small quantity.	Fragments of plants and fucoidal markings; Productus (especially P. Martini), Terebratula, Spirifer, and other shells.	East River, Merigonish, West River, Middle River, Economy, Wardrobe's, on Shubenacadie?
3. Reddish and white sandstones and marls, usually soft; beds of gypsum and limestone (the lowest bed usually a non-fossiliferous limestone); veins and fissures with ores of iron, manganese, copper, &c.	Productus (especially P. Lyelli), Terebratula, Encrinites, Corals, Spirifer, Pecten, Avicula, &c. &c.	East River, Antigonish, Shubenacadie, Onslow Mountain, De Bert R., Windsor, Pugwash, Wallace, &c.
4. Reddish-brown conglomerates and hard grits; some dark and grey sandstones, and brown and dark shales.	Various plants.	Antigonish, Shubenacadie, Truro, Salmon R.

Newer Coal Formation, Sandstones, &c.

In several parts of the eastern section of Nova Scotia, there are extensive deposits of sandstones and shales, principally of a brownish-red colour, and including some thin beds of concretionary limestone and grey sandstone. They contain a few calamites and other carboniferous plants. These beds constitute, I believe, the newest member of the carboniferous series, and are connected with the productive coal measures by a thick series of reddish-brown and grey sandstones, shales, and conglomerates, often abounding in


Geological Map
OF
PART OF NOVA SCOTIA
BY J. W. DAWSON, ESQRE.
n Lines indicate
revailing strike.
E
S
Cape
St George
Malignant
Cove
Arisaig
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S. Lake
Ogden's
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Antigonish
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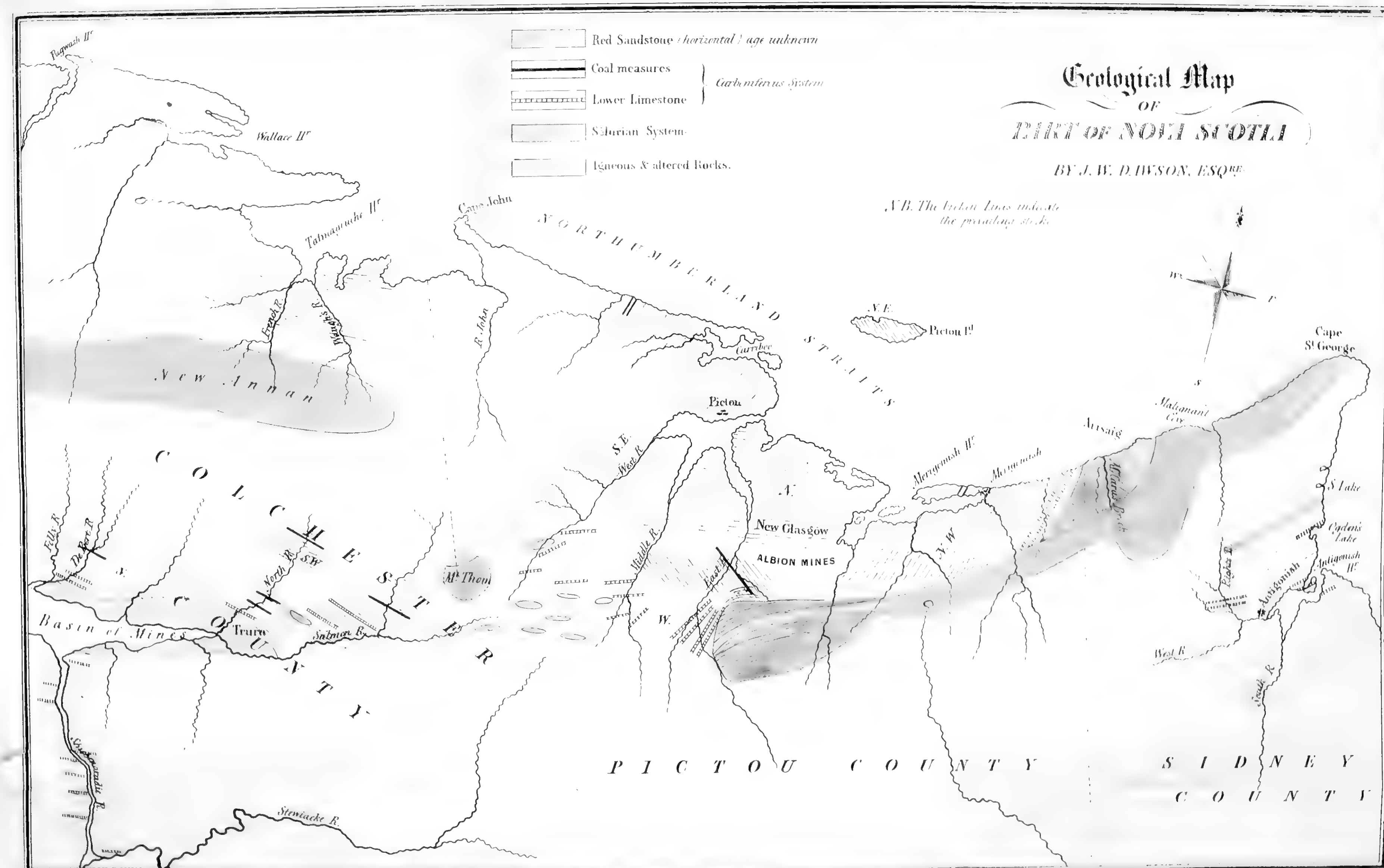
Antigonish


Geological Map
OF
PART OF NOVA SCOTIA
BY J. W. DAWSON, ESQRE.
Red Sandstone (horizontal) age unknown
Coal measures
Lower Limestone
Carboniferous System
Silurian System
Igneous & altered Rocks.
N.B. The broken lines indicate the prevailing strike.
W
E
S
Pugwash Hr
Wallace Hr
Tatmagouche Hr
Cape John
NORTHUMBERLAND STRAITS
French R
Waugh's R
R. John
New Annan
Carribee
Picton Id
Cape St George
Pictou
Malignant Cov
Arisaig
Merigomish Hr
Merigomish
S.E.
West R
N.
New Glasgow
ALBION MINES
N.W
Middle R
East R
W.
COLCHESTER COUNTY
Folly R
De Bert R
North R
S.W
Mt Thom
Basin of Mines
Truro
Salmon R
Stewiacke R
S Lake
Ogden's Lake
Antigonish Hr
Antigonish
West R
South R
PICTOU COUNTY
SIDNEY COUNTY

fossil plants. As these upper red sandstones have, however, been confounded with the gypsiferous formation, some of whose sandstones they often much resemble, I may shortly describe a section on the Waugh's and French rivers of Tatmagouche, exhibiting a portion of them, and at the same time illustrating the structure of a part of the Cobequid chain.

At the mouth of the French river are grey sandstones and shales, containing a few endogenites, calamites, and pieces of lignite, impregnated with copper ores. Beneath these appears a series of brownish-red sandstones and shales, with a few grey beds, occupying, in a regular descending series, about six miles of the river section. They contain, in a few places, nodules of copper glance, they are often rippled, and contain branching fucoidal marks. On one of the rippled slabs I found marks consisting of four foot-prints of an animal. These were three inches and a-half apart, and each exhibited three straight marks, as if of claws.*

The dips of these sandstones gradually increase in approaching the hills, and the lowest seen is a bed of grey sandstone, dipping at an angle of 30°. There is then a small break in the sections, succeeded by hard dark shales and slates, and hard brown grits, with a bed of limestone in which I could find no fossils, except a fragment of a Productus and a few fragments of encrinital stems in bad preservation. These rocks are much disturbed, but generally appear to dip at high angles to the northward. They are associated with masses of greenstone, amygdaloid, reddish syenite, and other igneous rocks. They appear to rise unconformably from beneath the sandstones of the low country; but whether they belong to the lower carboniferous or to some older system, I cannot at present determine.

I hope, at some future time, to be able more particularly to state the structure and relations of the newer members of the coal formation, but have not yet collected a sufficient quantity of facts to determine accurately their relations.

The horizontal red sandstone of Truro, which skirts the Basin of Mines, has no connection with the red sandstone of Tatmagouche, but is probably newer than any part of the coal formation. It is destitute of the grey sandstones and shales, and in several sections of it which I have examined, I have not found any fossils.

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3. *On* Concretions *in the* Red Crag *at* Felixstow, Suffolk. By the Rev. J. S. Henslow, M.A., F.G.S., Professor of Botany in the University of Cambridge.

I place on the table a selection from a large assortment of a peculiar description of concretions obtained from the Red Crag at

* These tracks resemble the marks of the claws of an animal *running* over a moderately firm surface, or *climbing* up an inclined plane. They are not unlike the marks left by the claws of small individuals of the River Tortoise on the sides of mud banks, but differ from them in showing traces of two feet only.

Felixstow, in Suffolk. In 1842 I was much puzzled to account for the nature of these concretions. At a cursory glance one might almost be inclined to pass them by as waterworn pebbles, as they lie abundantly interspersed among the comminuted shells which form the upper parts of the cliffs. I found more than one eminent geologist disposed to agree with me in considering them to be rolled masses of London clay which had been indurated subsequently to their deposition in the crag. On my again visiting Felixstow during the summer of the present year (1843), I determined to give them a particular examination; and although a formation which has been so thoroughly worked as the crag is not likely to afford a casual visitor the opportunity of gleaning much of novelty, I believe I have satisfactorily ascertained the origin of these concretions, and have added to the list of crag fossils the petro-tympanic bones of at least four species of Cetaceans. These latter, I am persuaded, have been overlooked among the many concretions of this formation. They are, however, of a different composition, and closely resemble, in this respect, the silicified fragments of bone so abundant in this locality. I believe the specimens I have procured will range under two types, each containing at least two species. I am not competent to the task of throwing any osteological light upon these fossils, but am happy to state that Professor Owen has undertaken their examination; and we may therefore expect before long to be in possession of all that can be said about them. It seems to me not a little remarkable, that all these specimens should have been procured within a very narrow compass, for I found none beyond the limits of two contiguous indentations in the cliff, a short distance to the north of Felixstow.

But, to return to the concretions to which I am more particularly desirous of directing attention. They exhibit a very great variety of forms. Many are more or less spheroidal, fusiform, and cylindrical; many are perfectly amorphous. They appear to be composed of a fine-grained compact ferruginous claystone, of a dark chocolate brown colour; but the surface, which is very smooth, and even polished, becomes pale by exposure. They often separate by natural flaws into three or more fragments, which are bounded internally by nearly plane surfaces. Many of them offer traces of organic association; and the result of an extensive examination has convinced me that they must all be considered as of coprolitic origin. I am not aware whether any analysis has ever yet been made of them.

I will now direct attention to the following peculiarities observable in some one or other of the specimens referred to:—

1. Two spiral masses.
2. A large perforated one, with traces of spiral or annular transverse convolutions.
3. Other smaller ones, the convolutions being longitudinal.
4. Common character of the cylindrical and fusiform ones, seen, by fracture, to be formed of *longitudinally* coiled folds, with a perforated axis.

5. Containing more or less distinct traces of fossils, apparently from *macerated* subjects.

Ex. gr. Vertebræ of cartilaginous fish.

Ex. gr. Crustacea, very numerous. N. B. Their remains in the Crag are never thus fossilised unless under coprolitic associations.

Ex. gr. Two echiniform masses.

6. Various forms, more or less amorphous.

7. With vermicular-like traces (Algæ?), as in the nodules from Green sand and Gault.

8. With *pitted* surfaces, as if from the escape of bubbles of gas.

9. Ditto on fragments of cetaceous (?) bones highly polished, and perhaps half digested.

10. Another description of nodule, less common, larger and more gritty, often containing organic matter, as shells, &c.

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4. APPENDIX *to Professor Henslow's Paper, consisting of a Description of the* FOSSIL TYMPANIC BONES *referable to four distinct Species of* BALÆNA. By RICHARD OWEN, Esq., F.R.S., Hunterian Professor in the Royal College of Surgeons.

THE fossils from the Crag at Felixstow, which have been submitted to my inspection by Professor Henslow, are the tympanic portions of the petro-tympanic bones of large Cetacea.

The tympanic adhering to the petrous portion by only two small surfaces is easily detached, and may be recognised by its conchoidal shape and peculiarly dense texture; the recent bone breaking with almost as sharp a fracture as the petrified fossils.

None of these are entire: the thin brittle outer plate which bends over the thick, rounded, and, as it were, involuted part, like the outer lip of such simple univalves as the *Bullæ* and *Leptoconchi*, is broken or worn away in the best specimens, all of which are rolled and waterworn.

We are led by the size of the specimens to the largest of the existing Cetacea for the subjects of comparison, as the Grampus, the Hyperoodon, the Cachalots (*Physeter*), and the true whales (*Balænoptera* and *Balæna*).

Two or three of the specimens are fortunately sufficiently entire to show the form of the tympanic cavity bounded by the overarching plate, with the proportion and direction of its anterior or Eustachian outlet, and most of them have the opposite or hinder extremity entire. We are thus enabled to determine that the majority differ from the tympanic bones of the *Delphinidæ*, including the *Grampus* and *Hyperoodon*, in having the hinder extremity of the bone simple and not bilobed; and some of them, in having the anterior outlet of the cavity partially enclosed by the extension of the outer plate around that end.

With regard to the Cachalot (*Physeter*), I regret that I have had no opportunity of comparing the Felixstow fossils with the tympanic bone in that genus, which I know only by the figures given by Camper* in his usual sketchy style. Cuvier, who founds his notice of the tympanic bones of the Cachalot on the same figures, states that they most resemble those of the *Delphinidæ;* but are less elongated and less bilobed posteriorly. The figures show still more clearly that the tympanic cavity is continued freely forward out of the anterior end of the bone, and terminates by a relatively wider outlet than in the *Delphinidæ.*

If the idea thus given of the form of the tympanic bone of the Cachalot be correct and conformable to nature, the comparison of the Cetacean fossils becomes limited to the true whales (*Balænidæ*), in the few known species of which the distinctive characters of the tympanic bones are afforded by their relative size and the shape of their inferior surface.

In *Balænoptera* the tympanic bones, according to Cuvier, are very small in proportion to the head, and are equally convex at their inferior surface.

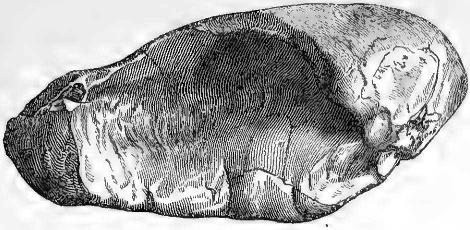
As none of the fossils in question have been found *in situ,* with any part of the cranium, their size in proportion to that of the animal cannot be judged of; but in the specimens that have been least injured and water-worn, the inferior surface shows the flattened or gently concavo-convex undulation which characterises the tympanic bone in true *Balænæ.*

In regard to the differences which are observable in the tympanic bones of the two known species of Balæna (*Bal. mysticetus,* and *Bal. australis, capensis,* or *antarctica*) Cuvier† merely observes that "though slight they add to the motives which led him to believe the Arctic whale and that of the Cape to be specifically distinct." This remark at least encourages us to regard the characters derivable from the tympanic bone as sufficiently determinate to be a guide in the distinguishing of species; and with this conviction I have proceeded to compare the fossils in question with the recent tympanic bones of the two existing species of Balæna.

In them the thick convex involuted portion of the tympanic bone is slightly and unequally raised above the level of the cavity formed by the over-arching wall, but in the *Bal. antarctica* it gradually decreases in thickness to the anterior or Eustachian angle; while in the *Bal. mysticetus* the thicker posterior part is defined by an indentation from the thinner anterior part. In both species the thinner part of the convex border is distinctly continued to the anterior limit of the cavity; in both the extent of the involuted convexity, inwards, is not well defined, but it gradually subsides, and the convexity is exchanged for the concave curve of the overarching wall. I purposely omit the mention of the slight difference in other parts of the tympanic bone of the *Balæna mysticetus* and *antarctica,* since the condition of the fossils would not admit of the application of those differences in the determination of their affinities.

* Anatomie des Cetacés, Pls. xxiii. xxv.

† Ossemens Fossiles, 4to., v. pt. i. p. 376.



Petro-tympanic bone of Balæna affinis.*

One of the most complete of the fossil tympanic bones, which measures five inches in length, resembles the *Bal. antarctica* in the slight elevation of the posterior part of the involuted convexity and its gradual diminution to the Eustachian end of the cavity: it resembles both *Balænæ* in its traceable continuation to that end, and in the gradual continuation of the concave outer wall from the involuted convexity; this convexity is indented also, as in both recent Balenæ, by vertical fissures narrower than the marked indentation which distinguishes the *Bal. mysticetus:* these fissures are almost worn out by friction in some of the specimens. The more perfect one under consideration is not, however, identical with the *Bal. antarctica.*

The upper surface of the bone maintains a more equable breadth from the posterior to the anterior end, the outer angle of which, being well marked in the fossil, is rounded off in the recent specimen; the under and outer surfaces of the tympanic bone meet at an acute angle. The above characters are sufficiently marked in the specimens of the fossil tympanic bones to justify their being regarded as belonging to a species distinct from the known existing *Balænæ*, but nearest allied to the *Bal. antarctica*, and which I propose to call *Balæna affinis.*

A second species is more unequivocally indicated by the distinct definition of the involuted convexity; and the extent of the slightly concave surface extending from it to the commencement of the overarching wall; the anterior extremity of the involuted convexity is equally well defined, and a wide concavity divides it from the anterior extremity of the Eustachian cavity. The thickest part of the involuted convexity is not very prominent. The under and outer surfaces of the bone meet at a right angle.

The species indicated by the tympanic bones of this form may be termed *Balæna definita.*

A third form of tympanic bone differs from the first in the shorter and more convex form of the involuted part, the anterior

* This engraving is one of a series (illustrating each of the four species) prepared for Prof. Owen's work on the "British Fossil Mammalia and Birds" now in course of publication. The cut was very kindly lent by the publisher (Mr. Van Voorst) to illustrate this paper in the "Proceedings."—Ed.

end of which is divided from the anterior end of the cavity by a concave border one inch in extent; the internal border of the involuted convexity is also better defined than in *Bal. affinis;* but the overarching wall begins to rise close to it, divided from it only by a deep and narrow rugged fissure instead of by a broad and gently concave tract, as in *Bal. definita.*

Both the outer and under surfaces of these specimens are more rounded than in the two preceding species; but being more mutilated and water-worn, the characters derivable from the external parts of the bone are of less value. The characters above specified, which are furnished by the involuted convexity, are decisive as to the specific distinction of the present fossils, which therefore indicate a third species of extinct whale, which I propose to call *Balæna gibbosa.*

There is a fourth form, which differs from the last in the less degree of convexity of the involuted part, but more particularly in its outer border being notched or indented, as in *Balæna mysticetus,* by a vertical angular impression deeper and wider than the smaller vertical fissures.

The comparative shortness of the involuted convexity distinguishes this species from the existing *Balænæ* and the *Bal. affinis,* the notched and less convex involution from *Bal. gibbosa,* and the immediate rising of the overarching wall beyond the inner boundary of the involution from the *Bal. definita.* I propose for this species the name of *Balæna emarginata.*

January 3d, 1844.

Major Thomas Austin, of Bristol, and George Harcourt, Esq., M.P., of Newnham Court, Oxfordshire, were elected Fellows of this Society.

The following communications were read: —

1. *On the Occurrence of the Genus* Physeter (*or Sperm Whale*) *in the Red Crag of Felixstow.* By Edward Charlesworth, Esq., F. G. S.

Some years since, whilst looking over a collection of fossils in the possession of Mr. Brown of Stanway, I was struck by the appearance of a cylindrical nodule from the Red Crag of Felixstow, which seemed to me to exhibit indications of an organic structure unlike that of any fossil body which had previously come under my notice. With the permission of its owner I had a section made of this fossil; but the characters which it presented upon being cut did not enable me to arrive at any determination respecting its real nature.

At a subsequent period, I learned from Mr. Brown that the nodule in question had been submitted by Professor Owen to microscopical examination, and identified as the tooth of a Cachalot.

In the reports of the British Association for 1842, this tooth is included in the list of British Fossil Mammalia; but Mr. Owen, through mistake, has there assigned it to the "Diluvium of Essex." I am informed by Mr. Brown, that he procured the specimen from a man at Felixstow, who stated that he picked it up on the beach; and as several of the rarest known Crag fossils have been obtained at this spot under similar circumstances, there is no room to doubt its being a genuine fossil of the Crag formation. The mineral condition of the tooth is likewise so very remarkable, and so totally unlike that of the Mammalian remains which occur in the diluvial or lacustrine deposits, that this alone, in the absence of all other evidence, would have sufficed to determine its geological antiquity.

The valuable communication submitted to the last meeting of the Geological Society by Professor Henslow, upon the discovery of Cetacean remains in the Red Crag of Felixstow, immediately brought to my recollection the existence of this Cachalot's tooth in the cabinet of Mr. Brown; and that gentleman having, within the last few days, been so good as to forward the specimen to me, I am now enabled to submit it to inspection. Through the kindness of Mr. Nasmyth I have had the opportunity, upon this occasion, of comparing the structure presented by the fossil with sections of recent Cachalot's teeth, and the result has been to satisfy me of the correctness of Professor Owen's determination.

A species of the genus Physeter may therefore now be added to the four species of Red Crag Balænæ already enumerated by Professor Owen, and the occurrence of this genus must, I think, be regarded as a very interesting addition to the list of Cetaceans discovered by Professor Henslow in the Felixstow cliff.

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2. *On a* Fossil Forest *in the Parkfield Colliery near Wolverhampton.* By Mr. Henry Beckett.

The fossils alluded to in the following notice, occur in an open work, that is, the superincumbent strata have been pared off, and we find the coal (which belongs to what is called the "bottom coal,") well exposed to view. The bed has been bared for upwards of two years, but the fossils do not appear to have attracted attention, till Mr. William Sparrow and myself, whilst tracing the great faults of the South Staffordshire coal-field, accidentally stumbled upon them, and were struck with their number and their evident resemblance to trunks of trees.

Since that time, by the kind permission of the Parkfield Company, and with the assistance of Professor Orlebar, of the Royal Bengal College in Bombay, I have carefully removed the coal attached to the roots of one of the trees.

We found the stump to be perfectly bituminized, but broken off about two inches above the level of the coal measure, the inner part being somewhat hollowed to about the level of the coal itself: the surface and edges of the broken part were smoothed or probably water-worn. The tree bared was not flattened, but preserved precisely the same appearance which I have noticed with peat timber in Ireland, and was 4 feet in circumference. The principal root extended southwards 22 inches, terminating abruptly. The other roots spread out in a similar manner,—not in separate forks, but in an apparently continuous mass, showing that the plant required a broad base for its support. There were no appearances of a tap root; in fact, the nature of the tree would not require it; neither were any fibrous filaments visible. The trunk and roots were covered with a bark about half an inch thick, the coaly matter of which being more brittle, though considerably more compact in its texture than either the body of the tree or the circumjacent bed, also possessed a more smooth and bright surface, when broken.

The bark externally was either perfectly smooth, or marked by irregular longitudinal striæ, differing altogether from Calamites or Sigillariæ. Within the bark was the hollow cylindrical trunk, about 2 inches across the cylinder, the coal composing which was, as before observed, more earthy in its character, but was concentrically lamellar in its structure; some thin laminæ being of a brighter and better quality than the mass.

The interior of the plant was filled with a blended mass of coal and shale.

The trees are all upright and bear undoubted evidence of having grown on the spot.

The thickness of coal in which the stumps are found is only 5 inches. On breaking the coal *with the grain*, we met with impressions (very faint however) of reed-like plants and Stigmariæ.

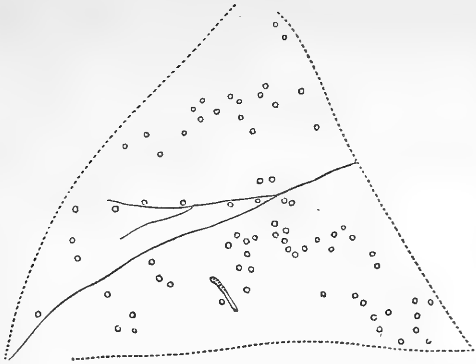
Beneath the coal was the bed in which the trees must have grown, and this (as now compressed and indurated) is 3½ inches thick. It is composed, at the top and bottom, of a dark-brown or brown-black bituminous shale, inclosing a band of fire clay, half an inch thick.

The shale bed contains impressions of the *Lepidodendron, Ulodendron, Stigmaria,* and probably other species of plants, and I discovered one fragment proving the existence of animal life—a solitary scale of *Megalichthys Hibberti.*

It is remarkable that, though our field in general abounds with the bivalve shells often described as Unios, I have only found one specimen in the open work, and that in an upper bed.

There were no appearances of the roots passing into the shale; but from the peculiar arrangement of the central part of the trees, I am induced to suspect that the shale may have occupied an internal position considerably above the level of that in the bed.

On breaking through the shale, we discovered in a second seam of coal what at first struck us as being a prolongation of the roots; but, on further search, another forest was found below the first. In the upper bed we counted seventy-three trees in



about a quarter of an acre (as shown in exact position on the accompanying sketch), and in the second they appeared equally abundant, as we laid bare three trees in as many yards square. The characters of the lower trees were similar to those described, but longer portions of the trunks were developed, the thickness of coal being seventeen inches in the spot opened; but this varies in other parts of the bed. These trees do not pass through the upper shale, but the trunks occupy the whole thickness of this second coal-bed, and we found the substratum to consist of a shale, similar to that above, and 5 inches thick; while below this was a bed of fire clay, seven inches thick, reposing upon a third bed of coal in which trees were not found.

I should perhaps add that the upper coal is capped with fire clay, in which no traces of the trees have been observed.

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3. *Description of the Remains of numerous* Fossil Dicotyledonous Trees *in an Outcrop of the Bottom Coal at Parkfield Colliery, near Bilston.* By William Ick, Esq., F.G.S.

At a depth varying from forty to fifty yards below the Ten-yard stratum of the South Staffordshire coal-field, there are usually found three deposits of coal, called the *Top*, the *New Mine*, and the *Bottom Coal.* When these beds can be readily worked, they are scarcely inferior in value to the Ten-yard coal, the *Top* and *New Mine* deposit, with the intervening shales and partings, often forming a series of strata eight yards in thickness. Below this a few beds of ironstone occur; then a bed of fire clay about three yards in thickness, and immediately under this the *Bottom Coal.*

At Parkfield Colliery, $1\frac{1}{2}$ miles west of Bilston, and at about the same distance south of Wolverhampton, there is a fine outcrop of this *Bottom Coal,* which is now being got in open work. In one part the overlying fire clay has been removed, and the surface of the coal exposed, over an area of a somewhat triangular shape, for about 2,700 square yards.

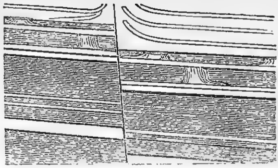
This terrace of coal exhibits on its surface one of the most remarkable accumulations of the fossil remains of the vegetation of the coal period ever exposed to view.* There are upwards of seventy trunks of trees, apparently dicotyledonous, broken off close to the root, and several of them are more than 8 feet in circumference; the prostrate trunks lying across each other in every direction. One of these measured 30 feet, another 15 feet in length, and several others a few feet less. They are invariably flattened to the thickness of from one to two inches, yet both upper and under side preserve a distinct trace of bark. The stumps, also, exhibit a distinct ring of bark, which, as usual, has become a bright coal, with a crystalline fracture; while the interior or woody part is a dead-looking coal, nearly approaching to cannel coal.

These stumps seldom rise much above the surface. Many of them are surrounded by a circular ridge, formed by the materials of the bed accumulating round them. In a few cases the place of a trunk is marked by a circular depression in the coal, the trunk having been probably removed with the overlying fire clay. In some of the stumps the thick diverging roots may be traced by clearing off the coal, nearly a yard from the circle of bark; and I was enabled to clear away from one of the trees the surrounding coal and shale, down to the substratum of fire clay; but no trace of stems or of the long radicles or leaves of stigmaria were found, either in the shale or fire clay. Impressions, more or less distinct, of stems of *Stigmaria ficoides*, are found in the shale in some parts of the deposit; but in no case, so far as we could discover, could any connection be traced with the adjacent trunks. Many spots between the trunks are almost covered with impressions of Calamites, two or three distinct species of which may be recognised, in some places forming groups of six or eight square feet. The stems of *Lepidodendra* with the impressions of the scales finely preserved, and *Lepidostrobi*, are also scattered in profusion over the surface; and mingled with these vegetable remains are occasionally found the teeth and other fragments of fishes. There are also found ring-shaped bodies, sometimes in pairs, which appear to me to be identical with the bodies figured in Plates 8 and 10 of Dr. Hibbert's Paper on the Fresh-water Limestone of Burdie House, in the 10th Vol. of the Trans. of Roy. Soc. of Edinburgh, p. 169.; and said to be the scales of *Megalichthys Hibberti*, which have lost their external lamellar structure.

Not the least curious circumstance, in connection with this deposit, is, that although the whole is not more than 12 feet in thickness, there are at least three distinct beds of coal, each of which exhibits on its surface the remains of an ancient forest of

* See diagram, p. 43.

large trees. A reference to the annexed section will show the position of these beds. The upper growth of vegetation is on a stratum of coal 10 inches thick, under which is a band of clay 2 inches thick; this lies undisturbed on the south end of the platform, but is removed from a few yards south of the centre to the northern extremity; and the second bed is there exposed, covered, like the upper, with trunks, &c. The coal is here about 2 feet thick, and rests on a band consisting of 4 inches of shale and 8 of fire-clay. Five feet below this grew the third forest; the surface, where the upper beds have been removed, exhibiting similar large stumps of trees, *Lepidodendra*, *Calamites*, &c.



Section of the fault and fossil trees in the Parkfield Colliery.

At Millfields colliery, one mile to the east, the same beds are found at a depth of 126 yards.

In several points of view, the deposit at Parkfield must be interesting to geologists. The position of the trees, in each bed of coal, seems almost to preclude all doubt of their having grown and perished on the spot where their remains are now found, and the roots are apparently fixed in the coal and shale, which was the original humus in which they grew.

As is generally the case with stems found prostrate in coal, these stems are flattened. The woody tissue perished before the superincumbent strata were deposited, leaving nothing but a tube of bark, which readily yielded to pressure. This is well seen in a specimen, in which the bark is preserved, as well on the under as on the upper side, while no woody tissue lies between; the liber, or inner side of the bark, from each side of the stem being crushed into contact. It is from this cause that the ligneous structure of coal fossils is so rarely preserved. The large trunks, in nearly all cases, have been reduced to mere cylinders of bark, probably by a process similar to that pointed out by Mr. Hawkshaw, and now to be seen in tropical forests, where, by a combination of causes, a large tree is reduced, in a few months, to a hollow tube which yields to the slightest pressure. In this state, if a stem fall, it is flattened; if it remain erect, the interior becomes filled up with the ferruginous or carbonaceous materials of the surrounding bed, which occupy the place of the rings of woody tissue.

Whatever may be our success in discovering the botanical character of these trees by microscopic aid, the evidence is not slight that they were most of them allied to Coniferæ; and few who have carefully compared the Lepidodendra with the leaf-bearing stems of the *yew*, *spruce-fir*, or various species of *pine*, can have much doubt of the fossil plants being allied to these recent ones.

In conclusion, I may observe that I have been induced to make this communication to the Geological Society, because it is one of the very rare instances of the surface of a bed of coal being exposed over a large area. It is very probable that similar interesting glimpses of the vegetation of a former world would be frequently seen, if, instead of working in the dark and cutting down the edges of the strata, we could remove at once the upper covering, as at Parkfield, and expose to the day the face of coal on which the ancient forests grew.

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4. *Some Account of a* Fossil Tree *found in the Coal Grit near Darlaston, South Staffordshire.* By John S. Dawes, Esq. F. G. S.

Within the last few days (Jan. 1844), an exceedingly well-preserved and extraordinary specimen of a fossil tree has been discovered in a stone quarry near the town of Darlaston. The rock, which also contains Calamites and other drifted coal fossils, is the White Grit, which overlies the thin carboniferous measures, on the north-eastern side of the South Staffordshire coal field; the fossil, 39 feet in length, lies in the ripple-marked stone, at a depth of 16 yards from the surface, the nearest bed of coal being ten yards below it. The root end is towards the deep, and in a westerly direction. Its angle of inclination is about 6°, which also corresponds with the dip of the strata; distinct traces of four branches may be observed upon the stem, three of which, when it was found, were still attached, and apparently in the position in which they grew, but one of them was moved aside from its original direction. They extended in length from 6 to 8 or 9 feet, having a diameter varying from 6 to about 4 inches, and the upper one yet remains attached, and shows a remarkable uniformity in its thickness. The others were in part broken to pieces, and some of them lost before I was aware of the specimen being in the quarry; but I understand that each appeared to terminate abruptly, having a small portion of coaly matter adhering to the end. There is also some appearance of a fifth branch projecting in a contrary direction, but possibly this may belong to another specimen, still imbedded lower in the quarry. The following are the dimensions as nearly as can be ascertained while it remains *in situ:*—diameters of stem, at the lowest part, 14 inches and 6 inches; distance to the first branch 11 feet 6 inches; diameters at this point 16 inches and 6 inches; distance from this to the second branch 5 feet 6 inches; diameters 18 inches and 6 inches; distance to third knot 7 feet; diameters 16 inches and 12 inches; distance again to the upper branch 6 feet 6 inches; diameters 17 inches and 10 inches. From this part to the top, the distance is 8 feet 6 inches, where the breadth is suddenly contracted to less than 8 inches, and immediately beyond the fossil is converted into a thin narrow layer of coal, showing in a remarkable manner a gradual change from the stony mineral into that substance. This upper part, which has been traced about 18 inches further, still continues to penetrate the solid rock, and the lower end has been uncovered to the further extent of 3 feet 9 inches, where this part also is found to enter the side of the quarry; so that the whole length of this splendid fossil, so far as it is yet traced, is upwards of 44 feet, and its greatest breadth is not more than 20 inches. At this point it has evidently been the most compressed, being here only about 4 inches in depth; but from the second branch to within 3 or 4 feet of the top, the tree maintains, in a remarkable manner, almost its original proportions. It will at first sight appear extraordinary that the breadth within 6 feet of the lower end should not exceed 12 inches; this however, without doubt, arises from the greater degree of carbonisation which is evident at this part, and indeed marks of the original exterior may be traced upon the adjoining stone to the extent of 19 inches. The substance of the tree, though not silicified, is hard and fine-grained, differing entirely in appearance from the rock which surrounds it, having become more highly impregnated with iron, to which probably its present state of preservation is to be attributed. It is evident that the mineralising process must have commenced prior to any extensive decay, for in all probability the structure has been well preserved. Microscopic sections, which I have not yet been enabled to obtain, will of course afford the best evidence as to its affinity with other fossils, and with recent wood; but I may observe that there is an appearance of concentric rings, and, moreover, a large development of pith, but differing probably from every other described fossil stem. The bark, in general, has been converted into a thin layer of bright coal, which becomes fractured, and in part separates, on removing the overlying rock; but no trace of leaf-scars or punctures have yet been detected either upon the stem or its branches; the decorticated exterior, particularly of the latter, which presents a smooth surface with broad irregular striæ, having a waved and somewhat twisted appearance. These branches show indications of cicatrices, as though other lesser ones had formerly been attached to them; and it may be remarked that small branches exhibiting this peculiar exterior have repeatedly been met with in the South Staffordshire coal district. I may mention, in conclusion, that I have obtained some excellent sections of the wood, which show that the structure is remarkably perfect, and prove the tree to have been coniferous.

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5. *On the* Trap-rock *of* Bleadon-hill, *in Somersetshire.* By the Rev. D. Williams, F. G. S.

Since the author's last communication on this subject *, the completion of the Railway cutting through the western point of Bleadon Hill has disclosed several new and remarkable facts; and these have so materially changed his views respecting the origin

* Geological Transactions, 2d ser. vol. vi. p. 561.

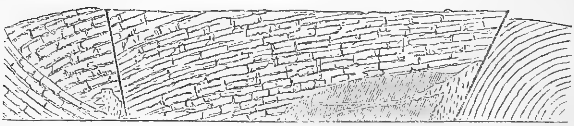
of trap and other rocks, that he has been led to draw up a supplement to his former papers.

The Mountain Limestone of Bleadon Hill and that of Uphill have been disconnected by two great downcast faults since the lias was deposited, that on the Bleadon side ranging E. by N. and W. by S., and that on the Uphill side N. E. and S. W. In the space between them, which is about a quarter of a mile broad, the surface consists of lias and new red sandstone.

In the cutting the Bleadon fault is finely exposed, and its southern side presents a great slickenside wall of limestone and trap, which dips to the south at an angle of 70°. On the northern side of the fault, the lias is seen, curiously faulted, to some little distance; it then dips considerably towards the fault, the inclination increasing, and the beds at last going down with the fault, the lias inclining towards it at an angle of 45°. The lias, where abutting against the trap, has no appearance of having been altered by it.

SECTION I.

WESTERN SIDE OF RAILWAY.



a. Mountain limestone. *b.* Lias.
a′. Altered mountain limestone. *p.* Trap.

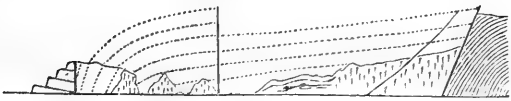
On the western side of the Railway, not far from its northern end, an insulated mass of Mountain limestone is seen standing several feet in advance of the vertical cutting. Though much altered and deprived of the usual planes of bedding, it may readily be identified by its nodules of chert and crinoidal stems and plates.

Little doubt can be entertained that it was once the continuation of four thick beds, which rest on its southern flank, and in the process of quarrying have separated from its surface. Nearly half the base of this insulated mass of limestone has been removed, and replaced by trap, the surface of contact between the two being very rough and unequal; and a foot or two further towards the north there rises from beneath this altered limestone a mass of trap, 9 feet thick at its base, which, as it ascends, gradually tapers, and at the height of from 20 to 25 feet is reduced to a thin string, or enters into joints of the limestone. The limestone is highly altered, and the limestone walls of the joint are singularly rough and rugged throughout. The limestone is traversed by a long, narrow, irregular crack, in which are found thin seams and plates of trap and trappean matter.

Fifty-four feet to the south of the first mass of trap, another irregular mass of the same rock shows itself, and ascends through the beds of limestone diagonally, overhanging on its southern side. Close to the northern side of this mass, a well-defined joint cuts the limestone from its base to its summit, so that between this joint and the trap there is a thin strip of limestone which, on its side next the trap, is very irregularly indented.

Section II.

Eastern side.



Proceeding next to the eastern side of the cutting, and beginning at its northern end, the lias (*b*) is first seen, dipping towards the wall of limestone and trap. On the opposite side of the fault, and at the base of the limestone is seen a mass of trap (*p′*), the upper surface of which runs nearly parallel to the calcareous beds above it. Further southward, however, that surface becomes irregular, and descends more rapidly than the beds of limestone; and near its southern end the mass of trap descends at an acute angle below the level of the cuttings. Further southward, a second mass of trap appears, and at a short distance a third, and then finally a fourth.

The author next describes the alterations produced in the limestone on the eastern side of the cutting.

At the northern fault, the face of the wall of limestone that lies above the trap is eroded in places into broad shallow cavities filled with trap and trappean matter, the trap having generally selected the joints and fissures in the limestone, and being therefore variable and unequal in thickness here, as on the other side of the cutting.

Three of the beds of limestone have been affected by the intrusion of the trap: the lowest varies much in thickness, and is reduced where the trap appears. The second bed is affected and sometimes cut off by the trap, and sometimes becomes blended with the superior bed of limestone, and towards the fault dips down towards it. This latter bed abuts against the fourth mass of trap (towards the south), the contact being rough and rugged.

The curvilinear fault above noticed has shifted the beds of limestone. On the southern side of this fault, we find resting on the southern flank of the fourth mound of trap a mass of altered limestone, which, as it approaches the summit of the trap, tapers upwards and disappears. The surface of this wedge of limestone, where in contact with the trap, presents the same pitted and irregularly eroded appearance which has been before noticed in limestone similarly situated.

Near the middle of the first or northernmost mass of trap, and entirely insulated by it, a patch of limestone was found. This was in some parts attenuated to a thin lamina, and in others terminated in long and slender strings. It was imbedded in the trap to the depth of about a foot.

As to the mineralogical character of the Bleadon trap, it is of a reddish-brown, or greenish-grey colour, and is usually traversed by veins and strings of calcareous spar, which often pass into yellow crystalline limestone. It contains, in abundance, small spherical kernels of calcareous matter, which are usually coated by red oxide of iron. Less frequently it contains steatite, and still more rarely glassy felspar. The rock is rather tough than hard, and decomposes so freely, that specimens of it adhering to the limestone are not readily procured.

The altered limestone has lost its original blue tint, and, in proportion to the alteration it has undergone, has become, first, light-red; secondly, buff; thirdly, bright deep yellow; and lastly, deep-red. In all its bright and deep-red stages, it is crystallised into obtuse rhomboids, like calcareous spar, into which it passes. All the above gradations are frequently seen in the same bed. From its original state of extraordinary hardness the altered limestone has become very crisp and brittle.

The distance from the trap to which the alteration of the limestone extends, is from 5 to 25 feet.

The author is of opinion that the principal shifts, faults, and dislocations which are observable in the limestone beds at Bleadon, took place prior to the intrusion of the trap, and are not attributable to that intrusion. In two instances, however, joints are observable which run through the limestone and the trap continuously; though they are more obscure in the latter than in the limestone.

Reasoning on the preceding facts, the author states his inability to account for them, on the supposition that the trap was injected or forcibly intruded into its present position.

Referring to the southernmost mass of trap, visible on the west side of the cutting, it will be seen that the outlines of the limestone on the southern and northern margins of the trap do not correspond; so that it cannot be supposed that the beds have been parted asunder; nor do the beds adjacent announce anything of the sort. If it be supposed that the limestone, which filled the space now occupied by the trap, has been forcibly removed, the overlying beds bear no evidence of any displacement at all; the deep acute-angular indentations of the mass would be very unfavourable to such removal; and there is no mass of limestone visible above or elsewhere, which in any way agrees in form with the mass of trap.

If it be supposed that the trap was injected into some previously existing cavities, into the hollows and inequalities of which it became moulded, that would not account for the extent to which alteration is manifested in all the rocks around, nor for their unequally altered condition, amounting in some instances to indications of active fusion; nor will it explain the occasional spots and irregular forms of trap which are insulated in the limestone.

Referring to the patch of limestone entangled in the northernmost mass of trap, on the eastern side of the cutting, the author states his conviction that no fragment of a similar limestone, of like forms and dimension to that in question, could be separated from its parent rock by mechanical agency of any kind, unless by the most elaborate design; so thin are the plates and so slender are the strings of this limestone patch, which is insulated in the trap.

The explanation of these phenomena which the author has to offer is, that the lime-rocks have been reduced *in situ* by tranquil fusion, and have been converted by subsequent cooling and crystallising into the trap which now replaces them, occupying the very position before occupied by the limestone.

The patch of limestone insulated in the trap, the author conceives to have been a calcareous fragment, which had escaped entire fusion; and he can imagine no process in nature to account for the spots of trap, insulated in the limestone, except that of intense heat.

The author notices that there is nowhere to be met with, in the proximity of the trap, any extraneous matter which might be referred to the action of liquid lava on the limestone; but it is all limestone, or all trap. What, he asks, can have befallen the portions of the limestone beds which have disappeared, unless they have been melted up, and converted into trap?

The author does not mean to question the fact that, in certain instances, trap and other volcanic rocks have been forcibly introduced among sedimentary and other rocks; but only wishes to show that, in other instances, there is evidence that the presence of trap is attributable to the reduction of pre-existing rocks by volcanic agency.

These views led the author to arrange Volcanic Products under two heads, the immediate and the intermediate; the former consisting of such products as have been fused down and crystallized *in situ*, or have been ejected from submarine vomitories, or subaerial craters; the latter, of such rocks as have been acted upon more or less extensively, and only partially reduced by active fusion, and were therefore in different states of reduction when the temperature was finally withdrawn. In the former he comprises granite, porphyry, the several varieties of trap, tufaceous ash, breccia, grit, flinty chlorite, talcose and clay slates; in the latter head he comprises gneiss and mica-, chlorite-, and hornblende- schist.

January 17, 1844.

Eaton Hodgkinson, Esq., F.R.S., of Manchester, and Lieutenant-Colonel Sabine, R.A., F.R.S., were elected Fellows of this Society.

The following communications were read: —

1. *On certain* Crustaceans *found at Atherfield by Dr. Fitton.* By T. Bell, Esq., F. R. S., Professor of Zoology in King's College, London.

[The notice of this paper in the "Proceedings" is postponed.]

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2. *On the Occurrence of* Phosphorite *in Estremadura.* By Charles Daubeny, M.D., F.R.S., Professor of Chemistry in the University of Oxford; and Captain Widdrington, R. N., F.R.S.

A statement having frequently been made by mineralogical writers, that there exists in the Spanish province of Estremadura an extensive formation of Phosphate of Lime, it was considered by some leading Members of the Royal Agricultural Society of England an object of importance to learn the truth of these statements; and the authors were, therefore, commissioned to ascertain where and under what circumstances the substance in question was found; what facilities existed in the country for procuring it and conveying it to the coast; and whether, if used as a manure, it was of a nature to serve as a substitute for the bone earth, now employed extensively in husbandry.

The original authority for the statement, that there occurs in Estremadura a certain mineral which, when thrown upon live coals, becomes phosphorescent, was found to be William Bowles, who, in his introduction * to the Natural History and Physical Geography of Spain (2d edit. 4to. Madrid, 1782, p. 6.), relates, that, at the foot of a range of mountains running E. and W., and called the Mountains of Guadalupe, and in the immediate vicinity of a place called Logrosan, the royal road is traversed obliquely, from N. to S., by *a vein* of Phosphoric stone. This stone was said to be of a pale colour, and without taste; and, when sprinkled upon live coals, to emit a blue flame, but no smell.

Proust, the distinguished chemist, in a letter to the French chemist, D'Arcet, dated Madrid, 12th of September, 1787 (which letter is published in the Journal de Physique for April, 1788), communicates the important information, that the mineral in question, of which he had received specimens from an apothecary at Madrid, gives off phosphorus when heated with charcoal in a retort. He quotes from the work of Bowles the passage above referred to; states that he has not been able to visit the spot where the mineral is found; and, from information which he has received, gives the following account, varying from that of Bowles in several particulars.

* 1st edit. 4to. Madrid, 1775. — French translation of do. 8vo. Paris, 1776. — 2d edit. of the original, 4to., Madrid, 1782. — Italian trans. of 2d edit., with notes, by Don J. N. D'Azara, 2 vols. 4to. Parma. 1783.

"This stone is found near Logrosan, a village in the jurisdiction of Truxillo, in the province of Estremadura. It occurs, *not in veins, but forms entire hills.* The houses and the walled enclosures of the fields are built of it."

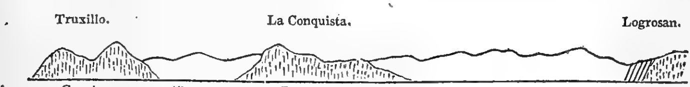
On reaching Madrid, the authors were informed by the head of the Department of Mines, that the mineral formed a vein in granite.

The authors, after this introductory notice, then proceed to give an account of their researches.

Between the tertiary table-land of the two Castiles, and the descent of the south-eastern escarpment of the Sierra Morena, as you enter on the plains of Andalusia, a district of country intervenes, over a large portion of which a formation of clay-slate, with occasional masses of quartzite, forms the fundamental rock. In proceeding from Madrid, it was to the south of Talavera de la Reyna, at the village of Calzada de Oropesa, that this formation first appeared. In the steep ravine through which the Tagus flows near the broken bridge of Almaraz, dark blue slate appears in vertical strata. Puerto di Miravete is the culminating point of this formation, from which a vast table-land is seen intersected by low flat-topped ridges, rising from three to four hundred feet above the plain, and studded over with conical hills. The above ridges, according to Le Play, are occasioned by beds of quartz; and this statement agrees with the observations made by the authors above Almaden. The quartzite is either compact, granular, or brecciated, or constitutes a fine-grained sandstone. The conical hills consist of granite, which has forced its way through the slate. Examples of this occur at Truxillo, and a league onwards on the road to Logrosan. Then slate re-appears, then granite for the space of a mile ; then slate again; which continues to Logrosan. To the south of that village, granite again appears, rising to the height of four or five hundred feet. With this exception, all the rocks around Logrosan, and thence as far as the Monastery of Guadalupe, consist of the clay-slate and quartzite.

The granite is much decomposed, and divides into blocks, which strongly resemble Cyclopean walls.

The following is a general representation of the respective situations of the slate and granite.



a. Phosphorite beds of Logrosan. *
Base, seven Spanish leagues.

* The slaty beds are grouped according to the following order:—

1. Dark blue, homogeneous, and excessively hard and compact fissile slate, intersected by veins of quartz. This is the common building-stone at Logrosan.
2. A soft and talcose slate.
3. A micaceous slate.
4. Alternating layers of talc and granular quartz.
5. Brecciated and slaty beds.

The authors could not learn that, in the neighbourhood of Logrosan, the slate contains any fossils, although, according to Le Play, it contains near Almaden an abundance of *Spirifer attenuatus* and of a *Terebratula;* and, according to the miners of Almaden, Trilobites had been found in it. These slates are referred to the Silurian period.

Between the granite and the slate there occurs a more crystalline rock, resembling mica slate, and said by Le Play to contain chiastolite. The authors met with this rock between Almaden and Cordova, near the granite of Viso.

Logrosan is a considerable village, about seven Spanish leagues S. E. of Truxillo. In the neighbourhood of the village the surface of the slate is undulated, the difference of level between the heights and depressions being about fifty feet. It is in the clay-slate that the Phosphorite occurs. See the section in the last page.

It may be traced on the surface or immediately beneath the soil, running in the direction* of the rocks themselves, that is, from N. N. E. to S. S. W., for the distance of nearly two miles. It terminates southwards not far from the base, and a little to the east of the granite hill. The summit of the hill and its north-eastern declivity consist of granite; but the side nearest the phosphorite consists of clay-slate. At this point the phosphorite is 16 feet wide, and extends to an unknown depth. It has been penetrated to the depth of only 10 feet.

As was noticed by Bowles, the seam crosses the road leading from Logrosan to Guadalupe, and it forms an inconvenient rise in the road where it crosses. To level this, the seam had been broken down, and its fragments had been used to repair the neighbouring walls, and in the construction of a fence that separates the road from an olive plantation, and it seemed here to be very little altered by exposure to the weather. The rock is a compact clay-slate, of indistinct slaty cleavage, and is disposed in beds inclining from the granite, but nearly vertical. The seam of phosphorite is only 7 feet thick, and it is only the middle portion, to the width of 3 feet, that is in a state of purity. The rest consists of phosphorite, alternating with layers of hornstone, containing iron and a trace of phosphate of lime. Other small seams of phosphorite proceed obliquely from the main seam, and penetrate the clay-slate to some distance.

The mineral is disposed in zones, after the manner of agate, round centres of crystallisation, each zone being an assemblage of converging crystalline spiculæ. Pure white zones of the mineral are often separated, one from the other, by their dark-brown layers, tinged with oxide of iron. Between contiguous zones, having different centres, void spaces often occur, and when this is the case, the surface of the mineral next the cavity is mammillary. Crystals of quartz also occasionally line these cavities.

From the point where it crosses the road, the deposit was traced

* Le Play speaks of the Phosphorite as intersecting the clay-slate.

in a S. S. W. direction, across the olive plantation, and down a gentle declivity, until it was lost sight of.

The following is the mean of two analyses that were made of the purest specimens of phosphorite that could be selected:—

Silica - - - -	1·70
Peroxide of iron - -	3·15
Fluoride of calcium - -	14·00
Phosphate of lime - -	81·15
	100·00

The authors take occasion to remark that, in seven varieties of Apatite which were analysed by Gustavus Rose, from 4·59 to 7·69 of fluoride of calcium were detected; and they call the attention of chemists to the association of the elements of Fluorine and Phosphorus which takes place in the Phosphorite of Estremadura, as it does in recent and fossil bones and teeth.

The only practicable route at present for conveying this mineral to the coast is by a six-days' journey in bullock cars, or on the backs of mules, to Seville.

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3. *Notes on the* Cretaceous Strata *of* New Jersey, *and other Parts of the United States bordering the Atlantic.* By C. Lyell, Esq., M.A., F.R.S.

The cretaceous and tertiary deposits of America, which intervene between the Alleghany mountains and the Atlantic, bear a great resemblance in mineral character to the sandy and argillaceous portion of the formations of the same age in the south-east of England. If all the white chalk, with its flints, together with the cherty beds of the green sand, were omitted, the remaining cretaceous strata in our island would consist of loose incoherent sand with green particles, red and highly ferruginous sandstones, white sands, and (in some places) beds of lignite; the overlying tertiary deposits, consisting of marls, clays, and variously coloured sands occasionally exhibiting green particles, like those of the green sand below the chalk; and as in the bottom of the London basin near Reading. Such, for the most part, is the succession of the beds in New Jersey; and, further south, in Maryland and Virginia, the Eocene strata are often as full of green particles as the cretaceous, so that they are only distinguishable by their fossils and relative position. Even the Miocene strata are sometimes, as in Virginia, of a blueish-green colour, and contain green particles of a similar kind. This fact alone of the identity in lithological character of the secondary and tertiary strata of the United States is calculated to put us on our guard against inferring that the green and ferruginous sands of New Jersey correspond in age to the lower rather than the upper part of the European cretaceous system. It is scarcely possible, on recognising so many of the common organic forms which are familiar to us in connection with the cretaceous rocks on this side of the Atlantic, and seeing them occur in beds which have the exact mineral type of the beds below the Gault, not to feel a strong inclination to regard them as the equivalents of our green sand, and to consider the white chalk as wanting. But when we dismiss from our minds, as we ought to do, the bias derived from the consideration of the mineral aspect of the beds, and compare the fossils of New Jersey with those derived from the European chalk, we find the agreement upon the whole to be far greater with the beds occurring in Europe above the Gault, than with those which are found below it. We are indebted to Dr. Morton for having pointed out, in 1834, the general agreement of the organic remains of the American and European cretaceous fossils, while, and at the same time, he and Mr. Conrad correctly observed that almost all the species were different. He divided the strata of New Jersey into the ferruginous sand, which he compared to our green sand formation, and the calcareous strata, which he identified with the white chalk of Europe. Prof. H. D. Rogers has since divided the New Jersey cretaceous beds into five formations, which are very useful, topographically considered, but which may be overlooked in the present paper, because only two of them, namely, those alluded to by Dr. Morton, have as yet yielded a sufficient number of fossils to entitle them to rank as palæontologically distinct.

In an excursion which I made in New Jersey, in September, 1841, in company with Mr. Conrad, we went first to Bristol, on the Delaware, next, by Bordentown, to New Egypt, and returned by the Timber Creek, recrossing the Delaware at Camden. On this occasion I had an opportunity of examining the strata of both these formations, and I collected nearly all the fossil species described by Dr. Morton, together with some few additional ones. I shall now, therefore, briefly notice these two deposits and their fossils, and consider them in reference to their European equivalents.

Although in this part of New Jersey there is no white chalk with flints, so characteristic of rocks of the same age in Europe, it is still impossible to glance at the fossils and not be convinced that Dr. Morton was right, as before hinted, when in 1834 he referred the New Jersey deposits to the European Cretaceous era, and remarked that the American species of shells were nearly all new or distinct from those before described, and yet very analogous to those of the chalk already known. Of the two well-marked subdivisions of the Cretaceous system the lower consists in great part of green sand and green marl, and was supposed by Dr. Morton, as already mentioned, to be the equivalent of the English green sand, while an upper or calcareous rock, composed chiefly of a soft straw-coloured limestone with corals, was thought to correspond with the white chalk of Europe. But after carefully comparing my collection, comprising about sixty species of shells, besides many corals and other remains, I have arrived at the conclusion that the whole of the New Jersey series agrees in its chronological relations with the European white chalk, or, to speak more precisely, with the formations ranging from the Gault to the Maestricht beds inclusive. Among the shells, in determining which I have been assisted by Professor E. Forbes, not more than five out of sixty seem to be quite identical with European species; but several others approach very near to, and may be the same as Europeans; and at least fifteen may be regarded as good geographical representations of well-known chalk fossils belonging for the most part to beds above the Gault in Europe. There are a few very peculiar forms among the American testacea, such as *Terebratula Sayii* Morton; and I found among the univalves a Bulla, but casts of the genus had previously been mentioned by Dr. Morton, and although not yet known in the European chalk a species occurs on the Continent in beds of the Jurassic system.

In the upper or straw-coloured limestones, I found on the banks of the Timber Creek, twelve miles south-east of Philadelphia, six species of corals* and several echinoderms, chiefly allied to *upper* cretaceous forms. The same calcareous formation also abounds in Foraminifera characteristic of the chalk, comprising, among others, the genera *Cristellaria*, *Rotalina*, and *Nodosaria*. Besides the shells there are also several remains of fishes, and of the series obtained by myself all those referred to the genus *Lamna* resembled species occurring in our chalk. They have been examined for me by Sir P. Egerton. One of them seems to approach very closely to *Lamna appendiculata*, and another comes very near to *Galeus pristodontus*; and indeed, if we may judge by so few specimens, seem identical. These are fossils of our upper chalk in Europe. There are also several forms of *Carcharias* not very unlike some tertiary species given me from the New Jersey chalk, several of which are figured by Dr. Morton; I will not dwell upon these however, since in Europe also there are many of the cretaceous Squalidæ which can scarcely, when the teeth alone are considered, be distinguished specifically from tertiary fossils.

There are three Saurian vertebræ in the New Jersey green sand in the collection of the Geological Society, which I have submitted to Mr. Owen's inspection. One of these, from the green sand of Mullica Hill, is the anterior dorsal vertebra of the Mosasaurus. Another is the posterior cervical vertebra of a Pliosaurus, a genus which Mr. Owen has constituted to include a portion of the Plesiosauri, and which approach still more nearly to the true Saurians. The vertebra in question resembles very closely that of *Pliosaurus brachydeirus* of the Kimmeridge clay. Until very lately, the Plesiosaurian type was not known higher in the series than in the Oolites; but it has now been shown to ascend to the chalk of Europe, so that its occurrence in the New Jersey strata is in strict accordance with European analogies. The third specimen (pre-

* These have been described by Mr. Lonsdale, and the description and figures will be given at the end of the present paper.

sented, I believe, by Professor H. D. Rogers) is labelled, "Woodstown, New Jersey;" a locality where those beds occur to which the great mass of shells before alluded to belong. It is a vertebra, penetrated by the green particles of the sand. Mr. Owen refers this to the dorsal vertebra of a crocodile of his *Procœlian* division, or those which, like the recent crocodiles, have the concavity in the forepart, and the convexity behind. This fact is important, as hitherto the Procœlian crocodiles in Europe have not been found in beds older than the eocene.

In concluding these remarks on the ferruginous and green sand formation of New Jersey, I may observe that the identification of four or five species out of sixty fossil shells with European cretaceous fossils would give an agreement of about seven per cent., which is by no means a small amount of correspondence, when we consider that the part of the United States above alluded to is distant between 3000 and 4000 miles from the chalk of Central and Northern Europe, and that there is more than 10° difference in the latitudes of the two districts compared, on the opposite sides of the Atlantic. It may doubtless be true, that the influence of temperature during the Cretaceous period was less powerful in limiting the range of species than it is now; and that the same forms prevailed more uniformly from India to Sweden, than they do at present. Nevertheless, the cretaceous fossils of Northern and Southern Europe differ sufficiently to show that the climate had then no small influence in causing distinct geographical provinces of species; and it seems natural that those species which are very abundant in Europe, such as *Belemnites mucronatus*, or those which have a great vertical range, such as *Pecten quinquecostatus*, should be the fossils found, if any, to recur in a distant part of the globe.

In the next place I proceed to give some account of the upper fossiliferous division of the New Jersey cretaceous deposit, which is for the most part arenaceous, but contains, in many places, layers of limestone and calcareous sand, with corals slightly aggregated together. It has been traced by Mr. Rogers to a distance of about 60 miles in a north-east and south-west direction, from Prosper Town to near Salem, having rarely a breadth of half a mile, and the thickness being from 6 to 20 feet. Its importance is derived, geologically speaking, from its fossils, and, in an economical point of view, from its affording the only lime procurable in this district. I saw the formation in question, on the banks of Timber Creek, a stream which flows into the Delaware, three miles below Philadelphia. The principal locality is twelve miles S. E. of Philadelphia, about a mile and a half south of the village of White Horse, in Gloucester County, New Jersey. Here a bed of soft calcareous stone, about 20 feet thick, is seen made up, in great part, of corals of the genera *Eschara*, *Escharina*, *Cellepora*, *Tubulipora*, and others*, together with the remains of echinoderms, such as *Cidaris* and *Spatangus*. It contains also some shells, as *Scalaria annu-*

* See the description of these corals by Mr. Lonsdale, in the Appendix.

lata, *Gastrochæna*, and *Teredo*, the whole indicating the sandy bottom of a shallow sea. I was so strongly reminded of the coralline crag of Sudbourn, and other places in Suffolk, when examining this rock, that I had some difficulty at first in persuading myself that it was not a tertiary deposit. It is, in a great part, a mass of white calcareous sand, more or less aggregated together, and the upper surface has been irregularly scooped out and rendered undulating, and is covered with a newer deposit of red clay and gravel, without fossils, the surface of which is even and level. This white sand and limestone pass downwards into light-green and ferruginous sand, with quartzose grains.

Near Hornerstown, I saw, on a branch of the Timber Creek, to which Mr. Conrad conducted me, a bed of this coralline aggregate, 8 feet thick, resting on the green sand or lower deposit before mentioned, with its characteristic fossils.

We have now to consider whether the calcareous or upper formation has been referred with propriety to the chalk. Mr. Forbes has examined the Echinoderms, and is of opinion that they are decidedly analogous to cretaceous forms. One of the species of *Spatangus* belongs to the same group as *S. subglobosus* of Goldfuss, a group which forms the genus *Holaster* of Agassiz, and which that naturalist regards as very characteristic of the upper part of the Cretaceous system.

One also of two species of Cidaris is allied to *C. vesiculosus*, and to other upper cretaceous species of Europe.

Dr. Morton had already observed, in regard to the corals, that some of the species resemble a Maestricht fossil, figured by Goldfuss; and the reader is referred to Mr. Lonsdale's comments on this subject in the Appendix.

The fossil called by Dr. Morton "*Belemnites ambiguus*," though probably not related to the Belemnite, is closely allied to a fossil which I have collected myself in the chalk of Sweden, associated with *Belemnites mucronatus*.

The last-mentioned, or upper of the two fossiliferous formations of New Jersey, has been called by Dr. Morton and Mr. Conrad the Medial Cretaceous, because there are others still higher in position in the Southern States, which they refer to the chalk period. One member of these, a white limestone, seen extensively on the Santee canal, and in other parts of South Carolina, as well as at Jacksonborough and Shell Bluff in Georgia, I have shown, in a former communication to the Society, to be Eocene tertiary. Another portion, called the Nummulite limestone of Alabama, I have not examined, and can therefore offer no opinion respecting it.

Upon the whole, the collection of fossils which I made in New Jersey confirms the principal conclusion to which Dr. Morton arrived, that there is a remarkable generic accordance between the fossil mollusca, corals, echinoderms, fish, and saurians of the cretaceous group, in New Jersey and in Europe. But the general analogy of the generic, and the identity of some specific, forms, which Mr. Forbes and Mr. Lonsdale have assisted me in comparing, has led me to refer all the fossiliferous formations of New Jersey to that part of the European series which ranges from the Maestricht beds to the gault inclusive.

North Carolina.

Of the same age are certain strata in North Carolina, at a place called Lewis's Creek near South Washington, forty miles north of Wilmington, and 340 geographical miles south-west of New Jersey, where I found *Belemnites mucronatus, Ostrea vesicularis, O. subspatulata* (a remarkable and new species figured in the Appendix), *Cellepora tubulata*, and other fossils.

The association of *Cellepora tubulata*, which abounds in the upper cretaceous formation of New Jersey at Timber Creek with *Belemnites mucronatus* in this locality of South Carolina, is important, as helping to show the near relation of the coralline limestone of New Jersey to the green sand containing Belemnites.

Georgia.

Some fossils have been communicated to me by Dr. Cotting, from Georgia, which make it probable that there are cretaceous strata there, lower than those of New Jersey; as among them are a *Pholadomya* and an *Ammonite;* both of which Mr. Forbes finds to be closely allied to certain Neocomien species from Neuchâtel.

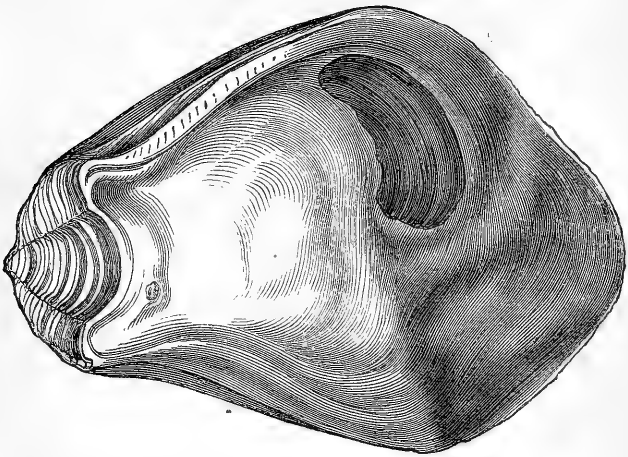
In the collection of Mr. Conrad, from Alabama, I saw a species of Hippurite, derived from the cretaceous strata of that State, which I believe is the only example of any fossil of the Rudist family derived from the cretaceous rocks of North America. It affords another point of analogy between the cretaceous fauna co-existing on opposite sides of the Atlantic.

It is interesting to find, as the result of this investigation, that the marine fauna, whether vertebrate or invertebrate, testaceous or zoophytic, was divided at the remote epoch under consideration, as it is now, into distinct geographical provinces, although the geologist may every where recognise the cretaceous type, whether in Europe or America (and I might add India). This peculiar type exhibits the preponderating influence of a vast combination of circumstances prevailing at one period throughout the globe, circumstances dependent on the state of the physical geography, climate, and organic world, in the period immediately preceding, together with a variety of other conditions.

Appendix I. — *On the* Fossil Shells *collected by* Mr. Lyell *from the Cretaceous Formations of* New Jersey.

1. *Description of New Species.* By Professor Edward Forbes.

Most of the fossil shells (amounting to sixty species) collected in New Jersey during Mr. Lyell's excursion with Mr. Conrad have been already described in Dr. Morton's excellent work. The following, however, are new species:—



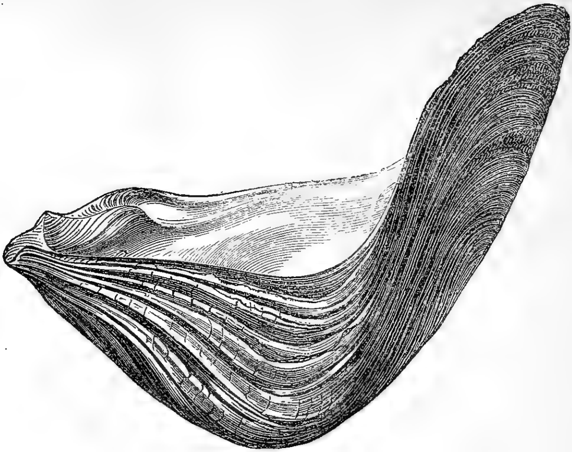
Ostrea subspatulata *L. & S.*

Interior of the Lower Valve.

[*Two thirds the natural size.*]

1. Ostrea *subspatulata.** Lyell and Sowerby. Shell obovate somewhat trapeziform; generally thick; higher than wide; narrower at the dorsal than at the ventral or basal end, which is turned downwards at an obtuse angle; somewhat foliaceous externally; muscular impression placed very near the base. Locality, Lewis's Creek, South Washington, North Carolina.

* Ostrea obovata, spatulata; valvâ inferiore, convexâ, arcuatâ, posticè crassissimâ; superiore subdepressâ.

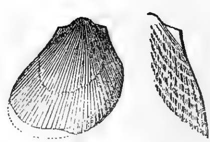


Ostrea subspatulata *L. & S.*

Side View of Lower Valve.

[*Two thirds the natural size.*]

2. LIMA *reticulata*. Lyell and Forbes. L. testâ ovatâ, obliquâ, inflatâ, tenui, longitudinaliter sulcatâ, sulcis reticulatis, numerosis. Habitat, Nov. Jersey.

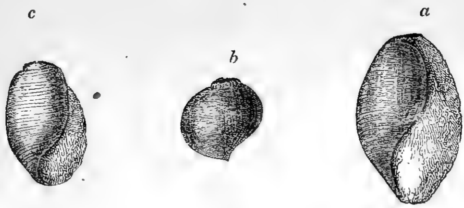


Lima reticulata *L. & F.*

3. TEREBRATULA *Vanuxemiana*. Lyell and Forbes. T. testâ suborbiculare, valvis bicarinatis, longitudinaliter costatis, costis

Terebratula Vanuxemiana *L. & F.*

intermediis minoribus, valvâ superiori convexâ, areâ late triangulare, foramine magno, valvâ inferiori convexiusculâ, margine frontali subbisinuatâ. Habitat, Nov. Jersey.

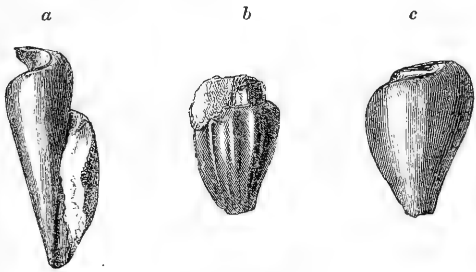


a. Bulla Mortoni.
b. Natica.
c. Tornatella.

4. Bulla *Mortoni* (*a*). (Cast.) Ovate, inflated, resembling in form B. *hydatis*, spire concealed, surface spirally furrowed, the furrows bearing traces of punctation.

5. Natica (*b*). (Cast.) Of a small globular species with a deeply channelled suture, spirally sulcated, and obsoletely reticulated whorls and depressed spire. Locality, New Jersey.

6. Tornatella (*c*). (Cast.) Oblong, bearing traces of spiral striæ; spire exserted, subdepressed; sides of body-whorl somewhat flattened; columella perforate; aperture lanceolate. Locality, New Jersey. Allied to *T. bullata* of Morton, which, however, is a much more ventricose species.



Casts of Voluta.

7. Voluta. (Casts.) *a*, Shell linear, lanceolate, whorls smooth. *b*, Shell ovate, whorls smooth. *c*, Shell ovate, whorls angular above, distant ribs.

Note. — The figures are all of the natural size, except the Ostrea, which is two-thirds in linear dimensions.

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2. *List of Species common to the American and European Cretaceous Systems.*

Ostrea larva (O. falcata *M.*)
—— vesicularis
Gryphœa costata
Pecten quinque-costatus
Belemnites mucronatus

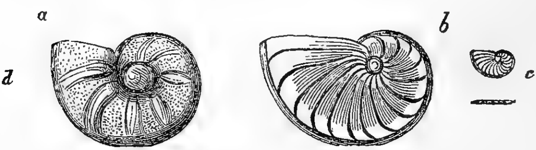
3. *List of New Jersey Species, Representatives of which occur in the European Cretaceous Beds.*

New Jersey Species.	*Probable representative European Species.*	Geological locality in Europe.
Spatangus n.s.	S. subglobosus	
Cidaris	C. vesiculosus	
Terebratula fragilis *M.*	T. biplicata	(*Upper green sand*)
———— floridana *M.*	T. Defrancii et striatula	(*Upper chalk*)
Plicatula urticosa *M.*	P. inflata	(*Chalk marl and upper green sand*)
Inoceramus Barabini *M.*	I. Crippsii	(*Chalk and green sand*)
Cucullea vulgaris *M.*	?	
Trigonia thoracica *M.*	T. alæformis	(*Green sand*)
Pholadomya occidentalis *M.*	P. gigantea	(*Lower green sand*)
Phorus leprosus	P. canaliculatus	(*Lower chalk*)
Scalaria annulata	S. Dupiniana	(*Gault*)
Natica petrosa *M.*	N. excavata	(*Gault*)
Voluta	Several lower chalk species.	
Hamites arcuatus	?	
Ammonites placenta	A. clypeiformis	
Baculites ovatus	B. anceps.	

4. *List of Peculiar Forms found in the New Jersey Cretaceous Formations.*

Terebratula Sayii *M.*
Ostrea subspatulata *n. s.*
Crassatella vadosa *M.*
Venilia Conradi.

Notice of the Foraminifera. By Mr. Lyell.



a. Rotalina. (*d.* nat. size.)
b. Cristellaria. (*c.* nat. size.)

The above are figures of the two genera of Foraminifera from the upper beds at Timber Creek, alluded to in the paper.

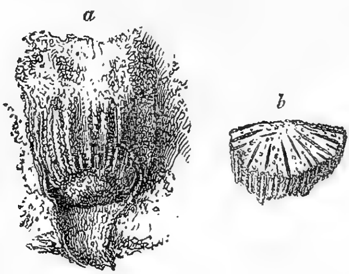
I am not aware that any attention has hitherto been paid to the fossil foraminifera of the American cretaceous strata, to which I find no allusion in Dr. Morton's works. They are very abundant in the coralline rock of Timber Creek. Mr. Forbes has examined some of them for me, and these belong to the genera Cristellaria, Rotalina, and Nodosaria. All these genera occur in the chalk of Europe. One of my American species of fossil Cristellaria is specifically identified by Mr. Forbes with *C. rotulata* of D'Orbigny, which occurs in England, France, and Germany, ranging from the upper greensand to the white chalk. It is another instance of species found most abundantly in Europe, recurring in the American chalk. There are two other species of the same genus at Timber Creek, one of them very large. There are two species of Nodosaria. The Rotalina, which is very abundant, is closely allied to a species of our chalk.

APPENDIX II.—*Account of* SIX SPECIES OF POLYPARIA *obtained from Timber Creek, New Jersey, and described by* WILLIAM LONSDALE, Esq. F.G.S.

THE following is a list of the species:—

1. Montivaltia atlantica *Lonsdale* (Anthophyllum atlanticum *Morton*).
2. Idmonea contortilis *Lonsdale.*
3. Tubulipora Megæra *Lonsdale.*
4. Cellepora tubulata *Lonsdale.*
5. Escharina? sagena *Lonsdale* (Flustra sagena *Morton*).
6. Eschara digitata *Morton.*

1. MONTIVALTIA ATLANTICA.



a. Nearly perfect specimen, exhibiting the lamelliferous or upper portion in its true position, and the inferior hollow cone.
b. Portion of the upper surface slightly worn down, to show the characters of the lamellæ.

Inversely conical; lower or non-lamelliferous portion nearly equal in length to the upper or lamelliferous; enveloping crust extending nearly to the superior termination of the cone; lamelliferous portion variable in form; lamellæ very numerous; centre, contorted plates terminating inferiorly in a distinct umbilicus or boss; superior termination of the cone nearly flat.

This coral is described by Dr. Morton under the name of ANTHOPHYLLUM ATLANTICUM. (Silliman's Journ. vol. xviii. pl. 1. f. 9, 10. Essays on Org. Rem. &c., p. 61. 1829. Journal Acad. Nat. Sc. Philadelphia, vol. vi. pl. viii. f. 9, 10. pp. 123, 124. 1830. Synopsis Org. Rem. &c. pl. i. f. 9, 10. p. 80. 1834.)

Dr. Morton states (Essays, pp. 61, 62. Synopsis, p. 80.) that he derived his characters of the genus Anthophyllum from Goldfuss; and the lamelliferous portion of the coral under consideration, as represented in Dr. Morton's excellent figures, bears a strong general resemblance to some of Goldfuss's species (Petref. pl. xiii. f. 10, 11. pl. xxxvii. f. 15.). The fossil is probably generically identical with that represented in pl. xxxvii. f. 15. There is also a general agreement in Dr. Morton's figure 10. (pl. i. Synopsis) with Schweigger's *Anthophyllum cyathus* (Beobachtungen, Tabular Arrangement, vi.), particularly as given in Esper (Pflanzenthiere, Madrep. tab. xxiv.); but the American fossil, when preserved in its true position, clearly differs from the generic characters proposed by Schweigger, and adopted with various modifications by succeeding authors, including Goldfuss. The *Anthophyllum cyathus,* as well as the corals typical of the four other divisions of Schweigger's comprehensive genus, are lamelliferous throughout, whereas the American fossil, as beautifully shown in one of the Timber Creek specimens (*a*), consists of an upper lamelliferous portion or nucleus, and an inferior non-lamelliferous portion or hollow inverted cone.

This great peculiarity of structure apparently agrees with Lamouroux's characters of his genus *Montivaltia:* "Polypier .... presque pyriforme, composé de deux parties distinctes, l'inférieure ridée transversalement; la supérieure presque aussi longue que l'inférieure, ... presque plane au sommet, légèrement ombiliquée et lamelleuse" (Exposition Méthodique, p. 78.); and in his observations on the Caen specimens of *Montivaltia* he says, "elles sont géodiques" (ibid.). This peculiar structure would agree perfectly with the hollow inverted cone of the American coral, and the characters of the "partie supérieure légèrement ombiliquée et lamelleuse" accord well with the structure of the lamelliferous portion. De Blainville (Man. d'Actinologie, p. 336.) says, Lamouroux's figures are "*forte inexacte*," but there is enough of resemblance in them, particularly in figure 9. (Plate 79.) to support a generic agreement with the Timber Creek fossil, the "partie inférieure, ridée transversalement," being represented in the American specimens by the cast of the hollow cone, and the higher extension of the envelope being considered only a specific difference. Lamouroux's coral figured by Guettard (Mém. iii. p. 466. pl. 26. f. 4, 5.), but named by De Blainville *Montivaltia Guettardi* (De Bl. Man. d'Actinol. p. 336.; see also *Anthophyllum Guettardi*, p. 340.), bears even a closer resemblance to the Timber Creek specimens. Guettard graphically compares it to a "cupule de gland de chêne."

Dr. Morton, in his careful researches for analogous cretaceous fossils, refers to Faujas St. Fonds's figures of Maestricht corals, particularly to Pl. xxxviii. f. 1. 5. (Hist. Nat. de la Mont. de St. Pierre de Maestricht). Between those figures and the American coral there is a great general similarity; but a rigid comparison will show that there are important differences in the structural details, particularly in the centre of the apparently lamelliferous portion. The Maestricht fossils, or casts, are moreover wholly siliceous; and therefore, as they do not exhibit any traces of the original lamellæ, they cannot lead to the inference that the original coral consisted of two distinct structures. It is most probable that those casts represent only the terminal cup of an ordinary lamelliferous polypidom. It was the preservation of the lamellæ in the upper part, and the total want of any trace of them in the lower, which led to the belief that the Timber Creek specimens belong to the genus Montivaltia.

The total length of the finest specimen (*a*, see figure), is about $1\frac{1}{2}$ inches, and the greatest breadth nearly $\frac{3}{4}$ of an inch; the two portions, as before stated, are of about equal length. The whole form of the coral is an inverted cone, terminating downwards in a bent point. The lamelliferous portion is cylindrical, or slightly contracted towards the base, and there is often a tendency to bend to one side. The lamellæ are very numerous, amounting probably to eighty; and are represented in well-preserved specimens by layers of calcareous spar. They were apparently of unequal dimensions; and their lower terminations are distinctly rounded or semicircular without any signs of fracture, and, consequently, of having extended downwards into the existing hollow cone. The sides of the lamellæ were apparently hispid, rows of indentations occurring in the earthy matter, which filled the intervening spaces of the original coral. The superior terminations of the lamellæ were unequal, certain of them, probably twenty in all, protruding above the others; and these range inwards, uniting with the central contorted plates. The characters exhibited in a slightly worn-down specimen prove also that the upper termination of the coral was not cup-shaped, but flat, with possibly a slight central depression (*b*).

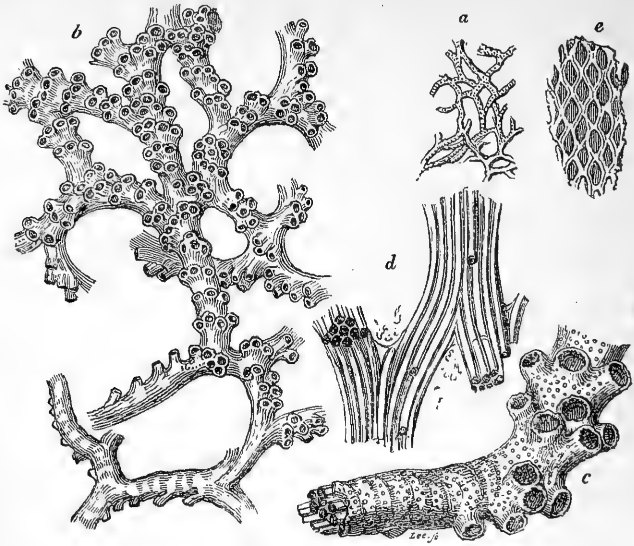
The centre of the lamelliferous portion consists of plates more or less horizontally contorted in the body of the cylindrical mass, and vertically at the superior and inferior terminations, forming in the latter position either a marked central rugose depression as shown in Dr. Morton's figures (*loc. cit.*), or a subordinate projecting cone (*a*).

The interspaces between the original lamellæ are occupied by earthy casts, constituting a very conspicuous portion of the coral; and from their well-defined rounded edge, as well as their decided termination downwards, they might be considered as the true lamellæ. It is clear, however, from their bearing the impression of hispid surfaces, that they are mere casts, formed while the original lamellæ existed. The material of which they consist is more or less argillaceous, and includes numerous foraminiferæ.

Of the nature of the portion represented by the hollow cone, no opinion can be offered. That it possessed a certain amount of solidity, and had structural details which resisted, for a time, decomposition, is evident from the earthy matter which filled the spaces between the lamellæ not having penetrated downwards into the cone, and from the marked characters of these casts. It is clear, also, from the preserved vestiges of the crust which enveloped the lamelliferous portion, as well as from the surrounding cavities mentioned by Dr. Morton, that the external wall or integument must have been thin.

Locality. Timber Creek.

2. IDMONEA CONTORTILIS *Lonsdale*. Sp. n.



a. Branches natural size.
b, Portion of the same magnified, and exhibiting the contorted mode of growth.
c. Part of a branch more highly magnified, to show the pores in the surface.
d. Magnified portion of the reverse side (*e.* nat. size), exhibiting the range of the tubes, exposed by fracture.

Branches compressed, bifurcated, contorted and anastomosed; tubular openings projecting, variously grouped; no marked, continuous, central line between the groups; reverse surface slightly convex, furrowed transversely, and streaked faintly by the separating walls of the tubes.

In the absence of the central line or medial ridge, and of a regular bilateral arrangement of the tubular openings, this coral differs from the generic characters of Idmonea as given by Lamouroux (Exp. Méthodique, p. 80.), and repeated by Milne Edwards (Ann. Sc. Nat., 2d series, vol. ix. Zool.); but it agrees in the general distribution of the openings with the latter author's enlarged figure of *Idmonea transversa* (loc. cit. Pl. ix. fig. 3.; likewise Recherches sur les Polypes; Mémoire sur les Crisies, &c.); De Blainville also, in his description of the genus, says, the openings are disposed "en demi-anneau ou en lignes brisées" (Man. d'Actinol., p. 419.). There is a slight resemblance between the Timber Creek coral and the *Cellepora echinata* of Goldfuss (Petref. xxxvi. f. 14.), an Astrupp tertiary fossil, but which is said to be attached to a Terebratula.

The branches are slightly convex on both sides (see figures), and so greatly contorted that the reverse surface of some portions of a specimen are completely turned round. The tubular openings project more or less, and are variously grouped, but with a tendency to a transverse linear arrangement. The furrows between the openings are smooth, or but faintly traversed by longitudinal lines, marking the range of the tubes; they are, moreover, minutely porous (*c*). On the reverse side very small pores may also be detected, though not generally, in consequence, probably, of the thickening of the external layer by matter secreted through them. This remark applies likewise to those between the tubular openings. On the inner surface of the layer, forming the reverse side, the pores are very distinct and numerous.

The tubes are angular (*d*), and have a considerable range, bending conformably to the contortions of the branches. The substance of their walls is not often well preserved, but where it is retained microscopic foramina may be also detected.

No changes, incident upon age, have been noticed, except the probable thickening of the outer layers on both surfaces: no cases of young tubes have been observed.

Locality. Timber Creek, New Jersey.

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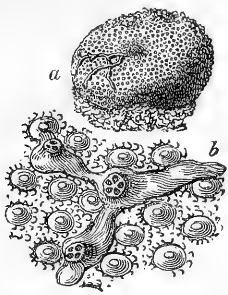
3. TUBULIPORA MEGÆRA *Lonsdale.* Sp. n.



a. The coral of the natural size, to exhibit the general resemblance to the smaller species of Alecto.
b. Portion magnified, showing the characters of the attached fasciculi and the tubercular openings.

Dichotomous, fasciculi of tubes slightly conical; mouths of the tubes united in a round, slightly projecting tubercle.

To the unassisted eye this coral presents a perfect agreement with Lamouroux's genus Alecto, consisting apparently of simple tubes, and not of fasciculi of 2 to 5 tubuli.

The fasciculi or branches gradually increase in breadth between the points of bifurcation, the broadest part being adjacent to the mouths. Externally they are round, but the outline of the surface is apparently modified by the papillæ of the Echinite to which they are attached. The tubuli, where they have been accidentally exposed, are arranged laterally. The tubercle, composed of the mouths, or probably the abraded base of the vertical portion of the tubuli, is reflected vertically upwards, or is inclined at a considerable angle: it is cylindrical, and much less in diameter than the adjacent portion of the fasciculus. The mouths themselves are not arranged in a line, or in the same manner as the tubuli, but grouped so as to occupy the least possible breadth; they are small, rounded on the exterior side, but flattened or angular at the points of contact.

Locality. Timber Creek.

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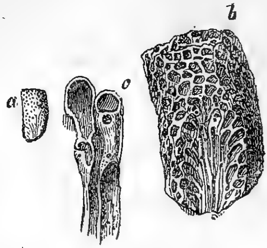
4. Cellepora tubulata *Lonsdale.* Sp. n.



a. Portion of a branch of the natural size.
b. The same magnified, to show the elongated characters of the central cells.
c. Magnified, elongated cells from the interior of the branch, with a perfect mouth and foramen under the proximal lip. The microscopic pores in the walls of the cells are likewise given.

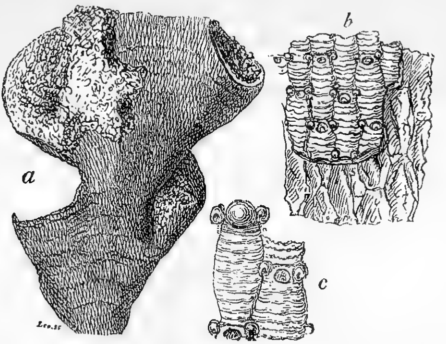
Branched; branches round, dichotomous; cells irregularly aggregated, ovoid elongated or tubular; mouth semicircular, large; proximal lip straight with a minute foramen in the centre.

The external surface of the branches rarely presents cases of perfect cells. Where they occur, they exhibit the usual ovoid form, and the mouth is well defined, being bounded completely by the distal arched covering of the cell; there is also a foramen under the proximal lip. More generally the surface presents a confused congeries of circular or angular openings, leading into ovoid cells. Internally, the branches exhibit, when fractured transversely or longitudinally, a perfectly tubular character in the cells comprising the axis of the branch (*b*), the cells being of great length and angular from lateral interference or compression; but towards the distal termination, as displayed in one instance, the ovoid form of the ordinary condition is assumed, by a swelling outwards, and the mouth is bounded by a regularly curved surface, the proximal lip being also supplied with a minute foramen (*c*). The prevailing form of the cells composing the mass of the branches is, however, ovoid, but variable in outline as well as in size and position. The cells are also much more numerous than is represented in fig. *b*.

The minute foramen on the proximal lip was probably connected with the base of the spinous process, so frequently exhibited in recent and fossil species of Cellepora. On the surface of the sides of the tubular cells, and also on those of the ovoid, minute connecting foramina may be detected, well defined, and occasionally bounded by an opaque, or thickened, circular line.

Localities. Lewis's Creek (South Washington, North Carolina), and Timber Creek.

5. Escharina*? sagena.



a, General mode of growth, the exposed surface being the reverse side of a layer of cells.
b, Cells composing portion of an inner layer; also reverse side of the opposite layer.
c, Cells forming part of an outer layer; one of them with a gemmuliferous vesicle.

Foliaceous, cells in two or more opposite layers, successively encrusting, but separable; cells oblong or hexagonal, defined by a slightly depressed line, arranged in alternate rows, but not conformably in succeeding layers; outer surface of cell nearly flat, ribbed; mouth at the distal extremity, small, round; gemmuliferous vesicle large, hemispherical; accessory foraminated vesicles two, over the mouth.

In the notice of this coral (Synopsis, &c. p. 79., pl. xiii. f. 7.), Dr. Morton describes it under the name of *Flustra sagena*, but adds, "perhaps it is an Eschara."

This polypidom differs from described species of Escharina in its free, foliaceous mode of growth, in being composed of several opposite, enveloping layers, and in the facility with which the dorsal surfaces may be detached; but it has been thought advisable not to propose a new generic name for this and analogous fossil corals, the characters of Escharinæ being considered to be not fully ascertained. The *Cellepora nobilis* of Esper (Pflanzenthiere, Cellep. tab. vii.) exhibits similar consecutive layers of cells, but arranged around a cylindrical nucleus and not in free plates.

The foliations are of considerable dimensions, and are variously contorted (*a*), and sometimes anastomosed. The layers are thin, but when numerous the foliations exhibit considerable thickness. Specimens presenting the opposite layers in their original position are not common, in consequence of the facility with which they separate along the medial plane. Portions only of successive layers are also to be detected, and not very frequently. The perfect outer layer was noticed in only one instance. (*c*)

* *Escharina* Milne Edwards; *Lepralia* Johnston.

Of the earliest state of the cells no positive information has been obtained*; but it is inferred from the ribs, more or less distinctly traceable on the outer covering, that they were in the young stage entirely open, and that the outer surface was produced by a uniform development of rib-like processes from the side-walls of the cells, in the same manner as in certain species of recent *Escharina*.

In the only observed case of a perfect outer layer (*c*), the cells were oblong and slightly hexagonal, and separated by a faint, depressed line. The external surface was, to a small extent, convex; and ribs, though they were not prominent, could be detected, converging from the proximal and lateral walls towards the centre; and the medial line of junction might also be discovered. The perfect mouth, placed in the middle of the distal extremity, was small and round, and in the same plane with the outer surface, but the lips projected slightly. The hemispherical gemmuliferous vesicles were relatively large, and comparatively numerous. They were situated immediately over the mouth, and they altered the position of that orifice from a horizontal to an inclined position. The accessory foraminated vesicles were variable in outline but constant in occurrence and situation, springing from the sides of the mouth, and increasing in size as they ranged upwards and outwards. The foramen was often well defined. From the position of these vesicles, the breadth of the distal extremity was apparently much increased.

In subjacent or older layers (*b*) the substance of the coral was not often preserved, having been detached with the overlying series, and leaving only calcareous casts of the interior of the cells; but where it is retained, there were no marked differences of characters, as far as observation extended, except in the absence of gemmuliferous vesicles. The mouths did not appear to have been filled up by the animal, and the foramina of the accessory vesicles were occasionally open: the depressed lines between the cells were also preserved.

In fragments which exhibited only casts of the cells, the indications of the ribs were sometimes as strong as on the outer surface, and the form of the mouth was well shown; but there were only very slight indications of the accessory vesicles.

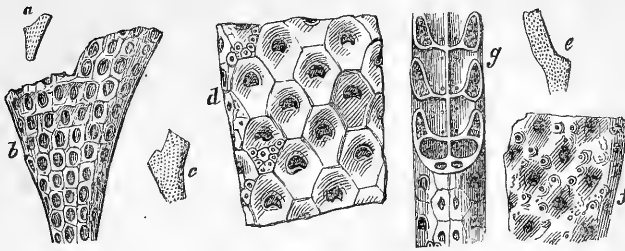
Of the lateral connecting foramina nothing decided was observed in consequence of the perishable state of the layers; but if the imperfect cells mentioned in the note* belonged to *Escharina* (?) *sagena*, the foramina were numerous.

The dorsal surface along the medial plane of separation (*a*) very much resembled that of *Flustra foliacea*, when artificially exposed.

Locality.—Timber Creek.

* On the surface of one specimen, some immature cells, consisting of only the dorsal and side walls, were observed, occupying the exact position of an ordinary layer of *Escharina sagena*, but there were no proofs that they belonged to that species; and all attempts to connect their structural details with those of the coral under consideration failed.

6. ESCHARA DIGITATA *Morton.*



a. b. Bifurcated branch, natural size and magnified, consisting of immature cells with the outer surface almost wholly open, and with no indications of a distinct mouth.

c. d. Portion of a bifurcated branch, with mature cells. To the right of figure *d* is a cell with an uniformly depressed surface, and conjectured to have performed the office of a gemmuliferous vesicle: to the left are irregularly foraminated cells.

e. f. Portion of an aged branch, with the characters of the mature cells obliterated by external additions and the production of irregular tubercles.

g. Magnified side view of a branch, to show the position of the lateral connecting foramina within the cells; and of the small or defective cells exhibited also in the edge of figure *d*.

Branched, branches compressed, dichotomosed; cells hexagonally pyriform, separated by a fine lineal groove; surface sloped inwards from the periphery; mouth semicircular or semi-oval; no accessory or gemmuliferous vesicles observed; lateral connecting foramina two, terminal one.

See Dr. Morton's Synopsis Org. Rem., Cretaceous Group, United States, p. 79. pl. xiii. f. 8. 1834.

Dr. Morton states that this fossil strongly resembles *Eschara dichotoma* of Goldfuss (Petref. tab. viii. f. 15.), a Maestricht coral, and there is a perfect agreement in the mode of growth, as well as a general resemblance in the form of the cell; but a considerable difference, in structural details, is visible when the two fossils are compared. The cells in both cases are hexagonal, but the sides of those composing the Maestricht *Eschara*, as given by Goldfuss, are very nearly, if not quite equal, and they are slightly but uniformly curved; whereas, in the Timber Creek specimens, the sides are almost invariably unequal, the proximal and distal being considerably smaller than the lateral, and the curvature is variable in amount and direction, giving the cell a pyriform aspect. The relatively broad grooves between the cells in *Eschara dichotoma* are represented in the American species by a fine line: the mouth of both fossils is semi-circular, but more completely so in the Maestricht than the Timber Creek coral; in Goldfuss's species, moreover, it is bounded, at the distal extremity, by a broad flat band which is extended around the whole periphery of the cell; while in Dr. Morton's coral the surface slopes inwards from the very edge of the cell.

These differences are not pointed out under the supposition that Dr. Morton conceived the two corals might be identical, for he was clearly aware of their distinction, but because both the Maestricht and Timber Creek deposits are members of the Cretaceous series, and the perfect agreement in generic outline with Goldfuss's figure (14 *a*), might lead a less careful observer than Dr. Morton to the inference, that the fossils are specifically the same.

The branches preserve a considerable uniformity of breadth, expanding only towards their bifurcation, and there very slightly, in consequence of the addition of one or more lateral rows. They diminish in thickness towards the edges, where they are rounded.

The cells on the opposite side of the medial line agree generally in position, and those forming the surface of the branches have a great regularity in size and relative proportions; but, at the point of bifurcation, and along the edges of the branches, small and imperfect cells may very frequently be observed, the latter exhibiting sometimes irregular pores in the external covering.

Of the earliest state of the cells no evidence was obtained; and of the condition after the formation of the side-walls only one case was noticed. It consisted (*a*, *b*) of a portion of a main branch, with part of another springing from a bifurcation. The surface of the greater number of the cells was wholly open, indicating considerable rapidity of development, or slowness in the formation of the exterior; and in only a few instances was there a commencement at the proximal extremity of the outer surface. The walls of the latest produced cells, or those at the superior extremity of the bifurcated branches, had a sharp edge without any line of separation; but in the cells of the undivided branch, and where the development of the external covering had commenced, fine grooves were perfectly visible. This great production of immature cells is analogous to many well-known recent examples.

In what was believed to be another step towards maturity, the surface of the cells was considerably developed, but the mouth was not regularly defined, the open part being large and circular. The structure of the mature cells is given in figure *d*, and in the specific characters.

The passages from maturity to what may be termed a state of decrepitude afforded some interesting structural details. In the first steps, the fine separating grooves between the cells were partially or completely obliterated, and a general thickening of the parietes was noticed; but these changes were not always most decidedly shown in the oldest cells of the branch, depending, apparently, in part upon the individual polype. In a specimen in which the above alterations were not so complete as in other cases, there appeared upon the surface of the cells several minute prominences, and one or two fractured vesicles. Some of the intermediate stages were not noticed; but in specimens believed to be far advanced towards extreme age (*e, f*) the surface of the cells was convex, instead of being concave; all traces of lines of separation were obliterated, the mouth was irregularly shaped, sometimes with a tooth-like projection on the proximal lip, and the whole surface of the branch was beset with perforated or abraded vesicles.* No instance of a perfect filling up of the mouth, which would characterise perhaps the oldest condition of the coral, was noticed. A due preservation of the specimens, which exhibited these stages, forbade any attempt to trace a connection between the vesicles and the polype cells; but a transverse section of a mature branch exposed clearly capillary tubes, passing through the substance of the thick external covering of the cell.

The lateral and terminal foramina in the walls of the cells were well exhibited. The former, two in number (see figure *g*), were relatively large, situated near the extremities of the cell, and close to the dorsal wall. In one beautifully exposed specimen, the presumed use of these foramina in the formation of cells was instructively shown. The specimen (figure *g*) displayed the sections of a series of cells with thickened parietes, and the lateral foramina, also the rounded edge of the branch composed of a regular double row of small cells, divided longitudinally by the usual middle or dorsal layer of separation. The mouths of these cells were small and round, and might be mistaken for lateral foramina; but the boundaries of the diminutive cells, to which they were the regular openings, were clearly to be traced. The length of these imperfectly developed cells was about half that of the full-grown; and the mouths accorded in position with the situation of the lateral foramina. It is, therefore, inferred, that each minor cell was produced by means of one lateral foramen, the perfect development not having taken place, owing to the absence, in the same longitudinal row, of a full-grown anterior cell. In consequence of the quincuncial arrangement of the perfect cells, each polype had, by means of the lateral and terminal foramina, immediate connection with six other cells.

Cases of monstrosity or deviation from the normal form occur, as before mentioned, near the edges and at the bifurcation of the branches; but it is believed that some entire branches were composed of irregularly-shaped cells, and might, without care, have been assigned to a distinct species.

No traces of accessory vesicles were observed, nor any satisfactory signs of a gemmuliferous vesicle. In one case the whole surface of a cell was deeply depressed (fig. *d*), and might have formed a receptacle for the development of gemmules.

Locality. Timber Creek, New Jersey.

* These vesicles or bladders must not lead to the inference that there is any resemblance between *Eschara digitata* and the recent coral *Cellepora cervicornis*. In the former case the bladder has no regular cellular structures, while in the latter there is always a perfectly developed mouth, with accessory vesicles.

January 31, 1844.

Seymour Tremenheere, Esq., was elected a Fellow of this Society.

The following communications were read:—

1. *On the Thickness of the* Lower Green sand Beds *of the* South East Coast *of the* Isle of Wight. By F. W. Simms, Esq., F.G.S.

The last time the Green sand beds below the Chalk were the subject of discussion before the Society, great diversity of opinion was expressed concerning the thickness of the group of beds denominated "The Lower Green sand." To remove all doubt on this point, Dr. Fitton proposed revisiting the south-east coast of the Isle of Wight, and requested my co-operation in determining their thickness. The following vertical section of the strata, seen in the cliffs of the south-east coast of the Isle of Wight, and including the three entire groups, viz:—

1. The Upper Green Sand,
2. The Gault,
3. The Lower Green Sand,

was made in company with Dr. Fitton, Mr. Mackeson of Hythe, and the President of our Society, during a visit we made to that coast in July last

The horizontal line over which these measurements extended, that is, from Atherfield point to the Cliff on the south of St. Catherine's Down, is about three miles in length. Along nearly the whole of this line, the coast is bounded by mural cliffs, except where slips have taken place (and these are often of considerable extent), and except where "Chines" (as they are called), that is to say, deep precipitous gullies, worn by the action of brooks in the argillaceous sands, open into the sea.

Where the cliff was mural, and direct measurement was practicable, the thickness of a bed was taken by the tape or graduated rod. Where direct vertical measurement was not practicable, as, for instance, where the fall of the cliff had obscured the continuity of the beds, the spirit-level was employed, as in ordinary engineering operations. Without the aid of that instrument it would have been difficult, if not impossible, to carry on a connected series of measurement over so long a base line with any tolerable degree of accuracy. By the means employed, however, a series of vertical measures was obtained, which I consider to be a near approximation to the truth.

The apparent dip of the strata, as seen in the cliffs, and as resulting from actual measurement, near Atherfield, was to the east 2°; but the true dip, as determined by the spirit-level at Atherfield Point, where the rocks were bare at low-water, was nearly south-east; and its amount was found to be 2°.

The junction of the Weald Clay with the Lower Green Sand is exceedingly well defined at Atherfield Point. That of the lower green sand with the gault, though not quite so obvious as the last-mentioned junction, is yet very satisfactorily ascertained — 1st, Below the Hotel at Black-gang-Chine, where the green sand forms a line of terrace projecting beyond the gault; 2dly, On the cliff eastward and immediately above Black-gang-Chine, where gault fossils occur at the very point of junction with the lower green sand. The junction of the gault with the upper green sand is well defined on the face of the cliff south of St. Catherine's Down, east of the Sand-Rock Spring, and above the road leading from Black-gang-Chine to Ventnor. The junction of the upper green sand with the white chalk marl is very well marked, near the summit of the same cliff.

The author stated that in the section, drawn according to scale, which accompanied this notice, he had given, not only the three principal groups, but also their more remarkable and best defined subdivisions, without pretending to describe, in needless detail, all the strata of which they are composed. From the particulars which he subjoins respecting these subdivisions, the following table is extracted: —

			Totals.
Chalk Marl.		*ft. in.*	*ft. in.*
Upper Green Sand.	Parallel layers of a soft rock, "hassock," which rapidly disintegrates by exposure; and of hard cherty sandstone, which, after weathering, stands out in high relief - - . - - -	37	
	Sand, with beds of stone and chert - - -	67	
			104
Gault.	Light-coloured gault, becoming gradually bluer -	43	
	Beds of decided blue colour. No fossils have been found, except in the very lowest beds - -	103	
			146
Lower Green Sand.	Lower green sand. No notice required - -	384	
	Bed containing oysters and Gryphœa - - -	21	
	Various beds not noticed - - - -	269	
	A bed of argillaceous sand, containing large lenticular, concretionary masses of very hard calcareous sandstone, locally termed "the crackers." These masses, when broken, are found to contain numerous fossils -	15	
	Blue argillaceous beds, the lowest of which approach in their character to fullers-earth. The upper of these beds contain Crustacea; the lower contain remains of Pinna. In the latter respect, these beds agree with the clay that lies beneath the sand and stone at Hythe in Kent, described in the paper read before the Society in June last. If this bed be the equivalent of the clay bed at Hythe, the crackers will represent the stone-beds at Hythe, decribed in the same paper. They also agree with the Hythe stone-beds, in being very nearly at the same vertical distance above the Wealden. For the purpose of comparison, the Hythe section has been drawn to the same scale as that of the Isle of Wight - - - - - -	59	
	Atherfield rock, containing many fossils - -	2 2	
	Dark greenish sandy clay, looking black when wet, containing many of the same fossils as the rocky bed	2 9	
			752 11

2. Report *on the* Lower Green sand Fossils *in the Possession of the Geological Society.* By Professor Edward Forbes, F.L.S.

The collection of Lower Green Sand fossils at present in the cabinets of the Society contains 131 species of Mollusca. Of these 82 are Lamellibranchiate Bivalves, 12 Brachiopoda, 23 Gasteropoda, and 14 Cephalopoda. Besides these, all well-marked species, there are a number of casts and fragments of species as yet undetermined.

Of the 131 Mollusca, 60 are additions to the list of Lower Green sand Fossils, published by Dr. Fitton in the "Geological Transactions." Of these 60 additional species, between 30 and 40 are undescribed forms. The remainder are species described in the memoirs of Leymerie, D'Orbigny, Roemer, and other continental authors, but which have been hitherto unrecorded as British, with the exception of a few included in Mr. Morris's catalogue.

All the species have been critically examined, and characters drawn up of such as are new.

The collection can by no means be regarded as complete, numerous additions, including several very beautiful species, having been very lately presented to the Society; and these there has not as yet been time to examine and place in the cabinets.

Of the lower green sand Mollusca in the collection, 35 agree with Neocomien species recorded by M. Leymerie, and about 30 with species from the Hillsthon and Hillsconglomerat of M. Von Roemer. Many species, which had received new names from those geologists, have proved, on examination, to be well-known British species, figured in the Mineral Conchology or elsewhere. Among these are several which are regarded on the Continent as characteristic of the so-called Neocomien beds.

Of Radiata, there are in the collection about 12 speeies of Polyparia and Amorphozoa, and 9 Echinodermata; of Annelida 8 or 9 species, and several Crustacea. Additions to this part of the collection are very desirable, especially better specimens of Echinodermata.

To complete the collection, fossils from the Speeton Clay, of which there are none in the Society's possession, are much wanted. The table now drawn up exhibits the species at present in the collection, and their relation to the French lower green sand fauna, and to that of Germany, as well as the British localities in which they have occurred. It appears from this table that the greater number of species are as yet only known as fossils of British strata.

[*Note.* It has been thought advisable to publish this report in its present form in the "Proceedings," as a record of what was done at the time. The catalogue referred to, enriched by many additions, and accompanied by figures of new species, will, it is hoped, be shortly placed in the possession of the Fellows of the Geological Society.—Ed.]

3. Report *on the* Collection *of* Fossils *from* Southern India, *presented by* C. J. Kaye, Esq., F.G.S., *and the* Rev. W. H. Egerton, F.G.S. By Professor Edward Forbes, F.L.S.

In the descriptive catalogue accompanying this report, and referring to the remains of invertebrate animals in the valuable collection of fossils from the South of India, presented to the Society by Mr. Kaye, and increased by an extensive series of specimens collected in the same localities by Mr. Egerton, 168 species of Mollusca are enumerated, 156 of which, as far as can be ascertained, are undescribed forms. There are also a number of species of Radiata.

The results of their examination may be briefly stated as follows:—

1st. The three deposits, viz. Pondicherry, Verdachellum, and Trinconopoly, described by Mr. Kaye, are *Cretaceous*, inasmuch as there are characteristic known cretaceous fossils in the collections from all of them, whilst no fossils of any other system occur. The nearest allies of the majority of the new species are cretaceous; and among the genera and subgenera are many which, as far as we know, are confined to or have their chief development in the Cretaceous system. The three deposits are connected with each other zoologically by the associations of certain species common to two of them, with others found in the third.

2d. Two of the three deposits, viz. Verdachellum and Trinconopoly, are of a different epoch of the Cretaceous era from the third, Pondicherry. The two former have several species in common (and those species among the most prolific in individuals), which are not found in the third. In them are found almost all the species identical with European forms. In several of the genera, of which there are many species, the forms are altogether distinct; although, judging from the evidence afforded by mineral character and association of species, the conditions of depth and sea-bottom at the time of the deposition of the strata seem to have been the same. The difference therefore must have depended on a representation of species by species *in time* and not *in depth.*

3d. The beds, apparently contemporaneous, viz. Trinconopoly and Verdachellum, may be regarded as equivalent to the upper green sand and gault; the European species they include being either characteristic upper green sand and gault forms, or else such as occur in those strata. The new species they contain are either closely allied to known upper green sand or gault species, or peculiar to the Indian beds.

4th. The Pondicherry deposit may be regarded as belonging to the lowest part of the Cretaceous system. In it almost all the fossils are new. Such as are analogous to known species are allied to fossils of the lower green sand of English geologists and Neocomien of the French. In the genus most developed in this deposit, viz. Ammonites, three fourths of the species belong to those subgenera especially characteristic of the "Lower Neocomien" of the Mediterranean basin; whilst, of the remainder, as many representatives of Oolitic fossils occur as of upper green sand. The resemblance between the Ammonites of this part of the collection and those of Castellane, in the south of France, is very remarkable, though the specific identity of any of them is doubtful. Having seen no account of the Conchifera of the Castellane beds, I cannot say how far the analogy is borne out among the bivalve Mollusca among the Indian species, of which there are many very peculiar forms.

5th. Considered in regard to the distribution of animal life during the Cretaceous era, this collection is of the highest interest. It shows, that during two successive stages of that era the climatal influence, as affecting marine animals, did not vary in intensity in the Indian, European, and American regions, whilst the later of the two had specific relations with the seas of Europe, which are absent from the earlier. The cause of this remarkable fact is not to be sought for in a more general distribution of animal life at one time than at another, but rather in some great change in the distribution of land and sea, and in a greater connection of the Indian and European seas during the epoch of the deposition of the upper greensand, than during that of the lower. To this cause must also be attributed the peculiar tertiary aspect of the Indian collections, depending on the presence of a number of forms usually regarded as characteristic of tertiary formations, such as Cypræa, Oliva, Triton, Pyrula, Nerita, and numerous species of Voluta, the inference from which, since not one of the species is identical with any known tertiary form, should not be that the deposits containing them are either tertiary or necessarily connected with tertiary, but that the genera in question commenced their appearance *earliest* in the Eastern seas, which, when we recollect that in those very seas at the present day, are found the great specific assemblages or capitals of those genera, whilst they have either disappeared or have few representatives in the seas of other geographical regions, is exactly what we should expect, *à priori*, to find. This fact would go far to support the theory, that genera, like species, have geographical birth-places as well as geographical capitals.

The fact, that of the few species found in the Indian cretaceous beds which are common to the same beds in distant regions, the majority are such as range through several deposits of different ages, supports the probability of a law which I have elsewhere indicated, viz. that *the range of the geographical distribution of species is usually correspondent to the range of their distribution in time.*

The probability of the proposed law, that the *marine faunas of distant localities, under similar conditions of climate, depth, and sea-bottom, maintain their relations rather by the representation of forms by similar forms, than by identity of species, is also borne out by the examination of these collections.*

These inferences can be only put forth as provisional, until a thorough examination of the deposits described by Mr. Kaye in their stratigraphical relations be made, and the fossils of those localities which he did not visit have been still further examined on the spot. To the palæontologist his collections are invaluable, as the specimens are in so fine a state of preservation, as to permit of an examination of their minute structure.

The descriptions of fifteen of the Trinconopoly species in the catalogues were furnished to Mr. Kaye by Mr. George Sowerby.

[*Note.* With regard to this report, it was also intended that it should have been accompanied by a descriptive catalogue of the fossils, and by figures of new species, and it is in so far, therefore, incomplete. It is published in this place as an indication of the important results actually arrived at by the study of these interesting fossils.—Ed.]

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4. *On the* Permian System *as developed in Russia and other Parts of Europe.* By Roderick Impey Murchison, Esq., F.G.S., V.P.R.S., and M. E. de Verneuil, Hon. Mem. Geo. Soc. of London.

On the part of his associates, M. de Verneuil and Count Keyserling, and himself, Mr. Murchison has previously explained in the Proceedings of the Geol. Soc. the nature of the various deposits which constitute the subsoil of European Russia. As in all other parts of the world which have been adequately examined, the Silurian rocks are those which contain the earliest forms of animal life, and in Russia they are overlaid by Devonian and carboniferous deposits, each of which is there singularly well defined by its organic remains and regular superposition.

In common with many other geologists, Mr. Murchison was formerly of opinion* that the above-mentioned three systems constituted the whole Palæozoic series, but the examination of Russia and Germany has led him to include also therein the next group in ascending order, or that to which he had assigned† the name of Permian.

When two or more conterminous formations are shown to have a community of fossils, it has recently been deemed essential to group them under one name; and following the practice of assigning to any such newly classed group a geographical name

* See "Silurian System," p. 46. *et seq.* In England Professor Phillips has, however, some time maintained that the fossils of the magnesian limestone ought to be grouped with the inferior strata.

† See "Letter to M. Fischer Von Waldheim, Sept. 1841"; Leonhard's "Jahr Buch," part i. p. 91. 1842; "Phil. Magazine," vol. xix. p. 418.

derived from the region where the strata are best developed, the term "Permian" was employed. This system was first proposed to embrace the deposits known in Germany as the Rothe-todte-liegende, Zechstein, Kupferschiefer, &c., and in England as Lower New Red Sandstone, Magnesian limestone, &c.

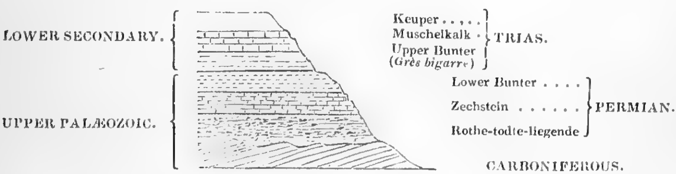
In communicating some of the results of a journey in Poland and Germany during last summer, Mr. Murchison, one of the authors of the present memoir, states that his object is to show that his first view concerning the inferior limit of this system is correct—to extend its upper limits, and from the distribution and character of its organic remains to demonstrate that it is of palæozoic age.

Near Zwickau in Saxony, and Waldenburg in Upper Silesia, productive coal-fields (in the latter country recumbent on carboniferous limestone) are unconformably surmounted by red conglomerate, sandstone and shale (the rothe-todte-liegende), which in those countries, as in Thuringia and Hesse Cassel, pass conformably upwards into the Zechstein or its equivalents. The same relations of a lower sandstone to the Magnesian limestone are, indeed, well known in England, and have been pointed out in detail by Professor Sedgwick. Seeing that these two deposits are so intimately associated, few, if any, geologists would wish to disunite them; but the question arises, what is the uppermost limit of this group. In Russia, beds of limestone identified with the Zechstein and Magnesian limestone by their organic remains are overlaid by a great thickness of marls, sands, and conglomerates, containing some of the same types of life as the lower members, particularly the plants which are very closely allied to and are in some instances identical with the vegetables of the carboniferous era. It became therefore desirable to ascertain whether similar palæozoic features were to be found in other parts of Europe. Now in Thuringia and Hesse Cassel, the Zechstein is, in numerous localities, conformably surmounted by red and spotted sandstones, in which no traces of fossils distinct from those of the Permian era are observable, the only land plant found in them (the *Calamites arenarius*) being inseparable from well-known carboniferous forms. This overlying sandstone being perfectly conformable to the Zechstein, may, it is conceived (like the overlying sandstones of Russia), be classed with that rock. In making this suggestion, the authors disavow the intention of derogating in any respect from the Trias of German geologists, also a tripartite system, and of which the muschelkalk is the centre, with certain red and mottled marls and sands beneath, and the keuper sandstone above. The Triassic system does not contain a single Palæozoic form, whether animal or vegetable, whilst the fauna and flora of the Permian are both so connected with the carboniferous and inferior systems, that they evidently constitute the last remnant of the same era. In the whole geological series, therefore, no two systems are more completely separated than the Permian and the

Trias, the one forming the uppermost Palæozoic stage, the other the base of the secondary deposits.

After showing that the "Grès de Vosges," as described by M. Elie de Beaumont, is one of the arenaceous equivalents of the Permian system, and after alluding to its development in the neighbourhood of Strasburg and in other parts of Europe, where it is well separated from the Trias, attention is directed to the fact, that as far as researches had yet gone, the Trias is always conformable to the Permian, whilst the "rothe-todte-liegende," or base of the latter, is frequently unconformable to the carboniferous rocks, on which it rests, and out of whose detritus it has often been formed. These phenomena, say the authors, prove that the most marked distinctions between the fossils of succeeding formations cannot be referred to physical revolutions of the surface; for in the examples cited there is a sequence of congeneric remains, where the succession of the strata has been powerfully interrupted (Carboniferous to Permian), and a total change of fossils where the contiguous formations are conformable (Permian to Trias).

These relations are expressed in this diagram:—



The Permian fauna is then considered, and is said to exhibit the last of the successive alterations which the Palæozoic animals underwent before their final disappearance. The total number of Permian species known to the authors in different parts of Europe (without reckoning certain ichthyolites not yet named, and a few doubtful forms of shells) is 166, of which 148 are characteristic of the system, 18 only being found in the subjacent Palæozoic rocks. The Brachiopods being viewed as the shells of most value in determining the durations of the ancient rocks, it is stated, that 10 out of the 30 Permian species are common to this system and the carboniferous. After some observations on the species of Productus, Spirifer, Orthis, Terebratula, Leptæna (Chonetes), which have lived on from earlier periods, it is remarked that no form of the Pentamerus, a genus peculiarly characteristic of the Silurian strata, has yet been found in the Permian strata, whilst the Brachiopod most frequent in the latter is the Productus, a genus very abundant in the carboniferous or conterminous deposits, but unknown in the Silurian. Among the Conchifers

(26 in number) the Modiola is very characteristic of the Permian system, both in Russia and England; and though the large species of Axinus so well known in England has not yet been found in Russia, its place is there taken by two other species of the same genus. The Avicula is also a good Permian shell, the *A. Kazanensis* being the best type in Russia, whilst the *A. antiqua* is there common to this deposit and the carboniferous.

The Gasteropods, so abundant in the carboniferous era, have undergone great diminution before the formation of the Permian strata, and have had great difficulty in accommodating themselves to new conditions; still more so the Cephalopods, for the forms of Goniatites, Nautili, and Orthoceratites, so very common in the preceding epoch, are almost unknown in this system, a fragment or two of one genus (Nautilus ?) alone having been found in all parts of Europe. This scarcity of Cephalopods at the close of the Palæozoic series has a remarkable parallel in a subsequent geological period ; for as these animals were reproduced in vast abundance and under many new forms in the Triassic, Jurassic, and Cretaceous systems, so towards the termination of the last of these we perceive a second and similar disappearance of the greater number of the shelly Cephalopods. The extreme reduction of the Gasteropods at the close of the cretaceous period, as indicated by M. Alcide D'Orbigny, is also pointed out as an additional feature of analogy to the Permian changes. Trilobites, so eminently characteristic of the Silurian system, and which dwindle away to a few small species in the carboniferous system, are unknown in the Permian of Western Europe and in Russia, and are only represented by a species of Limulus. Fishes, on the other hand, are numerous in proportion to the other Permian classes, 43 or 44 species being named, and several from Russia being yet undescribed; these are all, with one exception, absolutely peculiar to the stratum in which they occur, thus confirming the truth of the generalisation of Agassiz, that these vertebrata mark with great precision the age of the stratum in which they are found. Lastly, the Permian beds of Russia, like the Dolomitic conglomerate of England and the Kupferschiefer of Germany, contain bones of thecodont Saurians, indicating the earliest appearance of animals of that high organisation, and their direct association with Palæozoic shells and plants, some of which are undistinguishable from true carboniferous species.

After thus following it back *in time*, the Permian fauna is next considered in horizontal extension or *distance*, the fossils of Russia being compared with those of similar age in western Europe. The number of species collected by the authors in Russia is 53 or about one third of the total number of the whole European fauna of the period, and of these 32 are peculiar to Russia, a large number when the recency and rapidity of the survey of the authors is adverted to; and when it is considered that 33 species only were found by Professor Sedgwick in deposits of this age in England, and 41 according to the recent tabular view of Geinitz is the total number known in Saxony where the Zechstein is very fully elaborated. Like other formations of synchronous age when at great distances from each other, the Russian succession of Permian strata cannot be brought into a detailed analogy with that of western Europe. Instead of occupying a fixed place like the calcareous beds which represent the Zechstein, they inosculate with great thicknesses of fossiliferous grit, whilst Saurians and fishes with certain *Producti* and *Modiolæ*, as well as most of the plants, unquestionably occur in conglomerates, tufaceous limestones, and marls, which overlie the beds which contain Zechstein or Magnesian limestone fossils. In Germany, the Protorosaurus belongs to the Kupfer-schiefer which is below the Zechstein, whereas in Russia all the cupriferous and sauroid beds are above that rock.

In analysing the species common to the Permian system of Russia and the rest of Europe (by stating the number which have lived on from the carboniferous to the Permian, and the diminished proportion of the latter), Russia alone is appealed to, and three only of the Permian *species* of that country are found to descend into the Palæozoic rocks. The authors, therefore, infer that these results necessarily prove the existence of a relation between the greater or less duration of species and their propagation or extension to distant parts, thus confirming a law previously announced by one of them.

Some detailed observations then follow on the species in each class found in Russia, and Mr. Lonsdale is cited as having assured them that although the Permian corals are evidently Palæozoic in their generic characters, there is not a single species which is identical with a carboniferous form; and it is also remarked that of 20 species of Brachiopods found in Russia 8 are peculiar to that country.

Lastly, deriving their knowledge of the specific character of the plants from the examination of M. Adolphe Brongniart, aided by Mr. Morris, who had previously examined them, it appears certain, that whilst all the forms indicate a continuation of vegetable life of the same nature as that which prevailed during the carboniferous era, there are a few species (*Neuropteris tenuifolia*, *Lepidodendron elongatum*, and *Calamites Suckovii*) which are identical with carboniferous plants, and not one which can be compared with a triassic plant.*

The results of the inquiries of the botanist, the authors conclude by remarking, are therefore completely in accordance with those

* The species of plants, ten or twelve in number, which have been found in the Kupfer-schiefer or the sandy beds associated with the Zechstein in Germany, are chiefly marine fucoids, and have been termed *Caulerpites*. According to M. Adolphe Brongniart, the only terrestrial plants of these German strata are the *Teniopteris Echardi* (Germar), and a Neuropteris mentioned by Naumann, which not being determined must be considered doubtful.

of the palæontologist. They clearly prove that the Permian system is the uppermost stage of that long Palæozoic series, which, commencing with the lowest Silurian rocks, presents a connected succession of animal and vegetable life, the last traces of which passed away with the termination of the strata under review. Until Russia was explored, the upper member of these ancient rocks had scarcely afforded a trace of terrestrial plants. Neither in the British Isles nor in Germany had there been found more than one or two species of land plants in deposits of this age, not one of which has yet been fully identified or described. Now in reference to the Russian species, such of them as had been previously alluded to by other writers were placed by some in the carboniferous rocks, by others in the New Red Sandstone.* Our sections, however, have shown that neither of these views is correct; and as the Russian plants to which we have called attention, occur for the most part in strata distinctly *overlying* beds containing the fossils of the Zechstein, it is clear that certain red sandstones, marls and conglomerates, above that rock, belong to our Permian group, are wholly distinct from the Trias, and are truly Palæozoic.

We repeat, therefore, that we have now adduced ample botanical as well as zoological and stratigraphical evidence to vindicate the application of the collective word *Permian* to a succession of strata which had not been previously united through their geological relations and organic contents.

These proofs will, we trust, be considered as still more strongly borne out by the grandeur of the phenomena to which we have appealed; for the Permian deposits of Russia repose upon carboniferous strata throughout more than two thirds of a basin which has a circumference of not less than 4000 English miles.

A detailed tabular list of the animal remains of the Permian system in Europe was also given, mentioning the names of the authors who have described each species, the localities at which it has been found, and its vertical range in the Palæozoic series. This table will appear "in extenso" in the forthcoming work upon Russia, and in the meantime the following recapitulation is subjoined; but the authors express their regret that their table was drawn up without the benefit of the long-promised assistance of Professor Agassiz. His observations on a few of the Permian ichthyolites which were submitted to him will increase the number of that class of fossils.

* See a very recent memoir by M. Yasikoff, "Bull. de Moskou," 1843, part ii. p. 237., in which he refers an interesting portion of the Permian rocks described by us upon the Kama, and between that river and the Sok, either to the *New Red Sandstone or the Carboniferous Limestone.*

Recapitulation of the Fauna of the Permian System in Europe.

Classes.	Genera.	Total Number of Species in Europe.	Species exclusively peculiar to the Permian system in Europe.	Species found in older formations.	Species found in Russia.			
					a. Peculiar to that country.	*b.* Previously found elsewhere.		
						In the Permian and older formations.	In the Permian beds exclusively.	In older formations exclusively.
Polyparia - - - -	7	15	13	2	3	1?	2	
Echinodermata - - -	2	2	1	1				
Conchifera, Ord. Brachiopoda	7	30	20	10	8	3	4	5
Ord. Dimyaria -	10	26	26		8		3	
Ord. Monomyaria	5	16	15	1	4		3	
Mollusca, Ord. Gasteropoda	11	22	19	3	3			
Ord. Cephalopoda	1	3	3		1			
Annelida - - - -	1	2	2					
Crustacea - - - -	2	2	2		2			
Pisces - - - -	16	43	42	1	2			
Reptilia - - - -	4	5	5		1			
Total - -	66	166	148	18	32	3 or 4	12	5

INDEX

TO THE COMMUNICATIONS READ DURING THE SESSION

1842 — 1843.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY OF LONDON.

VOL. IV. PART II. 1844. No. 100.

AT THE

ANNUAL GENERAL MEETING,

16*th of February*, 1844,

THE following Report from the Council was read:—

In laying their Annual Report before the Society, the Council have the satisfaction of being enabled to state, that a considerable increase has taken place in the numbers of the Society during the past year as compared with several preceding years. In that period 17 Resident and 12 Non-resident Fellows have been elected and admitted; besides which, 4 others who had been elected in former years have paid their Admission Fees; making an addition of 33 new Fellows: there have been 8 deaths and 5 resignations, and 4 Fellows have been removed as defaulters from the Society; making a diminution of 17, and leaving a clear increase of 16 Fellows. There has also been one death amongst the Honorary Members.

At the close of 1842 the number of Fellows was 788, and at the close of 1843 it was 804, whilst the total numbers of Members at the same periods were respectively 868 and 883.

It is with much regret that the Council have to report that the expenditure of the Society has exceeded its income by the sum of £262 6*s*. 2*d*.; it will be seen however, that the expense of £556 15*s*., incurred in 1842, belongs to the second part of the sixth volume of the Transactions; and this has been carried to the account of the past year.

Only one composition has been received; but owing to the great pressure on the ordinary income of the Society, the Council have delayed adding this sum to the funded capital; so that the only increase in this portion of the Society's property, which they have to announce, arises from the present price of stock as compared with that of the same date last year, which is as £2598 to £2544. The number of existing compounders at the close of 1843 was 117, and the amount of compositions which had been received from them was £3685 10*s*., making a difference of only £1087 10*s*. between the amount of compositions received and the actual value of the funded property.

An act of the Legislature was passed during the last year, exempting scientific bodies from the payment of parochial and other local rates, whereby, in the case of this Society, a relief has been given, amounting, on an average of the last three years, to the sum of £32 7*s*. 9*d*.

The Council have further the satisfaction of announcing, that the late Mr. T. Botfield of Hopton-court has bequeathed to this Society a legacy of £31 10*s*. (the value of his composition had he lived), which has already been received : the Council consider it expedient that this sum should be added to the funded property.

The increasing number and importance of the papers communicating original information to the Society; the great drain which the publication of these papers would entail on the funds of the Society, should the Transactions henceforth be invariably published in the same form as the last six volumes of the New Series; the necessity in that case of long intervening delays between the reading of papers and their publication, in order that, by the accumulated savings of two or three years, means may be provided for defraying the cost of a new volume; the overwhelming arrears of unpublished papers, which in that case must necessarily accumulate, and might ultimately remain unpublished, have forced on the Council the necessity of considering whether by the adoption, to a certain extent, and at least for the present, of some less costly and more expeditious form of publication, as, for instance, by accompanying a very full abstract of the papers read by the necessary figured illustrations, justice might not in most cases be done to authors, and at the same time the expense be rendered commensurate with the funds of the Society.

A specimen of the suggested new form of publication will be submitted to the Fellows, before any conclusive determination shall have been taken on the subject.

The Council have resolved that the Wollaston Medal be assigned to the Rev. W. D. Conybeare, for his continued and effective services in the cause of Geology and of Palæontology, and they have directed that the balance of the annual interest of the fund be assigned to Mr. William Lonsdale, to assist in promoting his researches on Corals.

Report of the Museum Committee for 1844.

We have much pleasure in informing the Council, that the recommendations we offered in our last Report, have been acted upon during the past year, and that great progress has already been made in the arrangement of various portions of our large collection. Of the *Tertiary era,*—specimens have been received from almost every portion of the British series, presented by Mr. Greenough, Mr. Robert White, Mr. W. Card, Professor Henslow, Mr. S. Wood, and Mr. Ball.

A collection of Pleistocene Fossils from North America, presented by Mr. Lyell, has been added to the Foreign Museum, and

An extensive suite from Malta and Gozo has been received from

Lieut. Spratt, R.N., which has been incorporated with what the Society already possessed from those islands, and occupies 10 drawers.

Cretaceous era.—The suite of Fossil Remains from this series of the British strata in the Society's collection has undergone a thorough revision: all the species, ascertained to be new, have been described and named by Mr. Forbes, and a catalogue has been compiled. Mr. Forbes's attention has been especially directed to those species which have been recently procured from the lowest strata of this age in the south-east of England. On these he has made a special report, which has been read before the Society, so that it may suffice to state that this portion of our collection, which previously occupied eight drawers, has been extended to eighteen. This part of our collection has been enriched by donations from the President, Dr. Fitton, Mr. Simms, Mr. Hambrough, Mr. Austen, Mr. Ibbetson, and Mr. Wise.

The views and wishes expressed in our last Report have in this part of the collection been most zealously carried out by Mr. Forbes and Mr. Woodward. In order that the Society may derive full benefit from Mr. Forbes's scientific labours, we think it very desirable that his Report, when printed, should be accompanied by figures of the new species he has established.

A large collection of Cretaceous Fossils, from the neighbourhood of Pondicherry, Verdachellum, and Trinchinopoly, may be considered, from their novelty and beautiful state of preservation, among the most valuable additions made to our Museum. This suite has also been examined by Mr. Forbes. His results have been very recently laid before the Society, and we are of opinion that the Council cannot at the present moment more effectually assist geological science than by the publication of that Report, together with full illustrations of the fossil evidence.

For the portion of this collection first received the Society is indebted to Mr. Kaye, and for another portion from the same localities since received, to the Rev. William Henry Egerton.

Ophiura serrata, from the Chalk, was procured for the Society's collection by exchange.

Oolitic era.—We do not propose to make any special report on the nature of the accessions made to our collection in this part of the secondary series, as it requires examination and revision. Many donations of interest have been made by Mr. Cunnington, Mr. Ruskin, and Mr. Pratt: from the latter was received *Amphiura Pratti*, of the Oxford clay, described by Mr. Forbes in our 'Proceedings.'

Ophioderma Egertoni, from the Lias, also described, was obtained for this Society by exchange.

Palæozoic era.—The Society has received important additions in this portion of its collection, and nearly in every subdivision of this group.

Productæ from the magnesian limestone of Humbledon, presented by Sir Philip Grey Egerton, Bart.

A beautiful collection of fossils from Hook Point (Wexford), presented by the Earl of Enniskillen, contains the following Crinoids, in which order we previously possessed scarcely a determinable specimen :—

Actinocrinites 30-dactylus, A. aculeatus, A. elephantinus, A. lævis, A. Colei.

Platycrinites spinosus.

A very valuable collection of the palatal remains, teeth and spines of fossil fishes from the carboniferous limestone of the county of Armagh, has been received from Captain Jones, R.N., M.P., comprising 43 species, named by M. Agassiz, some of which are the originals of figures in the 'Poissons Fossiles.' This donation comprises the following genera and species :—

Psammodus rugosus, P. porosus, P. cornutus.
Helodus turgidus, H. didymus, H. lævissimus, H. planus, H. mammillaris.
Chomatodus truncatus, C. cinctus, C. linearis.
Cochliodus contortus, C. magnus, C. oblongus, C. acutus, C. striatus.
Cladodus mirabilis, C. acutus, C. basalis, C. striatus, C. marginatus.
Ctenoptychius macrodus, C. renatus, C. Psittacinus, C. lævissimus, C. Hastingsii, C. radicans, C. nutus, C. sagittatus, C. marginatus.
Ctenacanthus crenulatus, C. heterogyrus.
Asteroptychius ornatus.
Oracanthus confluens, O. minor.
Physonemus subteres.
Onchus plicatus, O. falcatus, O. rectus.
Pœcilodus parallelus, P. Jonesii, P. sublævis.

The fossils from the carboniferous group of Ireland had, till recently, been arranged according to the counties from which they had been procured: under Mr. Forbes's direction, Mr. Woodward has collected into one systematic series all the English and Irish fossils of this age.

Some Corals from the Plymouth limestone have been presented by Mr. Hennah.

The collection of Rhenish fossils, presented by Mr. Murchison, has been placed in drawers, and the Corals have been arranged and named after memoranda left by Mr. Lonsdale. Some additions have been made to our Dudley limestone fossils by exchanges with the Dudley Museum.

We are not aware of any other donations requiring special notice. We would suggest an alteration in the Museum, which would not be attended with any great expense, viz. that the window-shutters be removed, and the recesses fitted up with shelves, so that space may be gained for many of the large and interesting specimens in the Society's possession, which cannot at present be exhibited.

With respect to the Library, the Committee have to report that about 180 volumes and pamphlets have been received since the last Anniversary, and that the collection of Maps and Illustrations has been enriched by the addition of the Original Drawings engraved in the work of Prof. Agassiz on Fossil Fishes, the munificent donation of Lord Francis Egerton, and of the Charts and Maps published during the year by the Admiralty and Board of Ordnance.

ROBERT A. C. AUSTEN.
H. T. DE LA BECHE.
CHARLES LYELL.

Comparative Statement of the Number of the Society at the close of the years 1842 *and* 1843.

	Dec. 31, 1842.		Dec. 31, 1843.	
Compounders	118		117	
Residents	243		239	
Non-residents	427		448	
	788		804	
Honorary Members	27		26	
Foreign Members	49		49	
Personages of Royal Blood	4		4	
		80		79
	868		883	

General Statement Explanatory of the Alteration in the Number of Fellows, Honorary Members, &c. at the close of the years 1842 *and* 1843.

Number of Fellows, Compounders, Contributors, and Non-residents, 31st December, 1842				788
Add, Fellows elected during former years, and paid in 1843	Non-residents		4	
Fellows elected during 1843, and who paid	Residents	17		
	Non-residents	12		
			29	
				33
				821
Deduct, Compounders deceased			2	
Residents ,,			3	
Non-residents ,,			3	
Resigned			5	
Removed			4	
				17
Total number of Fellows, 31st Dec. 1843, as above				804

Number of Honorary Members, Foreign Members, and Personages of Royal Blood, 31st December, 1842..	80
Deduct, Honorary Member, deceased................	1
Total as above	79

Number of Fellows liable to Annual Contribution at the close of 1843, *with the Alterations during the year.*

Number at the close of 1842..........................		243
Add, Elected during 1843 and paid		17
Non-residents who became Residents		1
		261
Deduct, Deceased..................................	3	
Resigned..................................	4	
Compounded	1	
Became Non-resident.......................	10	
Removed..................................	4	
		22
Total as above....		239

Deceased Fellows :—

Compounders (2): Samuel Boddington, Esq.; Thomas William Maltby, Esq.

Residents (3): Dr. James Franck; Dr. James MacDougle; George William Wood, Esq.

Non-residents (3): Thomas Botfield, Esq.; John Buddle, Esq.; Benjamin H. Bright, Esq.

Honorary Member (1): Dr. R. F. Forester.

The following Persons were elected Fellows during the year 1843.

January 4th.—Rev. William Wilson, B.D. Oxford, Vicar of Walthamstow; James Edward Davies, Esq., Middle Temple, Barrister; John Moreton, Esq., Chester Hill, near Uley, Gloucestershire; and Sir George Lefevre, M.D., 2 Porchester Place, Oxford Square.

January 18th.—Henry Hope, Esq., Deepdene; William Stevens Richardson, Esq., Temple, Barrister at Law; and Thomas Page, Esq., Member of the Institution of Civil Engineers, and acting Engineer at the Thames Tunnel.

February 1st.—William Johnson, Esq., Grosvenor Granite Wharf, and Richmond, Surrey; James Baber, Esq., South Place, Knightsbridge; and Evan Hopkins, Esq.

March 8th.—Rev. John Barlow, M.A., F.R.S., Trinity College, Cambridge, 22 Henrietta Street, Cavendish Square; and Captain James, Royal Engineers.

March 22nd.—Major-Gen. W. Morison, C.B., M.P., Madras Army, F.R.S. L. & E., Grosvenor Street; Thomas Oldham, Esq., A.B., 7 Suffolk Street, Dublin; Thomas Falconer, Esq., Putney Hill, Putney; and Henry William Bristow, Esq., Ordnance Geological Survey of Great Britain.

April 5th.—Edward Scott Barber, Esq., Newport, Monmouthshire, Associate Inst. C.E.; Charles Crompton, Esq., Barrister, Endsleigh Street, Tavistock Square.

April 26th.—Lieut-Colonel Dundas, C.B., Royal Artillery, Woolwich; and George Grote, Esq., M.A., 4 Eccleston Street, Belgrave Square.

May 10th.—James Jerwood, Esq., A.M., Middle Temple, Barrister, Southernhay, Exeter; Archibald Billing, M.D., A.M., Park Lane; Lieut. Thomas A. B. Spratt, Royal Navy; and Gabriel Hamilton Lang, Esq., Overtown, Dumbartonshire.

May 24th.—William Cubitt, Esq., F.R.S., V.P. Inst. C.E., Great George Street, Westminster.

June 7th.—George Tate, Esq., Alnwick; and Nicholas Wood, Esq., Killingworth, Newcastle-on-Tyne, Civil Engineer.

November 15th.—G. T. Vigne, Esq., Woodford, Essex.

November 29th.—Joseph Travis Clay, Esq., Rastrick, near Halifax; and Francis W. Jennings, Esq., M.R.I.A. of Cork.

December 13th.—Rev. Thomas Image, Whepstead, near Bury, Suffolk.

The following Donations to the MUSEUM have been received since the last Anniversary.

British and Irish Specimens.

Slab of Keuper Sandstone with footsteps from Warwickshire; Specimen of *Hybodus Keuperi* and other fossils from Keuper Sandstone of Warwickshire and Gloucestershire; Specimens from the Lias Bone-bed at Coomb Hill and Defford Common, Gloucestershire; remarkable concretions from the Tertiary Beds in the Isle of Man; Slabs with impressions caused by the motions of Mollusca, &c. from the Lias, Wainlode Cliff, Gloucestershire; Freshwater Shells from the Wealden Beds, Shotover Hill, Oxon; presented at various times by H. E. Strickland, Esq., F.G.S.

Paludinæ and *Uniones* from the junction of the London and Plastic Clays in the Railway cutting at New Cross; Fossils from the Gault near Folkstone; series of Fossils obtained in sinking a shaft in the Lower Greensand at Hythe, Kent; Fossils from the Lower Greensand at Atherfield in the Isle of Wight; and remains of Plants, Cyprides and Fish from the Wealden Clay, found in making the Tunnel at Blechingley, Surrey; presented by F. W. Simms, Esq., F.G.S.

Fossils from the Lower Greensand, Sandown Bay and Atherfield, Isle of Wight; presented by H. Warburton, Esq., M.P., Pres. G.S.

Fossils from the Lower Greensand and Weald Clay at their junction, Redhill, near Reigate; presented by the Rev. Prof. Buckland, D.D., F.G.S., and the President.

Fossils from the Lower Greensand, Red-hill, near Reigate; presented by Dr. Fitton, F.G.S., and R. A. C. Austen, Esq., Sec.G.S.

Series of Lower Greensand fossils from Atherfield, Isle of Wight; presented by Dr. Fitton, F.G.S.

Specimens from the same locality; presented by A. J. Hambrough, Esq., F.G.S., and L. L. B. Ibbetson, Esq., F.G.S.

Series of Fossils from the Lower Greensand at Peasmarsh, Surrey; *Cardium crassum* (Austen, M.S.) and Hinnites from the Upper Greensand, Blackdown; presented by R. A. C. Austen, Esq., Sec. G.S.

Fossils from the Lower Greensand, Hythe, Kent, and from the Gault at Copt Point, near Folkstone; presented by H. B. Mackeson, Esq.

Ichthyolites and other fossils from the Lower Greensand, Pulborough, Sussex; presented by P. J. Martin, Esq., F.G.S.

Fossils of the Lower Greensand and bones of the Iguanodon from the Hastings Sand, Isle of Wight; presented by Edward Wise, Esq.

Tooth of an undescribed species of *Lamna* from the Chalk, Charing, Kent; presented by William Harris, Esq., F.G.S.

Fossils from the Coral Rag, Oxford Clay and Cornbrash of Wiltshire; presented by William Cunnington, Esq.

Ammonite from the Calcareous Grit; and series of Fossils from the Carboniferous Limestone of Hook Point, Co. Wexford; presented by the Earl of Enniskillen, F.G.S.

Palatal remains, teeth and spines of 42 species of Fish from the Carboniferous Limestone of Armagh; presented by Captain Jones, R.N., M.P., F.G.S.

Slab of Sandstone with track of a Fish (*Ichthyopatolite, Buckland*) from Cheshire; presented by Miss Eliza Potts.

Sandstone cast of a Coal-measure plant (*Bothrodendron*) from Keynsham; presented by the Rev. J. C. Stapleton, F.G.S.

Productæ from the Magnesian Limestone, Humbleton Hill; presented by Sir P. G. Egerton, Bart., M.P., F.G.S.

Corals from the Devonian Limestone, Plymouth; Rev. R. Hennah, F.G.S.

A Fossil (?) found near Aberystwyth; presented by A. Thomas, Esq., F.G.S.

Cellular Limestone from Sampson's Bay, Ilfracombe; presented by A. Majendie, Esq., F.G.S.

Fossils from the Stonesfield Slate, Oxon; presented by J. Ruskin, Esq., F.G.S.

Fossils from the Kimmeridge Clay and Calcareous Grit, Shrivenham; and a Starfish (*Amphiura Pratti*) from the Oxford Clay; presented by S. P. Pratt, Esq., F.G.S.

Fossils from the Cambrian Slates at Pwllheli and Dolgelly; presented by J. Trimmer, Esq., F.G.S.

Mass of London Clay with Shells from the "West Rocks" S.E. of Harwich; presented by Capt. Beaufort, R.N., Hon. M.G.S.

Fragment of the "Blackwall Rock" (Conglomerate of the Plastic Clay); presented by R. Taylor, Esq., F.G.S.

Specimen of *Pinna affinis* from the London Clay, Bognor; presented by G. B. Greenough, Esq., V.P.G.S.

Specimens of Chalcedony and Fossils from the Chalk at Hemel Hempstead, Herts; presented by H. C. White, Esq., F.G.S.

Remains of Fish from the London Clay of Sheppey, and Mammalian Teeth and Bones from the Pleistocene deposit at Erith, Kent; presented by Robert White, Esq.

Plagiostoma (?) *spinosum* from the Chalk, and Teeth of the Rhinoceros and Equus from a Brickfield near Salisbury; presented by Mr. George Card.

Casts of the Tympanic Bones of Cetacea from the Red Crag of Felixstow; presented by the Rev. Prof. Henslow, F.G.S.

Fossil Seeds from the Lower Freshwater deposit at Hordwell; presented by S. V. Wood, Esq., F.G.S.

Sigillaria from the Coal-measures, Clutton in Templecloud, Somerset; presented by Dr. Pope.

Favosites from the Caradoc Sandstone, Haverfordwest; presented by Mrs. Day, of Swan-hill House, Shrewsbury.

Foreign Specimens.

Cretaceous Fossils from New Granada; presented by Evan Hopkins, Esq., F.G.S.

Mineral Alum from a Cave about forty feet above the level of Buchanan's River, Cape of Good Hope, and a species of *Pectunculus*; presented by Dr. Sinclair, R.N.

Specimen of Olivine in Basaltic Rock, from Cutch; presented by Capt. Postans.

Specimens of Opaline Wood from Van Diemen's Land; presented by M. C. Moxon.

Crystals of Carbonate of Lime, and of Native Copper with Magnetic Iron Pyrites in Quartz, from the Alten Copper-works, Lapland; presented by J. R. Crowe, Esq.

Pleistocene Fossils from North America; presented by Charles Lyell, Esq., F.G.S.

Specimens from Greece; presented by W. C. Trevelyan, Esq., F.G.S.

Fossils from the Inferior Oolite and Lias of Normandy; presented by A. Majendie, Esq., F.G.S.

Large species of *Spondylus* from Mexico; presented by John Taylor, Esq., V.P.G.S.

The Fossil Astragalus of a Quadrumanous Animal from the Sewalik Hills; discovered by Dr. Falconer in 1837 (see Geol. Proc. vol. ii. p. 568); presented by William Lonsdale, Esq., F.G.S.

Carboniferous Fossils from Australia; presented by J. S. Bowerbank, Esq., F.G.S.

Coal-measure plants from Australia; presented by the Rev. C. P. Wilton.

Collection of Silurian Fossils from Sweden; presented by E. H. Bunbury, Esq., F.G.S.

Collection of Tertiary Fossils from Malta and Gozo; presented by Lieut. T. A. B. Spratt, F.G.S.

Collection of Fossils from Pondicherry, Verdachellum and Trinchinopoly; presented by C. T. Kaye, Esq., F.G.S.

Collection of Fossils from Verdachellum, &c.; presented by the Rev. W. H. Egerton.

Miscellaneous.

Casts of metacarpal and other Bones of a Fossil Elephant from the Pleistocene of Kent; presented by W. Ball, Esq.

A Pentagraph; presented by H. Warburton, Esq., M.P., Pres. G.S.

Charts and Maps.

Ordnance Townland Survey of the Counties of Waterford, 42 sheets; and of Tipperary, 93 sheets; presented by Col. Colby, by direction of the Lord Lieutenant of Ireland.

The Charts, &c. published by direction of the Lords Commissioners of the Admiralty during the year 1842; presented by Capt. Beaufort, R.N., by direction of the Lords Commissioners of the Admiralty.

Geological Chart of the Oolitic Strata of the Cotswold Hills, by James Buckman, Esq., F.G.S. (2 copies); presented by the Author.

Map of the Island of Bombay, by Capt. Thomas Dickinson; and Map of the Khanat of Bokhara, prepared by Colonel Baron Meyendorff; presented by Major Jervis, F.G.S.

Carte Administrative et Industrielle comprenant les Mines, Minières, Carrières, Usines, &c. de la Belgique, in 9 sheets; presented by M. Ph. Vandermaelen.

Carte Géognostique du Plateau Tertiaire Parisien, par V. Raulin; presented by the Author.

Dobbs and Co.'s Relievo Map of England and Wales, Geologically coloured; presented by Messrs. Dobbs and Co.

Map of the Wine District of Alto Douro, by J. J. Forrester, Esq.; presented by the Author.

Geological Map of England and Wales, by R. I. Murchison, Esq., F.G.S.; presented by the Author.

The Original Drawings engraved in the work on Fossil Fishes, by Prof. Agassiz; presented by Lord Francis Egerton, M.P., F.G.S.

Two Lithographic Impressions of *Apiocrinites rotundus*, in the collection of J. C. Pearce, Esq.; presented by J. C. Pearce, Esq., F.G.S.

The following List contains the Names of all the Persons and Public Bodies from whom Donations to the Library and Museum were received during the past year.

Academy of Sciences of Paris.
Admiralty, The Right Hon. the Lords Commissioners of the.
Agassiz, Prof. L., For. Mem. G.S.
American Philosophical Society held at Philadelphia.
Ansted, Prof. D. T., F.G.S.
Athenæum, Editor of the.
Austen, R. A. C., Esq., Sec. G.S.
Austin, Thomas, Esq.
Austin, Thomas, Jun., Esq.

Ball, William Esq.
Beaufort, Capt. R.N., Hon. Mem. G.S.
Berwickshire Naturalists' Club.
Birmingham Philosophical Institution.
Bohn, Mr. J.
Bombay Branch of the Royal Asiatic Society.
Bowerbank, J. S., Esq., F.G.S.
Bravais, M. A.
British Association for the Advancement of Science.
Buckland, Rev. Prof., D.D., F.G.S.
Buckman, James, Esq., F.G.S.
Bunbury, E. H., Esq., F.G.S.

Card, Mr. G.
Chemical Society of London.
Claussen, M. P.
Colman, H., Esq.
Crowe, J. R., Esq.
Cunnington, J. W., Esq.

Dana, J. D., Esq.
D'Archiac, M. le Vicomte.
Daubeny, Prof., M.D., F.G.S.
De Castelman, M. F.
De Collegno, M. H.
Dépôt Général de la Marine de France.
Dobbs and Co., Messrs.
D'Halloy, J. J., Omalius, For. Mem. G.S.
D'Orbigny, M. Alcide.

Egerton, Lord Francis, M.P., F.G.S.
Egerton, Sir P., Bart., M.P. F.G.S.
Egerton, the Rev. W. H.
Egyptian Society.
Elie de Beaumont, M. L., For. Mem. G.S.
Enniskillen, Earl of, F.G.S.
Ethnological Society.

Faraday, M., Esq., F.G.S.
Favre, M. Alphonse.
Fischer de Waldheim, M. G., For. Mem. G.S.
Fisher and Son, Messrs.
Fitton, W. H., M.D., F.G.S.
Forbes, Prof. E.
Forrester, J. J., Esq.
Fox, R. Were, Esq.
Franklin, Sir J., K.C.H., F.G.S.

Geological Society of France.
Geological Society of Manchester.
Greenough, G. B., Esq., V.P.G.S.

Hambrough, A., Esq., F.G.S.
Harris, W., Esq., F.G.S.
Hennah, Rev. R., F.G.S.
Henslow, Rev. Prof., F.G.S.
Hœninghaus, Herr F. W.
Hogg, John, Esq., M.A.
Hopkins, Evan, Esq., F.G.S.
Humboldt, Baron von F. A., For. Mem. G.S.

Ibbetson, L. L. B., Esq., F.G.S.
Jervis, Major T. B., F.G.S.
Institution of Civil Engineers.
Johnston, Prof. J. F. W., F.G.S.

Jones, Capt. R.N., M.P., F.G.S.
Italian Society of Modena.

Koninck, M. L. de.

Lamont, Dr. J.
Lea, Isaac, Esq.
Linnæan Society of London.
London Electrical Society.
Lonsdale, William, Esq., F.G.S.
Lyell, Charles, Esq., F.G.S.

Mackeson, J., Esq.
Mackintosh, A. F., Esq., F.G.S.
Majendie, A., Esq., F.G.S.
Martin, P. J., Esq., F.G.S.
Matthews, Mr. William.
McClelland, J., Esq.
Microscopical Society of London.
Monticelli, Signor T., For. Mem. G.S.
Morris, Mr. J.
Moscow, Imperial Society of.
Moxon, Charles, Esq.
Murchison, R. I., Esq., F.G.S.
Museum of Natural History of Paris.

Nattali, Mr. M. A.
Newbold, Capt. T.
Newman, Edward, Esq.

Ordnance, Master-General of the.
Owen, Prof., F.G.S.

Pearce, J. C., Esq., F.G.S.
Percival, J. G., Esq.
Phillips, Prof. J., F.G.S.
Physiological Journal, Editors of the.
Postans, Captain.
Potts, Miss Eliza.
Pratt, S. P., Esq., F.G.S.

Raulin, M.
Redfield, W. C.
Robinson, F., Esq., R.N.
Roemer, M. F.
Rogers, H. D., Esq., F.G.S.
Royal Academy of Berlin.
Royal Academy of Brussels.
Royal Academy of Lisbon.
Royal Academy of Munich.
Royal Agricultural Society of England.
Royal Asiatic Society.
Royal Astronomical Society.
Royal College of Physicians.
Royal Geographical Society of London.
Royal Geological Society of Cornwall.
Royal Institution.
Royal Irish Academy.
Royal Polytechnic Society of Cornwall.
Royal Society of Copenhagen.
Royal Society of Edinburgh.
Royal Society of London.
Ruskin, J., Esq., F.G.S.

Silliman, Prof., M.D., For. Mem. G.S.
Simms, F. W., Esq., F.G.S.
Sinclair, Dr.
Sismonda, Signor Angelo.
Smith, Rev. Dr. Pye, F.G.S.
Society of Arts.
Spratt, Lieut. T.A.B., R.N., F.G.S.
Stapleton, Rev. J. C., F.G.S.
Stokes, Charles, Esq., F.G.S.
Strasburg Museum of Natural History.
Strickland, H. E., Esq., F.G.S.

Taylor, John, Esq., V.P.G.S.
Taylor, Richard, Esq., F.G.S.
Tcheffkine, General.
Thomas, A., Esq., F.G.S.
Trevelyan, W. C., Esq., F.G.S.
Trimmer, J., Esq., F.G.S.

Vandermaelen, M. Ph.

Warburton, H., Esq., M.P., Pres. G.S.
Wetherell, N. T., Esq., F.G.S.
Wheelwright, Mr.

White, H. C., Esq., F.G.S.
White, Robert, Esq.
Wiley and Putnam, Messrs.
Wilton, Rev. C. P.
Wise, Edward, Esq.
Wood, S. V., Esq., F.G.S.

Yorkshire Philosophical Society.

Zeisznera, M. L.

List of PAPERS *read since the last Annual Meeting, February* 17*th*, 1843.

Feb. 22nd & June 21st.—On some new species of Fossil Chimæroids, with remarks on their general affinities, by Sir P. G. Egerton, Bart., M.P., F.G.S.

——————— On the Geology of the neighbourhood of Bayonne, by S. P. Pratt, Esq., F.G.S.

March 8th.—On the Non-locomotive and locomotive powers of the family Crinoidea, by J. C. Pearce, Esq., F.G.S.

——————— Description of an entirely new form of Encrinite from the Dudley Limestone, by J. C. Pearce, Esq., F.G.S.

——————— On the Fossil Pine Forest of Kururkurrân on the East Coast of Australia, by the Rev. W. B. Clarke, F.G.S.

March 22nd.—An Account of the Post-pliocene deposits at Coptford, Essex, by John Brown, Esq., F.G.S.

——————— On the Tin Mines of Tannasserim, by John Forbes Royle, M.D., Professor of Materia Medica and Therapeutics, King's College, London.

April 5th.—On the Structure of the District on either side of the North Downs of Surrey, by R. A. C. Austen, Esq., Sec. G.S.

——————— Notice on the occurrence of Beds containing Fresh-water Fossils, in the Oolitic Coalfield of Brora, Sutherlandshire, by A. Robertson, Esq., F.G.S.

——————— On the occurrence of Freshwater Beds in the Oolitic deposits of Brora, Sutherlandshire, and on the British equivalents of the Neocomian System of Foreign Geologists, by R. I. Murchison, Esq., F.G.S.

April 26th.—On upright Fossil Trees found at different levels in the Coal Strata of Cumberland, Nova Scotia, by Charles Lyell, Esq., F.G.S.

——————— On changes in the Temperature of the Earth, as a mode of accounting for the subsidence of the Ocean, and for the consequent formation of Sea-beaches above its present level, by Robert Harkness, Esq.

May 10th.—On some new Ganoid Fishes, by Sir Philip Egerton, F.G.S.

——————— On the Coal Formation of Nova Scotia, and on the age and relative position of the Gypsum and accompanying Marine Limestones, by Charles Lyell, Esq., F.G.S.

——————— On the Coal-fields of Nova Scotia, together with a Geological Map of that Peninsula, by Abraham Gesner, M.D., F.G.S.

May 24th.—On the Geology of some points on the West Coast of Africa, and of the Banks of the River Niger, by William Stanger, M.D., F.G.S.

———— On the classification of Granitic Rocks, by Robert Wallace, Esq.

———— Additional Notes on the structure of the District on either side of the North Downs of Surrey, by R. A. C. Austen, Esq., Sec. G.S.

———— Observations on part of the section of the Lower Greensand at Atherfield, on the Coast of the Isle of Wight, by W. H. Fitton, M.D., F.G.S.

June 7th.—Note on the scratched surface of a Rock from Mount Parnassus, by W. C. Trevelyan, Esq., F.G.S.

———— On Ichthyopatolites, or impressions resembling the footsteps of Ambulatory Fishes on a flag-stone of the Coal Formation at Mostyn in Flintshire, by the Rev. William Buckland, D.D., Professor of Mineralogy and Geology in the University of Oxford, V.P.G.S.

———— Account of a section of the Strata between the Chalk and the Weald Clay in the vicinity of Hythe, by F. W. Simms, Esq., F.G.S.

———— Comparative Remarks on the Lower Greensand of Kent and the Isle of Wight, by W. H. Fitton, M.D., F.G.S.

———— On Insects in the Lias of Gloucester, by James Buckman, Esq., F.G.S.

June 21st, Nov. 15th & 29th.—On the Geology of North Wales, by the Rev. Adam Sedgwick, F.G.S., Woodwardian Professor in the University of Cambridge.

November 1st.—On British Fossil Ophiuridæ, by Edward Forbes, Esq., Professor of Botany, King's College, London. Communicated by R. I. Murchison, Esq., F.G.S.

———— On the Geology of Malta, by Lieut. A. B. Spratt, F.G.S.

November 15th.—On Fossil Remains of Animals in the Sewalik Hills, by Dr. Falconer, F.G.S., and Captain Cautley, F.G.S.

December 13th.—On the Geology of Cape Breton, by Richard Brown, Esq. Communicated by Charles Lyell, Esq., F.G.S.

———— On Nova Scotia, by J. W. Dawson, Esq. Communicated by Charles Lyell, Esq., F.G.S.

———— On Concretions in the Crag of Suffolk, by the Rev. John Stevens Henslow, Esq., F.G.S., Professor of Botany in the University of Cambridge.

January 3rd.—On the occurrence of the Genus *Physeter* (or Sperm Whale) in the Red Crag of Felixstow, by Edward Charlesworth, Esq., F.G.S.

———— On a Fossil Forest in the Parkfield Colliery near Wolverhampton, by Mr. Henry Beckett. Communicated by the President.

———— Some account of a Fossil Tree found in the Coal-grit near Darlaston, by J. S. Dawes, Esq., F.G.S.

January 3rd.—Abstract of a paper on the Trap-rock of Bleadon Hill, by the Rev. D. Williams, F.G.S.

January 17th.—On Crustaceans found by Dr. Fitton at Atherfield, by Thomas Bell, Esq., Professor of Zoology, King's College, London.

——————— On the occurrence of Phosphorite in Estremadura, by Charles Daubeny, M.D., and Captain Widdrington, R.N.

——————— On the Cretaceous Formations of North America, by Charles Lyell, Esq,, F.G.S.

January 31st.—On the South-east Coast of the Isle of Wight, by F. W. Simms, Esq., F.G.S.

——————— Report on the Lower Greensand Fossils in the Society's Collection, by the Curator.

——————— Report on the collection of Fossils from Southern India, presented by C. T. Kaye, Esq., F.G.S., and the Rev. W. H. Egerton, by the Curator.

——————— On the Permian System in Russia, by R. I. Murchison, Esq., F.G.S.

After the Reports had been read, it was resolved,—

That they be received and entered on the Minutes of the Meeting; and that such parts of them as the Council may think fit, be printed and distributed among the Fellows.

It was afterwards resolved :—

1. That the thanks of this Society be given to the Rev. Prof. Buckland, retiring from the office of Vice-President.

2. That the thanks of the Society be given to Dr. Mantell, Prof. Royle, the Rev. Prof. Sedgwick, Daniel Sharpe, Esq., and H. E. Strickland, Esq., retiring from the Council.

After the Balloting Glasses had been duly closed, and the lists examined by the Scrutineers, the following gentlemen were declared to have been duly elected the Officers and Council for the ensuing year :—

OFFICERS.

PRESIDENT.

Henry Warburton, Esq. M.P. M.A. F.R.S.

VICE-PRESIDENTS.

Charles Darwin, Esq. F.R.S.
Lord Francis L. Egerton, M.P.
G. B. Greenough, Esq. F.R.S. L.S.
John Taylor, Esq. F.R.S.

SECRETARIES.

Robert A. C. Austen, Esq.
William John Hamilton, Esq. M.P.

FOREIGN SECRETARY.

Sir H. T. De la Beche, F.R.S. and L.S.

TREASURER.

John Lewis Prevost, Esq.

COUNCIL.

Thomas Bell, Esq. F.R.S. & L.S.
Rev. W. Buckland, D.D. F.R.S. L.S. Prof. of Geology and Mineralogy in the University of Oxford.
Edward Herbert Bunbury, Esq. M.A.
Sir P. Grey Egerton, Bart. M.P. F.R.S.
Hugh Falconer, M.D. F.L.S.
W. H. Fitton, M.D. F.R.S. L.S.
Leonard Horner, Esq. F.R.S. L.S.
Robert Hutton, Esq. M.R.I.A.
Sir J. V. B. Johnstone, Bart. M.P.
Charles Lyell, jun. Esq. F.R.S. L.S.
R. I. Murchison, Esq. F.R.S. L.S.
Marquess of Northampton, Pres. R.S.
Prof. Owen, F.R.S. L.S.
Samuel Peace Pratt, Esq. F.R.S.

CURATOR.

Edward Forbes, Esq.

Valuation *of the Society's Property; 31st December* 1843.

Property.

				£.	s.	d.
Balances in hand, including 31*l.* 11*s.* 6*d.* Wollaston Fund and 36*l.* 1*s.* Geological Map..				224	8	8
Arrears due to the Society:	£.	s.	d.			
Admission Fees	33	12	0			
Annual Contributions	126	0	0			
				159	12	0
Estimated value of unsold Transactions				1309	10	6
Estimated value of unsold Proceedings				45	0	0
Value of Funded Property, 2706*l.* 19*s.* 1*d.* Consols at 96				2598	0	0
				£4336	11	2

Debts.

	£.	s.	d.	£.	s.	d.
Bills outstanding:						
Scientific Expenditure	5	0	0			
House Expenditure	3	0	0			
Proceedings	20	0	0			
				28	0	0
Cash belonging to "Wollaston Fund"				31	11	6
Cash belonging to Map Account				36	1	0
Arrears not likely to be received				110	0	0
				205	12	6
Balance in favour of the Society				4130	18	8
				£4336	11	2

[*N.B. The value of the Collections, Library and Furniture is not here included: nor is the "Donation Fund," instituted by the late Dr. Wollaston, amounting at present to* 1084*l.* 1*s.* 1*d. in the Reduced* 3 *per cent. Annuities; the dividends thereof being appropriated to the purposes of the Founder.*]

Signed, J. L. PREVOST, Treasurer.

Jan. 27, 1844.

Sums actually Received and Expended

RECEIPTS.

	£.	s.	d.	£.	s.	d.	£.	s.	d.
Balances in hand, January 1, 1843.									
Banker, including 32*l.* 0*s.* 11*d.* Wollaston Fund and 34*l.* 16*s.* 6*d.* Map Account				443	19	9			
Accountant to meet current expenses.				40	0	0			
							483	19	9
Arrears:									
Admission Fees				42	0	0			
Annual Contributions				96	12	0			
Transactions				4	18	6			
							143	10	6
Ordinary Income:									
Annual Contributions				746	10	6			
Admission Fees									
Residents (17)	107	2	0						
Non-Residents (12)	126	0	0						
				233	2	0			
							979	12	6
Composition							31	10	0
Transactions (sold)				165	15	0			
Proceedings (sold)				8	19	0			
							174	14	0
Geological Map							20	5	0
Wollaston Donation Fund, 12 months' Interest on 1084*l.* 1*s.* 1*d.* Reduced 3 per cents.							31	11	6
Dividends:									
Twelve months on 2706*l.* 19*s.* 1*d.* Consols							78	16	10
							£1944	0	1

We have compared the Books and Vouchers presented to us with these Statements, and find them correct.

Signed, R. HUTTON, LEONARD HORNER, } AUDITORS.

Jan. 27, 1844.

during the year ending December 31, 1843.

Payments.

	£.	s.	d.	£.	s.	d.
Bills outstanding:						
Scientific Expenditure	3	2	6			
Household Furniture	0	12	0			
Transactions	556	15	0			
Proceedings	81	11	2			
Miscellaneous Printing	6	10	0			
Collector's Poundage	5	7	1			
				653	17	9
General Expenditure:	£.	s.	d.			
Repairs of House	2	11	6			
House Expenses	146	11	10			
Taxes, Assessed	35	11	4			
Poor's Rates	10	12	0			
Sewer's Rates	2	13	0			
Parochial Charges	7	1	4			
Household Furniture	21	15	0			
Household Linen	2	11	0			
Legal Expenses	5	16	2			
				235	3	2
Insurance				9	0	0
Salaries and Wages:	£.	s.	d.			
Curator	150	0	0			
Sub-Curator	100	0	0			
Clerk	90	0	0			
Porter	80	0	0			
Servant	33	4	0			
Collector	25	3	0			
				478	7	0
Scientific Expenditure				52	16	2
Stationery and Miscellaneous Printing				45	15	0
Tea for Meetings				42	12	4
Cost of Publications:	£.	s.	d.			
Transactions	6	17	6			
Proceedings	144	1	1			
				150	18	7
Geological Map				19	0	6
Award of Wollaston Donation Fund:	£.	s.	d.			
P. A. Dufrénoy, Gold Medal	10	10	0			
Elie de Beaumont, Gold Medal	10	10	0			
Mr. J. Morris	11	0	11			
				32	0	11
Balances in hand:	£.	s.	d.			
Banker, including 31*l.* 11*s.* 6*d.* Wollaston Fund and 36*l.* 1*s.* Map Account	184	8	8			
Accountant to meet current expenses	40	0	0			
				224	8	8
				£1944	0	1

Estimates *for the ensuing year* 1844.

INCOME EXPECTED.

	Sub £.	Sub s.	Sub d.	£.	s.	d.
Arrears due to the Society, Dec. 31st, 1843. (See Valuation-sheet)				159	12	0
Ordinary Income for 1844 estimated:						
Annual Contributions (220 Fellows)				693	0	0
Admission Fees:						
Residents (15)	94	10	0			
Non-residents (15)	157	10	0			
				252	0	0
Compositions (2)				63	0	0
Sale of Transactions and Proceedings				170	0	0
Dividends on "Wollaston Donation Fund"				31	11	6
Ditto on 12 months' Consols, 2706*l.* 19*s.* 1*d.*				78	16	10
				£1448	0	4

EXPENDITURE ESTIMATED.

	Sub £.	Sub s.	Sub d.	£.	s.	d.
Debts outstanding. (See Valuation-sheet)				28	0	0
General Expenditure:						
Repairs of House	35	0	4			
Taxes	15	11	0			
Insurance	9	0	0			
House Expenses	150	0	0			
Household Furniture and Linen	25	0	0			
				234	11	4
Salaries and Wages:						
Curator	150	0	0			
Sub-Curator	100	0	0			
Clerk	100	0	0			
Porter and Housekeeper	80	0	0			
Servant	33	4	0			
Collector's Poundage	25	0	0			
				488	4	0
Scientific Expenditure				60	0	0
Stationery and Miscellaneous Printing				50	0	0
Tea for Meetings				50	0	0
Cost of Transactions and Proceedings				170	0	0
Arrears not likely to be received				110	0	0
Employment of the "Wollaston Fund"				31	11	6
				1222	6	10
Balance in favour of the Society				225	13	6
				£1448	0	4

Signed, J. L. PREVOST, Treasurer.

Jan. 27, 1844.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY OF LONDON.

VOL. IV. PART II. 1844. No. 101.

FEBRUARY 21, 1844.

The following communications were read:—

1. *Some Remarks on the* WHITE LIMESTONE *of* CORFU *and* VIDO. By Captain PORTLOCK, R.E., F.G.S.

As I have reason to expect that I shall hereafter be able to prepare a detailed account of the Geology of the Ionian Islands, and have at present but few data for a description of even the limited portion of the country as yet examined, I now only offer a few remarks on that portion of the white limestone which is adjacent to the city of Corfu, and occupies the whole of the Island of Vido, and on the more recent strata connected with it.

On approaching Corfu, the physical aspect of the country is very striking. Monte Decca on the south, and San Salvador on the north, the former with its sharp, broken, rugged outline, the latter with its conical peak rising from a long ridge, and both exhibiting steep faces marked by numerous deep furrows, by no means recall the ordinary forms of limestones in our more northern countries; but the type they present will, I think, be found to have a considerable geological range.

In the Venetian harbour of Govino a singular variety of this limestone may be seen, and is thence traceable in rough knolls running in a westerly direction to the north of the village of Potamo. Its dark, rugged, and often ochreous aspect, its sonorous fracture, and its impurities, are strong features of distinction between it and the ordinary white limestone. It is traversed by numerous crystalline veins of a yellow saccharoid carbonate of lime, which I have little doubt is highly dolomitic; and it is full internally of small bubble-shaped cavities, some of which are empty, and others contain a fine powder, the nature of which I have not yet determined. I believe this limestone to be of volcanic origin, or at least much changed, although no ordinary volcanic or other igneous rocks have as yet been discovered in the island.

Returning now to the white limestone of Vido and the vicinity of Corfu, it will be necessary first to consider whether the geological age of any part of it can be determined, and this is important, since, according to Dr. Davy, it belongs to the carboniferous limestone, and a conglomerate associated with it represents the old red sandstone, while, according to other accounts, the white limestone is oolitic, and the conglomerate tertiary.

The adjacent mainland with which these Corfu and Vido beds must be associated contains secondary strata, considered to be oolitic, and much resembling in mineral character the hardened chalk of England and Ireland; and Mr. Strickland, in describing the Geology of Smyrna, mentions that the more compact beds of yellowish limestone of that neighbourhood resemble the secondary limestones of the Ionian Islands. The former, however, are known by their fossils to be of lacustrine and tertiary origin. Mr. Strickland also, in alluding to the Geology of Zante, considers the lower beds as Apennine limestone, and the upper ones as tertiary; and the presence of Hippurites renders it probable that the former at least is of the Cretaceous period.

Restricting myself to the description of the limestone of Vido and the opposite shore of Corfu, I may first observe, that the greater portion, such as for example that of the citadel rock, the height of Fort Neuf and of Fort Abraham, is very indistinctly bedded, and vertical cleavage is visible on a large scale, more particularly at the citadel. I have as yet in vain sought for fossils at either of these localities, though the rock of Fort Abraham strongly resembles that of Vido, which contains a considerable quantity of them. Immediately below the citadel rock, forming its base, and dipping under it, is the limestone of Cape Sidero, which is composed of numerous and often minutely laminated beds, from half an inch to several inches in thickness. These beds are associated with layers and nodules of flint, and very often present a highly curious and interesting character, being made up of angular fragments of the limestone, with occasional flints, slightly displaced and re-cemented together: and this brecciated structure is sometimes so minute that it can only be detected by a lens, whilst in other cases it is coarser, and then readily disintegrates. At Cape Sidero the surface of the brecciated beds appears to me to have suffered erosion prior to the deposition of the other rock, portions of which are found in hollows on its surface. The same brecciated beds are seen more to the south, and may therefore underlie the massive beds of Monte Decca, just as they here do those of Cape Sidero. Similar alternating and highly laminated beds of white limestone and flints occur at the base of Fort Neuf, and again in Vido, at the base of the Tower Hill. Up to this geological point, I have as yet found no fossils, but in the massive limestone of Vido the case is different, and having fortunately noticed a fragment on the face of one of our quarries, I directed the attention of the workmen to the fact, and they were not long in discovering more. As the surface of Vido is only gently undulated, and there is no marked section, I have not yet been quite able to satisfy myself whether this limestone should, like that of the Corfu citadel, be considered to lie above the laminated beds, or below them. If the latter, the case is rendered easier. This limestone, like that of Fort Abraham, is full of fissures, which are often filled up with ochreous matter, and even in the finer fissures traces may be noticed of oxide of iron.

The fossils are very locally distributed: at the first fossil locality Terebratulæ only were discovered; but at another, not many hundred yards from it, Ammonites are in abundance: these latter are, however, always in such a condition, from the splintery character of the bed containing them, that specific identification is almost impossible, although I am inclined to think that they belong to Von Buch's division, *Planulati*, and therefore may be oolitic. Portions also of Univalves occur. Returning to the Terebratulæ, some of the first specimens resembled those of the chalk; but more perfect specimens presented the character of one of Von Buch's divisions, *Acutæ*, which as yet appears to go no further upwards than the oolites.

From a careful comparison of these fossils with the species most nearly allied, (*T. pala* and a species from the lower oolites of Dundry), I am induced to believe that the species which I obtained is new, and I propose to name it provisionally *T. Seatoniana*, in honour of the present Lord High Commissioner, who has expressed himself anxious to promote a geological survey of the islands. I think also the character of the species affords strong ground for believing that the strata here belong to rocks as low in the series as the oolites.

With respect to the tertiary strata, I can at present only state that in Corfu I believe that we have all the varieties (including the gypsum), mentioned by Mr. Strickland as occurring at Zante; and I consider there is little doubt that the range of strata extends from the newer Pliocene to Miocene, if not Eocene. In an extensive excavation in the citadel, a yellow indurated calcareous sand was cut into, and a beautiful, though small section exposed; dark laminated clays were interstratified with the sand, and associated with them was a seam of lignite (5 inches thick), which along the line of the excavation (450 feet in extent) exhibited numerous small faults at which the clay was always curiously contorted. Under the seam of coal was a more indurated portion of the calcareous sand, approaching to the character of hardened marl, and in this numerous examples of a Univalve were found, strongly resembling a Buccinum from Touraine.

2. *Account of the* Strata *observed in the Excavation of the* Bletchingley Tunnel. By Frederick Walter Simms, F.G.S., M. Ins. C.E.

A few months ago I had the pleasure of presenting to the Geological Society some fossils collected by me in the course of the construction of the Bletchingley Tunnel, upon the line of the South

Eastern Railway. These fossils consisted of bones of the Iguanodon, *Lepidotus Mantelli,* and five specimens of the plant *Clathraria Lyellii.* I now request the Society's acceptance of a fine specimen of the *Lepidotus Mantelli,* which was found in the excavation about two hundred yards from the western extremity of the tunnel.

The range of hills formed by the escarpment of the lower green sand extends between Red Hill and Tilburstow Hill, and its direction is nearly from west to east. Between Bletchingley and Tilburstow Hill, this range sends off a spur in a southerly direction. It was through this spur, in a line nearly parallel to the sand range, and about a mile to the south of it, that the railway tunnel, and the excavation at each end, were carried. The spur, in the line of the cuttings, consisted chiefly of Weald clay.

It was proved by the railway cuttings that this spur formed part of an anticlinal axis, which, as far as I can judge, extends across the Weald from the chalk of the North Downs in Surrey, between Merstham and Godstone, to the chalk of the South Downs in Sussex, near Ditchling. The surface waters that fall on the western side of this axis form feeders to the rivers Mole and Adur; those that fall on the eastern side feed the sources of the Medway and the Ouse.

In the excavation, at the east end of the tunnel, the beds were parallel to each other, and also to the surface of the ground, rising westward at an angle of about two degrees. The only organic remains, worthy of note, found in this part of the work, were a number of vertebræ of the Iguanodon, which I presented to the Museum of the College of Surgeons. Many remains had been thrown away, although I had given orders to the contrary.

As the work advanced towards the anticlinal axis, the strata showed symptoms of considerable disturbance, having numerous faults and displacements, which occasioned much trouble and difficulty in the construction of the tunnel. On the west of the axis, near the level of the roof of the tunnel, a detached mass of sand-rock, about fifty feet in length, lay across our path. From this a great body of water was discharged into the workings. The rock disappeared abruptly. The chief fossil remains which were found in the course of the tunnel works, were those before named, which are now in the possession of the Society.

The excavation at the western end of the tunnel, from whence the specimen of *Lepidotus Mantelli* was obtained, was full of faults and displacements, the strata dipping in various directions from W. by N. to E., and at almost every angle from 5° to 60°. This state of things caused much trouble on the south side of the excavation, by the continual slipping in of the earth; but on the north side no slip took place, and the slope stands apparently well. At the western end of the excavation, the ordinary dip was about 13° N.

In this cutting there were beds of sandstone, bearing a very strong ripple mark; these beds partook of the general disturbance.

The well-known displacement of the beds of the lower green sand, exposed on the road-side near the top of Tilburstow Hill, is about one mile and a quarter north-east of the excavation I have been describing.

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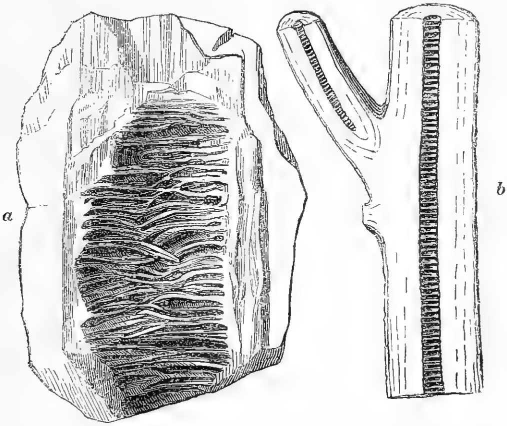
3. *Remarks upon* STERNBERGIÆ. By JOHN S. DAWES, Esq., F.G.S.



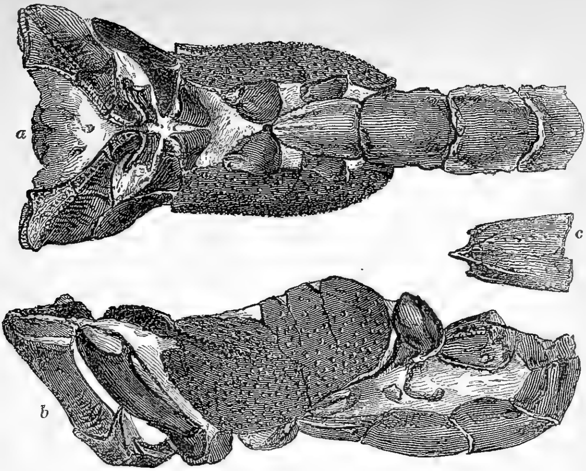
a. Fragment of *Sternbergia*, showing the internal central structure, apparently lamellar.
b. Portion of the branch of a walnut tree, showing somewhat similar structure.

IN the autumn of 1838 certain specimens of vegetable remains were discovered in the coal grit at Oldbury, near Birmingham, which appeared to show, very distinctly, the internal structure of those remarkable fossils, the Sternbergiæ. The circumstance was considered, at the time, completely to corroborate the opinion that they were distinct plants; but having recently examined these specimens with more attention, and having had an opportunity to compare them with others, since discovered, I am enabled, I believe, to point out that these curious columnar forms are merely casts of the medullary cavities of stems or branches of trees, similar to that at Darlaston, lately described; for, upon one of the fossils alluded to, the interior of which is composed of a series of horizontal plates, we find that a part of the woody tissue of the tree is still attached to the column, and another specimen which shows, upon its exterior, traces of the characteristic rings, exhibits also a considerable portion of adhering wood. But more direct evidence is afforded by a branch, now converted into ironstone (see fig. *a*), down the centre of which a distinct arrangement of similar plates may be observed, occasionally anastomosing or rather merging one into the other, exactly as the external forms of

Sternbergiæ would lead us to expect; and a smaller specimen from another district (North Staffordshire) appears still more clearly to show this connection. I may also mention that the pith of recent wood (*Juglandaceæ*), on losing its moisture, has occasionally been found to separate, after a manner somewhat similar (*b*). It is rare, however, that specimens in the fossil state, retaining this structure, have been met with, the plates having only been preserved when mineral matter has atomically replaced the cellular tissue, the plants having previously been in a dry or partially decayed state. In general, the material has filtered into and filled up the interstices, producing the usual cross-barred or ringed appearance of these fossils. Sometimes, cylindrical casts may be found which are marked externally by sharp, longitudinal, irregular striæ, representing probably a portion of the medullary sheath. The whole of the cellular tissue, in such cases, has previously been carried away; but a fine tree at Darlaston has afforded proof that under peculiar circumstances the mineralizing process may commence soon after the fall of the plant. Thus, in all probability, the central column of that specimen will retain the cellular structure. In conclusion, I may allude to the isolated and peculiar fragmentary state in which these cylindrical bodies occur. We find no attached branches, no roots, no leaves or leaf-scars; indeed, there is a total want of every part of a vegetable, by which these fossils might be identified as distinct plants: for the carbonaceous covering, now and then met with, and supposed to have been the bark, being sometimes very irregular is most likely accidental, or in some cases may arise from portions of attached wood having become converted into coal. Should the discovery of further specimens more completely prove these views respecting Sternbergiæ to be correct, we may perceive from their occurrence in, I believe, all our coal fields, how frequently a small cylindrical column alone remains when every other vestige of the magnificent plant from which it originated has been lost.

4. *On the* Thalassina Emerii, *a fossil Crustacean, forwarded by* Mr. W. S. Macleay, *from New Holland.* By T. Bell, F.R.S., Professor of Zoology in King's College, London.

This fossil, forwarded from Mr. Macleay and brought by Lieutenant Emery from Australia, belongs to the typical genus of a very remarkable family of decapod Crustacea, the *Thalassinidæ* (*Thalassiniens* of Milne Edwards), as Mr. W. S. Macleay has surmised. Of the genus in question, *Thalassina*, but a single recent species is known, and little has been ascertained respecting its habits. There is, however, reason to believe, that in this respect it agrees with the species most nearly allied to it in structure, several of which being found on our own coasts have afforded opportunities for more accurate observation. These, as far as their habits have hitherto been traced, are all of them burrowers, making their way to a considerable depth in the sand at various dis-



Thalassina Emerii *Bell.*

a. View of the under side, showing the tail turned over upon the belly.
b. Side view.
c. End view, showing the rostrum only.

tances from the shore. The species of the genus *Gebia*, which is very nearly allied to the present, are all to be obtained by digging in the mud or sand at low tide; and the *Gebia stellata*, as stated by Dr. Leach, form subterranean, horizontal, and winding passages, "often of a hundred feet or more in length." The same habit is also known to belong to Callianassa, another nearly allied genus.*

The recent species of the genus to which the fossil belongs, *Thalassina scorpioides*, is stated by Leach†, Desmarest‡, and others, to be a native of the Indian seas. Milne Edwards on the other hand gives the coast of Chili as its habitat. It is not impossible that it may have been found in both these localities; a specimen which I have in my possession was said to have been brought from India, but of this I have no positive evidence.

The fossil, which I propose to designate, after its discoverer, *Thalassina Emerii*, consists of the sides of the carapace, in tolerable preservation, the dorsal portion being quite lost; the first four

* The structure of these animals is adapted only for this mode of life, and is exhibited typically in the present genus. The narrow semicylindrical abdomen, the attenuated lateral lobes of the tail, and the filiform appendages of all the abdominal segments, evidently unfit them for swimming; whilst their fossorial habits are amply provided for by the strength and flatness of the two anterior pairs of thoracic limbs, which are admirably adapted for excavating the sand or hardened mud in which they reside.

† Zool. Miscell. iii. Mal. Brit.

‡ Consid. Gener. Crust. Dict. des Sc. Nat.

joints of the first and second pairs of legs are tolerably perfect; of the third and fourth pairs the basal joints alone remain, and the fifth pair is lost. The whole of the abdomen, with the exception of the third segment, is very perfect; it is abruptly bent forward upon itself, the terminal joint resting beneath the thorax, between the third and fourth pairs of legs (*fig. a*). The rostrum also is very perfect, broken off from the carapace, and lying vertically between the anterior legs (*fig. c*). It is prolonged into a grooved triangular tooth, and there is a small prominent tubercle on each side, at a short distance from it. The raised lines, circumscribing the rostral tooth, are continued backwards to some distance, as is also its deep median groove. A second raised line is continued backwards from the small denticle, or tubercle, on each side.

The similarity between this species, as far as the state of the fossil will allow of the comparison, and the recent one, is so great, that there is some difficulty in fixing upon valid distinguishing characters. It differs, however, in the proportion of the epimeral or lateral portions of the abdominal segments, which are somewhat less developed in the fossil than in the recent species, and in the form of its terminal segment, or middle lobe of the tail, the length of which is to its breadth in the fossil as 8 to 6, and in the recent species as 11 to 6. The sides of the carapace are, in the former, somewhat more uniformly covered with minute raised points, which, in both species, render the surface bistinctly scabrous.

This specimen derives additional interest from its being the only fossil crustacea which has yet been found in New Holland.

March 6, 1844.

The following communications were read :—

1. *On Two Fossil Species of* Creseis (?) *collected by Professor* Sedgwick. By E. Forbes, Esq., F.R.S., F.L.S., Professor of Botany in King's College, London.

Creseis is a genus of *Pteropodous Mollusca* established by M. Sander Rang to include several species of simple, more or less acicular shells. Their surface is smooth or transversely striated, rounded, and sometimes presenting a longitudinal groove. The animal resembles that of *Hyalæa*, but is not furnished with the two caudiform lateral appendages with which the *Hyalæa* is provided. All the species are small, none being more than an inch in length. They are oceanic animals, free swimmers, and their remains are found in abundance in the fine mud of great depths.

Certain Palæozoic fossils, which have hitherto been confounded with *Orthoceras*, but which present no traces of chambers, and in other respects bear a close resemblance to the shells of *Pteropoda*, appear to belong to the genus *Creseis*, though gigantic in comparison with existing forms. Both the species now described and figured were obtained from the Denbighshire flag-stones.

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1. *Creseis primæva.*

Very long, linear, dilated towards the oral extremity, smooth or with indistinct traces of longitudinal grooves.

Length of specimen (nearly entire) 8 inches.
Breadth at the aperture $\frac{10}{12}$ in.
Medium breadth $\frac{7}{24}$ in.

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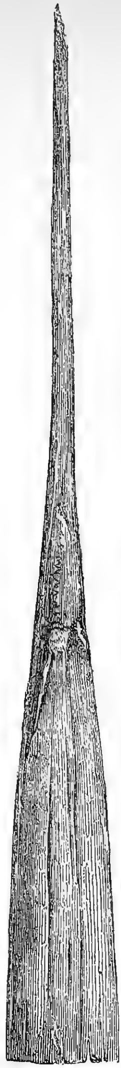
2. *Creseis Sedgwicki.*

Shell cylindric, tapering, linear, marked with very numerous fine, regular, transverse striæ. Aperture dorsally angular.

Length of fragment $\frac{18}{12}$ in. [Probable length of specimen, $4\frac{1}{2}$ inches.]
Breadth at aperture $\frac{5}{12}$ in.
Medium breadth $\frac{7}{24}$ in.
Breadth at the aperture of another fragment $\frac{8}{12}$ in.



1.

2.

1. Creseis primæva *E. Forbes.*
2. Creseis Sedgwicki *E. Forbes.*

2. *On the* Geology *of* North Wales. By Daniel Sharpe, Esq., F.G.S.

[The notice of this memoir is postponed.]

March 20, 1844.

William Pole, Esq., A.C.E., Professor of Engineering at Elphinstone College, Bombay, and Frederic Joseph Sloane, Esq., of Florence, were elected Fellows of this Society.

The following communications were read:—

1. *On* Fractured Boulders *found at* Auchmithie *near* Arbroath. By W. C. Trevelyan, Esq., F.G.S.

In a visit paid to the coast of Forfarshire in the summer of 1840, I observed, for the first time, at Auchmithie, near Arbroath, at the foot of a cliff consisting of old red conglomerate, some pebbles and boulders which had fallen from the rock above, and which, from their remarkable fractures and contortions, attracted my attention; and being in the same neighbourhood in the autumn of 1843, I found in the same spot many more specimens of the pebbles, some lying at the foot of the cliff and others remaining in their matrix.

Subsequently, in the picturesque conglomerate rocks at Dunottar Castle, near Stonehaven, I discovered similar appearances; but, in this instance, the pebbles were much larger, and the fractured ones even more abundant than in Forfarshire.

At Auchmithie, the pebbles which predominate in the conglomerate consist of granite, porphyry, gneiss, jasper, and reddish quartz—those of the quartz being chiefly abundant. Of most of these different kinds of pebbles, fractured specimens may be found.

The conglomerate is traversed by veins of carbonate of lime and sulphate of barytes; and it is in the neighbourhood, or in the actual course of these veins, that the fractured pebbles in many instances occur. Sometimes the parts of a pebble traversed by one of these fissures are faulted by it, and have their levels displaced to the distance of several inches. Thus it appears that the formation of the fissures and the fracturing of the pebbles have been contemporaneous.

It is to the bent appearance of some of these pebbles, and the appearance of their having been softened and the broken parts re-united as if by pressure, that I am desirous more especially to direct attention. These fractures, contortions, and adhesions, appear to be the effect of violent mechanical action and of heat.

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2. *On the Origin of the* Gypseous *and* Saliferous Marls *of the* New Red Sandstone. By the Rev. D. Williams, M. A., F. G. S.

For years past I have had great difficulty in accounting for the marls of the new red sandstone, and as none of the explanations yet given appear to me sufficient, or satisfactorily account for the absence of molluscous and zoophytous remains in these beds, and still less for that of the numerous plants entombed above and below them, I propose in the following observations to attempt to explain these phenomena, in the hope, to use the words of Sir H. Delabeche, of arriving at the "knowledge of the true causes which have produced" the remarkable aggregates in question. In examining the district of Bleadon with a view to account for the phenomena of trap rocks presented in the railway cutting*, I observed in the superficial coating of soil on the northern flank of the hill above Weston-super-Mare, such abundant fragments of vesicular trap, some of them having the aspect of recent volcanic scoriæ, others containing spherical kernels of decomposing calcareous spar and hæmatitic iron, that I entertained no doubt whatever that I was standing on a dyke of ancient lava. The occurrence of these fragments for about seventy-five yards, in an east and west direction, indicated its strike, and rendered it probable that the same appearance would recur in the neighbouring coast cliffs. Those brown, strange-looking rocks, therefore, with whose aspect I had been long familiar, were volcanic aggregates, and were, in fact, two of the most interesting and instructive of the large number which had fallen under my notice.

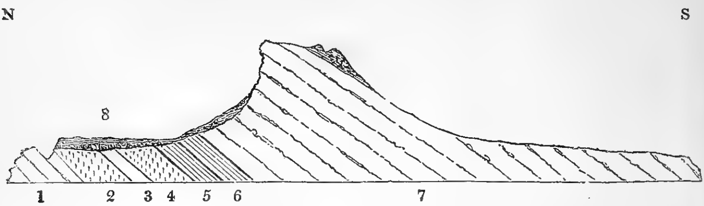
These trap rocks are perfectly distinct from each other, and the nether one abuts so closely upon the road which forms the common approach to the coast below the cliffs, that no geologist passing could fail to see it,—indeed, could scarcely avoid touching it; though, like myself, every one had hitherto failed to remark upon it. In truth, the lower trap so intimately resembles a brown sandstone, and the upper one has so much the aspect of a mass of the ordinary red marl with imbedded pebbles, and, at the most accessible approach, is for the most part so truly a red marl, that the circumstance of its having hitherto escaped notice is not surprising.

Every bed in the series is, however, so unequivocally disclosed, and so readily accessible along the shore, that no doubt whatever can be entertained of their several positions. I propose to describe them briefly in ascending order, as seen in the subjoined section.

* See *antè*, p. 293.

SECTION through the Western Extremity of WORLE HILL.

Horizontal base, ¼ mile.



No. 1. is the ordinary grey mountain limestone, dipping S. S.W. at an angle of 35°.

Resting upon this, and dipping at the same angle and in the same direction, are the lower beds of No. 2., consisting of an indurated, red, fine-grained marl, which is succeeded by softer and more marly shales. The harder varieties contain the *Turbinolia* (*Cyathophyllum*) *fungitis.* Overlying these are beds which have the appearance of a dull brown sandstone; but which the eye, assisted by a magnifying lens, discovers to be a congeries of minute, red and brown, concretionary, oolitic granules, loosely cemented together by a green, filmy substance, imperfectly filling up the interstices. It acts like a file on the nail, but yields, when triturated, a fine red powder. It effervesces briskly with acids; and near the overlying bed No. 3., it contains shining facets of plates of a minute encrinite. This series, so far as I could measure it, is from 20 to 25 feet thick.

No. 3. lies conformably to No. 2., and commonly consists of a pale red, crystalline limestone, sometimes of a bright flesh colour, with small crinoidal plates and stems. Its upper surface is often grey and crystalline, and shows but little alteration from the trappean mass, No. 4., which rests immediately upon it. It dips S. S.W. 35°, towards its outcrop, but not so much below.

No. 4. is an amorphous mass of red trappean marl, about 30 feet thick, containing numerous globular, angular, and irregularly-shaped concretions, many of them standing in high relief out of it. They are of very varying forms and dimensions, from the size of a pullet's egg to four or more feet in diameter; and all of them attest their volcanic origin, more or less, by the greater or less abundance of air cells, now filled sometimes by spherical crystals of calcareous spar, and more rarely by red hæmatitic or steel-grey iron ore. Sometimes these concretions are slightly vesicular, but at others they are more abundantly so than any trap rock I remember; and where the original air cells have been left void by the decomposition of the lime and iron, the matrix cannot be distinguished from a recent volcanic scoria. These lump-looking, angular, and concentric spheroidal concretions, are distributed irregularly through the softer marly mass. They all have a variegated or red-marl-like basis, and pass insensibly from the most indurated and tough varieties into a friable red marl. The more typical marly variety is often of a globular, concretionary structure, and is composed of concentric layers, which are variegated red, buff, and pale green in colour, and are so friable that, under a slight blow of the hammer, they crumble into small cuboidal or polygonal fragments. The intermediate varieties are characterised by different degrees of induration. Most of them are rather tough than hard, and towards the western extremity of the trap have the aspect (but evidently not the mineral structure) of some of the Lizard serpentines; and throughout the exposed range of this ledge for about a hundred yards, both the hardest and most friable varieties are traversed by numerous veins of red and white fibrous gypsum, or of fibrous gypsum and calcareous spar.

The softer and more friable variety is best seen at the Dripping Well (a broad chasm in the neighbourhood), where it has been raised beyond the reach of the sea. It is there intersected by numerous fine lines of fibrous gypsum and calcareous spar. A little to the west the entire bed has been exposed to the action of the waves; but a prominent serrated ledge, in advance of the cliffs, marks the continuation of the harder and more crystalline variety further westward, for the distance of about a hundred yards.

No. 5., which rests conformably upon the last bed, is a pale red quartz rock, exactly like the red quartz rock of the Hotwells and Brandon Hill, near Bristol, which has been supposed to represent the millstone grit of the northern counties.

No. 6. is much the same as the last; but is more calcareous.

No. 7. is the ordinary grey mountain limestone. Some of its beds, on the shore, are parted by a red marly substance, similar to that of the trap rock, No. 4.

No. 8. is apparently a raised beach. It consists of sea sand, aggregated together into a tough compact mass by calcareous infiltration, and rests on an accumulation of stones so imperfectly rounded as to be neither a conglomerate nor a breccia. The sand itself has the character rather of the sea sand of Cornwall than of the sand of Uphill and of the other adjacent bays, containing, as it does, a considerable proportion of highly comminuted shells.

With regard to the trap rocks, there can be no doubt that they were ancient lavas, erupted, at two distant periods, over the floor of the sea, while the mountain limestone was in process of formation; the interval of duration between them being indicated by the interposed bed of limestone, No. 3., of which duration it is the measure. But where did the trap come from, and how was it generated? If I could not appeal to the case of the Bleadon cutting, as sufficient proof of its having originated in the fusion and conversion of mountain limestone and other underlying deposits, there is a natural section close at hand which might help us to the solution of the problem. The effects of exposure have here considerably effaced the evidences which the cutting through the rocks at Bleadon disclosed so admirably; but I found no difficulty in at once recognising them.

In the memoir already referred to, I mentioned that the cracks or joints and irregular hollows were filled with a variegated marly substance; and at Weston I noticed the face and joint walls of the limestone bed to be deeply eroded by many of the same deep cavities, in all kinds of positions; and, in several cases, the joint walls are even now red and discoloured. In two instances, one of an open joint, the other a cavity, they were filled by the same variegated red, buff, and grey laminated marls that I had met with at Bleadon. Several of the cavities show, internally and on their edges, a strikingly rough and irregular outline. They are all of them many feet above the highest spring-tide level, and are often so overhanging or highly inclined that stones could by no possibility be contained in them; and the other limestone beds exposed along the coast exhibit nothing of the kind. The lower portion of the bed is hidden by an artificial platform of stones; but evidences enough remain, within the space of a few feet, to indicate the circumstances under which these trappean marl rocks were generated, and of the date when they were erupted. A north and south fissure, which has riven asunder the beds marked 2, 3, and 4. on the section, and which is partly filled at the bottom with a hard red marl, was probably the vomitory through which the upper trap was ejected.

Two instances of trap rocks, of the same mineral composition, one generated *in situ*, the other erupted, with the effects produced by both on the immediately adjacent rocks, are rarely perhaps to be met with so well disclosed and in so short a distance as in the case between the Bleadon cutting and the cliffs of Weston.

In using the terms fusion and conversion, I wish it to be distinctly understood that I never supposed that any one elementary earth or substance could be converted into another: such as that lime, for example, could become silex. I contend, only, that the limestone has been converted into trap, volcanic mud, or marl, as the case may be; and I entertain little doubt that a chemical analysis of these would show that the mineral constituents of the former existed in the latter; though, no doubt, in different, and, perhaps, very varying proportions.

I will conclude with one more remark on the immediate subject of this communication. The association of variegated marls, salt, gypsum, and magnesian limestone in various places at different geological levels appears assignable to some one cause which has been common to all. When, therefore, we mark the close analogy, the identity in many respects, of these peculiar aggregates with a variegated, gypseous and apparently magnesian marl, which is incontrovertibly a volcanic product, we may be supposed to have ascertained the common origin of both; and instead of multiplying causes, we ought rather to class them among the formations which owe their origin to volcanic action.

These gypseous marls, more or less adjacent to, and (as I consider) derived chiefly from the elevated and dislocated mountain limestone, are, in many respects, analogous to the crystalline and clay slates among the more disturbed grauwacke and other districts; and I entertain no doubt that other rocks referable to the same origin will be found accompanying such dislocated strata as are traversed by igneous rocks, to a greater or less amount, whatever the age of the strata may be.

April 3, 1844.

John Wilson, Esq., of St. John's Wood; Andrew C. Ramsay, Esq., of the Ordnance Geological Survey; and Charles Pope, Esq., of Temple Cloud, Somerset, were elected Fellows of this Society.

The following communications were read:—

1. *On the Occurrence of* Fossils *in the* Boulder Clay. By Robert Harkness, Esq., of Ormskirk.

There can be no doubt that the presence or absence of fossils in different formations is owing to other causes than the actual existence of animals and vegetables on the spot and at the time of deposition, and is, indeed, generally the result of local circumstances; but the "boulder clay," the formation of which the author of the present paper endeavours to explain the cause, presents similar characters in districts widely distant, and is also remarkable for the paucity of its organic remains.

The deposit in question belongs to the geological period immediately antecedent to the existing epoch, and consists of clay containing boulders of various kinds of rock, scattered without order through its whole mass. It occurs on various parts of the coast both of Great Britain and Ireland, but appears to be most fully developed in the basin of the Clyde, where it overlies a series of beds of fine clay containing numerous remains of shells. Similar remains have been found in many elevated sea beaches; and it has been concluded from the examination of them by competent naturalists, that the climate must have been more arctic at the time of their deposition than it is now in the places where they are found.

The author of this communication, referring to the known increase of temperature of the earth at increasing depths, and the law of change of temperature in the ocean at certain depths, thinks it possible that, although the land was exposed to intense cold, the sea might yet have contained certain animals requiring greater warmth which may have lived at considerable distance from the surface;

and he thinks it probable, for this and other reasons, that the deposit of the boulder clay was formed in a deep sea.

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2. *On the Traces of the Action of* Glaciers *at* Porth-Treiddyn, *in* Carnarvonshire. By Robert W. Byres, Esq.

Map of the supposed Path of the Glaciers from Snowdon.

a. Moel Hebog.
b. Moel Wyn.
c. Bedd Gelert.
d. Pont Aber-glas-lyn.
e. Brynteg.
f. Tremadoc.
g. Portmadoc.
h, h. Traeth Mawr.
i. Traeth Bach.

The following notice, bearing date the 16th of October, 1841, appeared in the Visitors' book at the Goat-Hotel, Beddgellert:—"Notice to Geologists.—At Pont-aber-glas-llyn, 100 yards below the bridge, on the right bank of the river, and 20 feet above the road, see a good example of the furrows, flutings, and striæ on rounded and polished surfaces of the rock, which Agassiz refers to the action of glaciers. See many similar effects on the left, or south-west, side of the pass of Llanberris. William Buckland."

This notice led me to search for the same effects in other places in the same neighbourhood, and I found similar traces on many of the rocks between Aber-glas-llyn bridge and Tremadoc. In February last curiosity led me into the Flag-quarry, which lies about 300 yards from the mail-coach road, at Porth-Treiddyn; and for the purpose of examining the joints and split of the rock, I ascended from the quarry to the top, where a space of ground had been cleared of the soil and detritus, preparatory to further quarrying. Here I was much struck by the polish and undulations of the surface of the rock; and a detail of my examination of these phenomena will leave no doubt, I think, that they are attributable to the action of glaciers.

The slope of the mountain at Porth-Treiddyn is to the north and north-east; and the dip of the rocks is in the same direction, at an inclination of from 17° to 22°, but the angle increases as you ascend.

At the spot which had been cleared, above the quarry, the detritus lying on the surface of the rock was from five to twelve feet thick. It consisted of various soils and gravel, of blocks of rock similar to the flags, and of boulders of porphyry and greenstone, in some of which the felspar crystals were very distinct. Some of these boulders were from three to four feet long, and from two to three feet in diameter.*

It is here, especially, that we have presented to us a perfect type of the glacier action. The surface of the uncovered portion of the rock, where it has not been disturbed by the workmen's tools, is rounded and polished in the most extraordinary manner. The surface is furrowed; and the furrows, where the rock is uneven, are from 1 to 2 feet deep, with their edges beautifully rounded off. On the broader slopes, striæ are very distinct. With a few exceptions, which I shall presently take occasion to notice, the furrows, striæ, scoops, grooves, and undulations, all shape their course, not in the direction which water would take, that is to say, in the direction in which the mountain slopes, northwards; but in a diagonal or slanting direction, towards the valley of the Glaslyn, that is to say, towards the east or north-east.

There are a few channels, from 1 to 2 feet deep, which run in a north-westerly direction; these channels appear to have arisen from the form of the rock compelling the superincumbent glacier, with its included blocks, to move that way, until the obstacle was overcome, when the moving mass resumed its original course.

With this example of glacier action for our guide, other places where, from lapse of time combined with other causes, the traces of that action have become somewhat obscure, and might consequently appear doubtful, will be regarded as affording clear evidence that there also the same cause has been in operation.

The same phenomena are traceable from Porth-Treiddyn higher up the mountain, to the very top, which is rather more than half a mile from the spot where these effects are first visible. In cutting the new road to the quarry, many rocks have been exposed, which show, by their polished faces, that the whole side of the mountain has been acted on.

* On the southern side of this mountain, and very much below the level of the quarry, may be seen broken and but seldom rounded masses of these rocks, in which felspar, hornblende, and shorl are disseminated.

Where light and air have acted, much of the delicacy of the cutting has been obliterated; besides which the surface is covered, in part, with heath and lichens. Notwithstanding these disadvantages, the most beautiful example of the power of a loaded mass, when making its way in a slanting direction, is to be seen on the high road, at the commencement of the new road to the quarry, exactly within the gate-posts. In this place, the more delicate striæ are visible, with the flutings and furrows; and these are cut in such a manner as to show that the pressure was downwards, the action slow, and the motion irregular; and in places where I have removed the moss and heath, the surface has a tolerable polish, readily perceived by any one who has seen the upper quarry. In this spot occurs an example in proof of slow action, in the work of grooving the rock. Two semicircular grooves, about an inch deep, and about a foot apart, proceed parallel to one another for some distance, when they gradually curve round and then meet, and one of the grooves proceeds onwards from the centre downwards. The form of the grooves may be represented by the letter Y. Here, as in other places, it is evident that the cutting substance changed its position, and for a time remained stationary, though still continuing its grinding action, since a cup or cell has been formed to a greater depth than the fluting above or below.

With so perfect a type as that of Porth-Treiddyn, of what Agassiz refers to glacier action, I have been enabled to trace that action at various other points in Carnarvonshire between Tremadoc and Aber-glas-llyn bridge, and also on the other side of the Glas-llyn river in Merionethshire; but the furrows and other striking peculiarities are not so evident in these other localities as they are at Porth-Treiddyn.

In the space represented in the drawing, glacier action may be observed,—

1st, at the town rock, immediately above the village of Tremadoc:

2dly, at the farm-yard:

3dly, at Porth-Treiddyn, already noticed:

4thly, at a point by the road side, where there occurs a perfect sample of polished rock. This lies a little beyond the rock-crystal quarry, where tabular crystals of titanite, called brookite (if I remember rightly) were procured.

5thly, at a point near Brynteg.

Beyond Brynteg, towards Aber-glas-llyn bridge, many other examples of glacier action may be seen, which are those referred to by Dr. Buckland.

In the foregoing remarks, I have confined myself to an extent of 6 or 7 miles; but I know that there are other cases, which at some future day I may explore; and I will now conclude by saying that I have attempted to describe one of the greatest curiosities in the country, which will amply reward, by its inspection, all lovers of geology.

3. *On the Existence of* Fluoric Acid *in recent* Bones. By G. Owen Rees, Esq., M.D.

The author in this communication wished to direct the attention of geologists to the experiments connected with the presence of fluoric acid in bones that have undergone no change consequent upon fossilisation. He states that in the experiments he made, the bones were tested both before and after calcination, but that there was nowhere the slightest indication of fluoric acid in recent human bones, although immediate evidence of its presence was obtained when fossil ivory was submitted to examination.

The analyses of fossil bones have, according to Dr. Rees' statement, shown the existence of a very large proportion of fluoride, in some cases as much as 10 or 15 per cent., which is an enormous increase on the largest proportion ever declared to exist in recent specimens. He argues, therefore, that since so much of the fluoride of calcium is introduced in fossilisation, the whole may have been.

He concludes by alluding to the unsatisfactory state of the question at issue, namely, whether the bone and ivory while undergoing the process of fossilisation have their phosphoric acid transmuted, or whether a fluoride exists undetected in the soft parts of animals, which during their decay decomposes the earthy salts of the bones.

April 17, 1844.

H. B. Mackeson, Esq., of Hythe, and Sir Thomas Edward Colebrooke, Bart., of Colebrooke Park, were elected Fellows of this Society.

The following communications were read:—

1. *Observations on the* Geology *of the Southern Part of the* Gulf of Smyrna *and the Promontory of* Karabournou. By Lieut. T. Spratt, R.N.

The observations contained in this paper continue the subject from the point at which it was left by Messrs. Strickland and Hamilton in their memoir on the geology of the neighbourhood of Smyrna*, and relate to the western boundary of the lacustrine deposits which lie to the south of the town of Smyrna, forming and in part surrounding the plain of Sedi-kieui; so called from a village of that name situated on its western margin.

Immediately over the village there rises a series of ridges, flanking a high mountain that forms one of the principal features in the arm of land which separates the two gulfs of Smyrna and

* Geol. Trans. 2d ser. vol. v. p. 393.

Ephesus. This mountain was the Corax of the ancients, and attains a height of nearly 4000 feet, stretching from shore to shore on both sides of the peninsula.

The north face of this mountain is channelled by deep ravines, and the intervening ridges attain a very considerable elevation, almost to their terminations; so that the whole mass rises abruptly out of the plains and from the shore at its base.

In lithological structure these ridges consist of dark-coloured shales and schists, which dip at high angles (from 30 to 50 degrees) round the central and most elevated part of the mountain, but the rocks which compose this central nucleus I had no opportunity of observing.

At the mouth of one of the deep valleys, descending from the summit of the mountain, is a hot bath, the position of which is marked on the map.* Besides the spring which supplies this bath, several hot jets of water rise through the sand in the bed of the torrent in the ravine, in one of which the thermometer stood at 150° Fahr.; and very lately in an attempt to sink a well through the alluvium of the adjoining plain at the base of the mountain, springs of hot water were met with at about 10 feet below the surface, so that there appears to be a considerable supply of heated water which deposits some mineral (apparently sulphur), and escapes by a subterranean course.

As the schists and shales appeared to be best developed in the sides of the deep valley which opens behind the hot springs, I ascended it for about four miles. Its sides were steep and precipitous, and I observed that the rocks consisted of a series of brown and greenish shales and schists, interstratified with quartzose grit and a hard sandstone, composed of particles of quartz and mica. Sometimes compact siliceous strata occur; and not unfrequently beds and nodular masses of jasper, as well as crystalline limestone. At the mouth of the ravine the dip was 35°; about a mile above increased to 50°, and two miles further, in contact with some igneous protrusions, the schists, &c., are nearly vertical. The volcanic productions in this neighbourhood appear to be of three kinds, and occur near each other, within the space of 200 or 300 yards, in the form of dykes, from 10 to 20 feet broad. In contact with the igneous rocks the shales were much more indurated than usual, and of a redder appearance on the exposed surfaces. Beyond the dykes the beds assume their former dip of 50° to the N.N.W.

These shaly and schistose deposits must be of very considerable thickness; at least a thousand yards of them being exposed between the mouth of the valley and the point to which I ascended; and, from what I was able to judge, they appeared to extend as far again, but I could nowhere discover a single trace of organic remains.

The next part I examined was a ridge about three miles to the

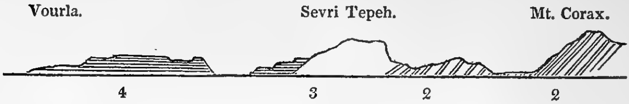
* See the map accompanying this memoir.

west of the Hot Bath Valley, on the summit of which stand two remarkable peaks, known by the name of the Two Brothers. These peaks, although separated only by a few hundred yards, consist of detached masses of a grey semi-crystalline limestone, of about 300 feet in thickness. A chain of calcareous matter, of variable thickness, may be traced through the whole mountain to the south-west, following the line of stratification; and being more durable than the associated shales, the harder rocks stand up in isolated points above the wasted strata in which they are embedded, and with which the stratification of the limestone is always conformable.

They are, however, split and shattered by numerous transverse fissures, which at a short distance appear like lines of stratification. In the shales which underlie these rocks occur calcareous laminæ as well as calcareous nodules, varying in size from that of a nut to that of an orange. The shales are here very friable, and of a pale chocolate or cream colour, like those at the foot of Mount Pagus, near the Caravan Bridge (mentioned in the memoir of Messrs. Strickland and Hamilton), and they contain crystals of a mineral which appears to be garnet. These shales are 300 or 400 feet in thickness, and below them others which are indurated are found in the valley above the hot baths.

At the western base of Mount Corax is a low isthmus crossing between the gulf of Smyrna and the bay of Sighajik, which separates the mountain from the district of Vourla. The greater part of the isthmus is an alluvium of gravel, covering the schist and shales; but on the opposite side of the isthmus these latter rocks reappear, dipping at the same angle as in the foot of Mount Corax (45° to W.N.W.), passing into a ridge of limestone, semi-crystalline, and greatly resembling the limestone of the Two Brothers; the crystalline condition, however, being in neither case due to any immediate contact with volcanic eruptions. The limestone now continues throughout the promontory in peaks and ridges, whose height varies from 1000 to nearly 4000 feet. Near the shore, on the west side of the isthmus, rises one of these peaks, which is sharp and conical, and crowned by an ancient fortress. On its western base repose, in a horizontal position, compact white calcareous strata and greenish marls, identical with the fresh-water deposits described by Messrs. Hamilton and Strickland as existing in the vicinity of Smyrna. These deposits occupy a considerable district round the modern town of Vourla, as well as in other parts of the Promontory of Karabournou and the islands within the gulf, and they are indicated in the map by the yellow colouring. Of the lacustrine origin of this formation there is the fullest evidence, from the number and variety of fresh-water shells which are found imbedded in the different strata, and in the probably contemporaneous fresh-water basins of the interior of Asia Minor. In some localities the fossils are very abundant, as on the road to Vourla, about two miles to the east of the town, and in the small islands which form the anchorage of Vourla.

Section from the Vourla Basin to the foot of Mount Corax.*



The lacustrine deposits surrounding Vourla extend to the head of the Gulf of Gul-bagtcheh on the west, but the promontory jutting out towards the Vourla Islands is divided across by a hill of brown trachyte, which separates the fresh-water formations at the extremity of the promontory from those in the Vourla basin, and has evidently overflowed the intermediate portion of the bed of this ancient lake. The adjacent islands present phenomena resembling those observed in the neighbourhood of Smyrna, and originated, most probably, at the same period. A vast eruption of volcanic matter seems here to have burst through the bed of the ancient lake, uplifting the sedimentary matter deposited in it into hills and islands, which vary from 100 to 600 feet in height.

The two northern islands, Long Island and Keelsali, consist almost entirely of porphyritic trachyte and of a white tufa; but the small islands to the south are principally composed of the fresh-water deposits in contact with, and frequently disturbed by, similar igneous productions, offering clear evidence of their later origin. These volcanic ejections form part only of a chain of similar eruptions which extends to the north, nearly in a straight line, as far as the Gulf of Adramitti.

The fossils from the Vourla Islands have been examined by Professor Edward Forbes, and are described in a note appended to this memoir.

The Karabournou promontory consists of a high central table mountain of grey limestone, along the east and north base of which runs a narrow strip of the calcareous and marly series, the bed, no doubt, of an ancient lake which formerly occupied the whole Gulf of Smyrna, and, perhaps, the whole archipelago. The limits of this lake are indeed as yet undefined, but there are indications of it in the Scio and Mitylene channels, where it ranges at the foot of the higher hills along the present sea-coast, as on the east side of Karabournou. I obtained fossils (Paludina) proving its fresh-water origin at the very northern extremity of Cape Karabournou, and a few yards only from the sea.

On the western flank of the high central table of limestone lies a broad chain of hills, composed of shales and schists, which correspond with those of Mount Corax. They dip to the east and

* The references both to this and the other sections are as follow :—

4. Fresh-water beds. 2. Shales and schist.

3. Limestone. 1. Erupted trap and serpentine.

E. S.E., at an angle of from 45° to 60°, and, in both cases, pass beneath the intermediate mass of limestone which occupies the entire district between them. The limestone is, in general, a grey compact rock, but is sometimes crystalline, as, for instance, near Ritri, anc. Erythræ, at a spot noticed by Mr. Hamilton. The crystalline condition is probably due in this spot to the proximity of recent volcanic ejections of trachyte, &c., which occur abundantly in the neighbourhood.

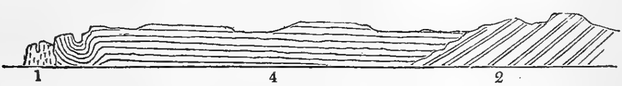
In the western part of the Karabournou promontory are found also igneous rocks of two periods, the one antecedent and the other subsequent to the date of the lacustrine formations. The former is presented in a hill of serpentine, several hundred feet in height, near Cape Koumour Baba, the northern extremity of the promontory, and upon its sides rest in undisturbed succession the parallel layers of the several calcareous strata and marls deposited at the bottom of the lake; the shales in contact have been much disturbed and altered, and are indurated into slate hardly distinguishable from slates of the older rocks. The trap rocks of the latter period occur in four localities, in each of which they differ in their mineral composition: the first is found on the shore opposite to the Island of Sahib, and its intrusion has evidently accompanied the disturbance indicated by the considerable dip of the adjacent lacustrine deposits. The trap contains numerous small drusy cavities, in which is always found a singular fibrous mineral.

The lacustrine deposits correspond exactly with those of Vourla and of Smyrna, both in colour and mineral arrangement. In the island of Sahib there are some good specimens of pisolite, interstratified with the calcareous portion of the deposit.

Sahib Island.

The above section exhibits portions of the whole series of rocks noticed in this paper. It illustrates the different ages of eruption and deposition; and commencing near the coast, about two miles to the west of Cape Koumour Baba (marked A on the map), it terminates at Sahib Island (marked B).

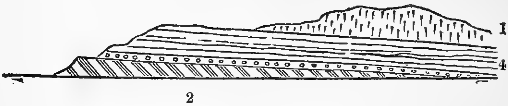
The next trappean rock is a peaked mass protruding from beneath the tertiary sediments at Cape Koumour Baba. These rocks are much contorted at the point of contact, but with the exception of appearing a little more indurated, they are not otherwise altered.



The above diagram exhibits a section presented in the cliffs that extend from the Cape about a mile to the westward, where their height is about 140 feet.

This section is exhibited in a line, drawn north and south, from the Cape to the serpentine hill, and goes through the fresh-water deposits. In this locality I procured one of the Paludinæ.

Following the coast down on the west side of the promontory, good sections of the shales and schists continue to be presented at every headland; but a few feet above the shore, under the village of Kutchuk Baghcheh, a small detached portion of the lacustrine deposit is again met with, extending for about half a mile in length and overlaid by a stream of brown trachyte, shown in the subjoined section.



This trachyte is similar to that which Mr. Strickland has remarked as occurring near Bournabat, and at Mount Pagus, above Smyrna. The trachyte contains fragments of an older basaltic rock imbedded in it.

The fourth example of the eruption of trappean matter is near the N.W. point of the bay of Erythræ, and is shown in the annexed section, which also indicates the relative superposition of the shales and limestone. The only difference between the former and those of Mount Corax is, that in the Karabournou district there is a larger proportion of jasper interstratified with the shales and schists. In every other respect it seems impossible to distinguish the rocks of the two localities.

Some time after making the observations in the Gulf of Smyrna above recorded, I had an opportunity of examining a portion of the coast opposite to Mitylene, near the islands of Adjano, where phenomena occur similar to those in the Gulf of Smyrna, viz. extensive trappean eruptions overlying portions of the lacustrine deposits, corresponding with those of Smyrna, Vourla, and Karabournou, and containing also black flints, as in all those localities, the identity being in every respect perfect. These beds, therefore, formed part of the great lake, although here the fossils were wanting. The trap forms a range of hills varying from 1000 to 2500 feet in height, extending from the Gulf of Sandarlic to the Mosco-nisi islands, at the bases of which the lacustrine deposits are occasionally visible. The largest portion of these is at Adjano, where the deposits dip under a high mountain of trachyte at an angle of 30°, the trachyte being stratified like that found near Smyrna. The tertiary hills on the margin of the Scio channel, near the town of Tchesmeh, and in the island of Scio opposite to it, seem also to be of fresh-water origin, as they closely resemble those of the Gulf of Smyrna.

The facts made out from these investigations tend to prove the former existence of a large lake in the eastern part of the Archipelago, where the sea now attains a very considerable depth*, and that subsequently a succession of volcanic eruptions on a grand scale took place over the bed of the lake. A long period of tranquillity must, however, have preceded these eruptions, during which 500 or 600 feet of a vertical series of beds had been deposited throughout the lake. By this sudden outburst of igneous matter, parts of the deposit were raised into hills of considerable elevation, whilst the accumulations of the heated and melted fluids poured over the bottom, formed mountains and high ridges of considerable extent round each focus of eruption. In the tertiary hills there is evidence of a denuding power at elevations above the present sea level.

Having carried this ancient lake into the depths of the Archipelago, the question then arises as to its former boundary, a question which extended observations only can determine.

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2. *Note on the* FOSSILS *collected by* Lieut. SPRATT *in the Fresh-water Tertiary Formation of the* GULF *of* SMYRNA. By Professor EDWARD FORBES, F.L.S.

LIEUTENANT SPRATT has found eleven species of fresh-water shells (all univalves) and a cast, apparently of a Helix, in the fresh-water limestone of Vourla.

Of these, two belong to the genus *Limneus*, one of which agrees with the *Limneus longiscatus* of the Paris basin and the Isle of Wight fresh-water bed, and the other is apparently the *Limneus ventricosus* of Brongniart; also a Paris basin shell.

Five species belong to the genus *Planorbis*. One of these is *Planorbis rotundatus*, a well-known eocene fresh-water fossil. Three are closely allied to, if not identical with, Paris basin fossils, and one is new.

Two belong to the genus *Paludina*. One of these appears to be the *Paludina atomus* of the Paris basin. The other is new.

One belongs to the genus *Melanopsis*. It is the *Melanopsis buccinoidea*, a species which, commencing its range in the oldest tertiary strata, has lived on to the present day, and is now a common inhabitant of western Asia, northern Africa, and the southern parts of Europe.

* At about five miles off the north extremity of Karabournou the depth is 100 fathoms, and continues to increase beyond.

One belongs to the genus *Melania*, and appears to be a new form.

On the whole, the evidence afforded by the fossils tends to show that the great fresh-water formation which skirts the Gulf of Smyrna and the coasts of many islands in the neighbouring portion of the Archipelago is of the age of the Paris basin and London clay. Whether the fresh-water tertiary basins of the interior of Asia Minor and of the valley of the Xanthus, and the islands of Cos and Rhodes, are of the same age, is very doubtful. Judging from the numerous fossils collected by Mr. Spratt and myself in those tertiaries, I am inclined to pronounce them of a different age and of later origin ; anterior, however, to the pliocene marine formations of Asia Minor and the Sporades.

I may add that Mr. Strickland, in his Memoir on the Geology of Smyrna, mentions a Unio, a Cyclas, a Helix, and a Cypris in the tertiaries of Bournabat which have not been met with by Lieutenant Spratt.

Impressions of the leaves of vegetables, too imperfect for determination, accompany the specimens laid before the Society.

List of the Fossils.

a. Planorbis Spratti *E. Forbes.*
b. Paludina Stricklandiana *E. Forbes.*
c. Melania Hamiltoniana *E. Forbes.*

1. *Limneus longiscatus* Brongniart.
   Many casts, not distinguishable from French and English examples.
2. *Limneus ventricosus* Brongniart ?
   The specimens closely resemble the recent *L. auricularius*. The spire appears rather shorter that it is represented in the figures of the French fossil, to which I have referred it.
3. *Planorbis rotundatus* Brong.
   Such specimens as retain the shell exhibit transverse sulcations of growth.
4. *Planorbis cornu* Brong. ?
   Specimens with the shell are spirally striated, like the recent *Planorbis similis*. Not having compared it with authentic French examples, I have marked this species with a query, though it closely agrees with the figures.
5. *Planorbis prevostinus* Brong. ?
   Too imperfect a specimen for certain identification.
6. *Planorbis planulatus* Desh. ?
   The inner whorls do not occupy so much space as they are represented to do in the French figures. It is closely allied to the recent *Planorbis nitidus*.
7. *Planorbis Spratti*, nov. sp. (woodcut, *fig. a*).


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5
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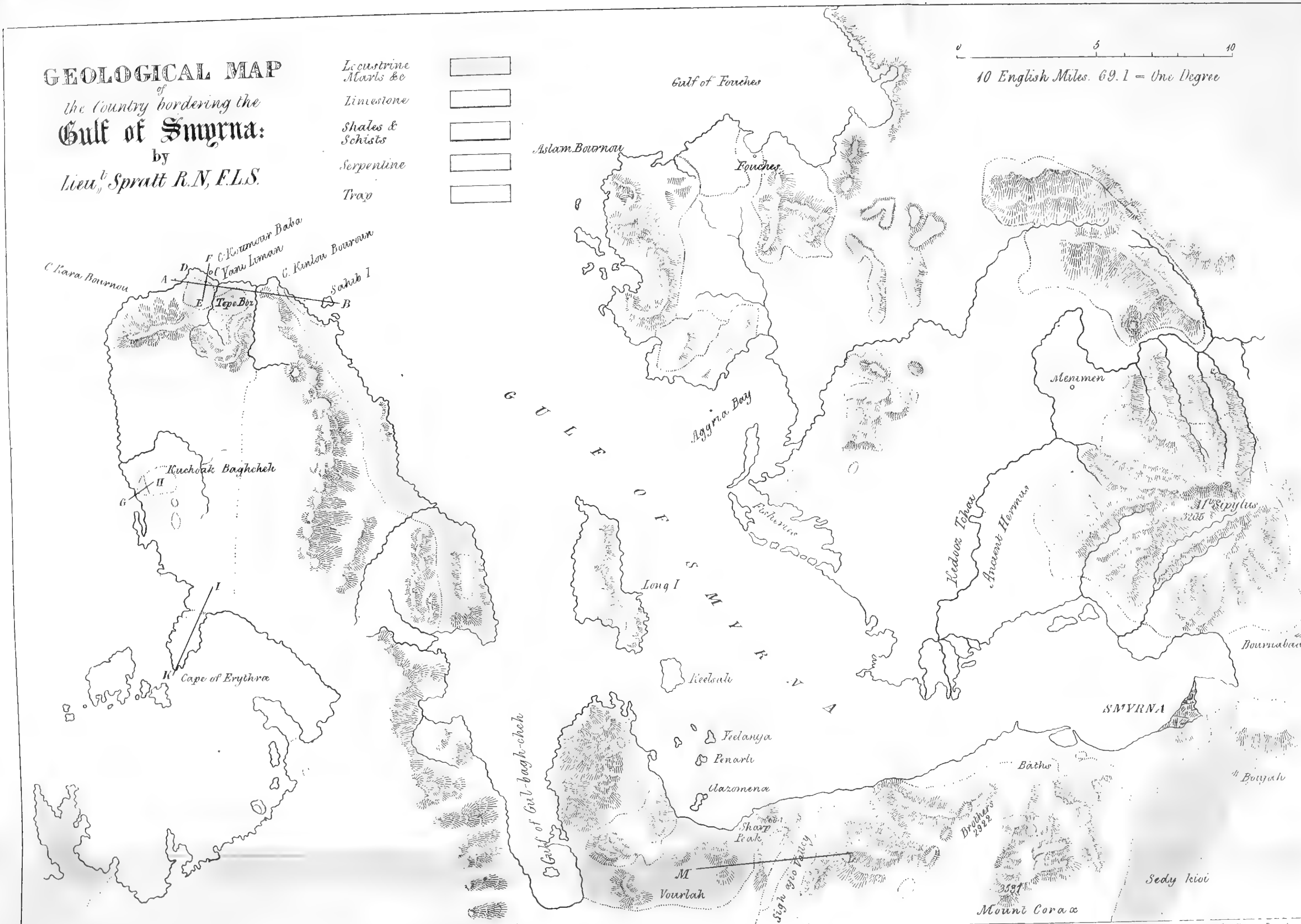
10 English Miles. 69.1 = One Degree.
Menimen
Mt. Sipylus
3205
Kedoos Tchai
Ancient Hermus



Printed by Reeve Brothers.

P. testâ discoideâ (lævigatâ), superne planâ, inferne profunde umbilicatâ; anfractibus crassis, superne angustis, quinis, subangulatis.

Lat. $\frac{2}{10}$. Crass. $\frac{1}{10}$ unc.

Closely resembling the recent *Planorbis contortus*, which represents this species in miniature. It is allied to the *Planorbis cylindricus* of Sowerby, from the fresh-water tertiaries of the Isle of Wight, but differs in the greater number of whorls, and their narrowness on the upper disk, which is very slightly concave.

8. *Paludina atomus* Brong.

A little Paludina, which appears to be identical with the Paris basin shell described by Brongniart under the name of *Bulimus atomus*, and rightly referred by Deshayes to the genus *Paludina*.

9. *Paludina Stricklandiana*, nov. sp. (woodcut, *fig. b*).

P. testâ globulosâ, lævigatâ, politâ, umbilicatâ; spirâ depressâ, obtusâ; anfractibus 3—4; *aperturâ ovatâ, superne angulatâ, marginibus crassis.*

Lon. $\frac{1}{10}$ unc.

A very minute but beautiful and distinct species, in form somewhat approaching Ampullaria. Its nearest ally is the *Paludina globulus* of Deshayes, a Paris basin shell, which is, however, imperforate, and not nearly so globose as the Asiatic species.

10. *Melanopsis buccinoidea* Auct.

A single specimen from the burying-ground in the island of Vourla.

11. *Melania Hamiltoniana*, nov. sp. (woodcut, *fig. c*).

M. testâ ovato-turritâ, anfractibus septem, lævigatis, longitudinaliter multocostatis, costis subsinuatis.

Lon. $\frac{1}{4}$ unc.

Apparently a very fragile shell, of which usually only the impressions remain. In sculpture it bears a close resemblance to a marine *Chemnitzia*.

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3. *On the Remains of* FISHES *found by* MR. KAYE *and* MR. CUNLIFFE, *in the* PONDICHERRY BEDS. By SIR PHILIP DE MALPAS GREY EGERTON, M. P.

THE fish remains collected by Mr. Kaye and Mr. Cunliffe in the neighbourhood of Pondicherry having been placed in my hands for examination, I have endeavoured to discharge the task committed to me to the best of my ability, by comparing the Indian fossils with analogous forms from other localities, and with the figures and descriptions given by Agassiz in the "Poissons Fossiles." The collection consists wholly of teeth; they are, generally speaking, in bad condition, few of the placoid teeth retaining their bases, a very essential element in the identification and description of species. Before proceeding to detail the characters of the several specimens, it may be advisable briefly to relate the results at which I have arrived from the study of these ichthyolites. With the exception of two specimens, the collection is entirely composed of teeth of squaloid fishes. Of these two exceptions one belongs to the Ganoid order and to the family of *Pycnodonts*, and it is probably a *Sphærodus*; the other is referred to the Cycloid genus *Enchodus*, the teeth very closely resembling those of *Enchodus* *halocyon*, a species common to the chalk of England, continental Europe, and North America. Of the Placoid remains, two species only belong to the section of the Squaloid family with serrated teeth, and both of them are referable to the genus *Corax*, which Agassiz informs us is restricted to the chalk. One species is not distinguishable from *Corax pristodontus* of the Maestricht beds. The other is undescribed. The Squaloid teeth with cutting edges compose the bulk of the collection. They are referable to at least a dozen species, all corresponding in the absence of plaits or striæ on the surfaces of the enamel. Although there are close approximations amongst them to the species both of the Cretaceous and Miocene period, yet it is somewhat remarkable that I have not seen a feature nor a character which recalls in the remotest degree the forms of the Eocene period. They belong principally to the *Odontaspid* type; one species being closely allied to, if not identical with, the *Odontaspis rhaphiodon* of the chalk of Europe. Two or three species are referable to the genus *Otodus*, one approaching *Otodus appendiculatus;* also from the chalk. Of the genera found in the Pondicherry beds, the following is the stratigraphical distribution assigned by Agassiz. The genera *Lamna*, *Odontaspis*, and *Oxyrhina* extend from the recent period to the Green-sand inclusive, the Jurassic species being now separated from Lamna under the generic title of *Sphenodus*, and from Oxyrhina under that of *Meristodon*. Otodus extends from the Crag to the Green-sand, and Corax is restricted to the true chalk. The Ganoid genus *Sphærodus* ranges from the Tertiary beds to the Oolite, and the Cycloid *Enchodus* is restricted to the chalk. The distribution of species is as follows:—*Lamna*, 5 tertiary and 1 cretaceous; *Odontaspis*, 5 tertiary, 4 cretaceous; *Oxyrhina*, 11 tertiary, 2 cretaceous; *Otodus*, 8 tertiary, and 5 cretaceous; and *Corax*, 5 cretaceous. Of the five Placoid genera we have twenty-nine species occurring in the Supercretaceous, and seventeen in the cretaceous deposits; but not a single species has yet been found anterior to the latter period. The evidence, then, afforded by the Pondicherry fishes appears to yield strong corroborative testimony to the accuracy of Mr. Forbes's views, derived from the study of the invertebrate remains of the same locality; and I fully coincide with him in assigning these strata to the cretaceous period. I am, however, inclined, considering the number of species collected which must be referred to genera which we know decrease in species as they descend in the stratigraphical scale, from the occurrence also of Maestricht species, and from the presence of the genera *Corax* and *Enchodus* not yet found so low as the Neocomian, to place this deposit higher in the system than Mr. Forbes is inclined to do from his investigations. As I have above stated, the Placoid teeth are for the most part mutilated, rendering the generic identification a matter of much difficulty and uncertainty, although the specific characters are good and distinct. Agassiz says*, "It frequently happens that

* Poissons Fossiles, vol. iii. p. 266.

the root and the lateral cusps are detached from the dental cone, and in this case it is very difficult to distinguish Otodus from Oxyrhina. I shall describe hereafter several species very well characterised, but of which the genus is doubtful, because the perfect root is not known." Again, in prefacing the genus Oxyrhina, he says, "When the base of the root is mutilated, it sometimes happens that one is in doubt whether the species belongs to the genus Oxyrhina, Lamna, or Otodus." He also remarks, after comparing the genus Lamna with Oxyrhina, "The steps from Otodus to Lamna are more gradual, and here we find some species which are actually on the limits between the two genera." Some of the Indian species are in this category, for we find the principal dental cone of the form and aspect of an Otodus associated with the long pointed cylindrical lateral cusps of an Odontaspis, and the flattened cultriform tooth of an Oxyrhina furnished with smooth lateral cusps which exclude it from that genus. It is with much hesitation that I have ventured to draw up the following descriptions of the more perfect specimens of the Pondicherry collections, from a consciousness of my own inability to grapple with this most difficult branch of fossil Ichthyology, not unmixed with doubts of the stability of the generic and specific characters as at present acknowledged in the "Poissons Fossiles." Agassiz has himself complained of the paucity of materials for arriving at any very definite conclusions as to the variations of form in the teeth occurring in the various positions in the mouth of the same species. Those naturalists who have studied the recent sharks are well aware of the extent of those variations in a single individual, and can, therefore, appreciate the difficulties under which Agassiz has laboured in attempting a systematic arrangement of the fossil Squaloids. As I am in hopes this distinguished Ichthyologist will shortly have an opportunity of examining the Indian collections, I offer the following descriptions as provisional rather than final; or, at all events, as giving the characters of forms in themselves distinct, but which may hereafter be grouped together under legitimate generic and specific denominations.

Cycloid Order.

Scomberoid Family.

Enchodus *serratus* Eg.—Three teeth from the Pondicherry beds, evidently belonging to the genus *Enchodus*. As I have before stated, they bear a very close resemblance to the species figured by Agassiz as *Enchodus halocyon;* at the same time (although the materials are too defective to warrant any definite conclusion), there are appreciable discrepancies of sufficient importance to induce me to abstain from identifying the Indian teeth with the species alluded to. The most perfect specimen, as compared with teeth of similar size of *E. halocyon*, presents the following distinctive characters. The surface of the enamel is more smooth and even, in consequence of the fineness of the longitudinal striæ, which in *E. halocyon* are coarse and strongly marked. The transverse bands are broader, and the form of the teeth is less attenuated. The most important feature it presents is in the finely serrate cutting edge, which in all the specimens I have seen of *E. halocyon* is smooth and entire. A second fragment corresponds in all these points. The third specimen is a smaller tooth, and only differs from *E. halocyon* in the smooth and highly polished surface of the enamel. None of these teeth are perfect. The length of the largest is half an inch, of the smallest two lines.

Ganoid Order.

Pycnodont Family.

Sphærodus *rugulosus* Eg.—All the tritoral teeth in the Indian collections appear to belong to one species of the genus Sphærodus. A pretty group in Mr. Kaye's series shows nine teeth *in situ* of those in use, and underneath there are the germs of several of their successors. Three detached teeth appear to have belonged to the same specimen. In Mr. Cunliffe's collection I have found two tritores, considerably larger than the specimens alluded to above, but evidently belonging to the same species. In size these teeth resemble those of *Sphærodus Lens*, the smallest species figured by Agassiz; in regularity of form they approach nearer to *Sphærodus parvus*; but they are distinguished from these species and all others figured by Agassiz by the wrinkled or shrivelled appearance of the superficies of the teeth. This is visible even in the smallest specimens, and forms a well-marked and easily appreciable specific character.

Placoid Order.

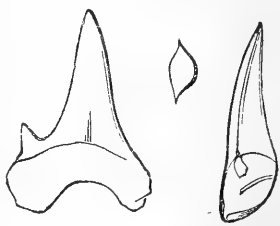
Squaloid Family.

Corax *pristodontus* Agass. Poiss. Foss. vol. iii. p. 224.—A single fragment is the only evidence upon which rests the supposition that this species enjoyed the extended geographical range indicated by its occurrence in the Cretaceous system of Europe and India. This specimen shows the outer surface of the hinder portion of a sinistral tooth. The base is wanting. It corresponds in minutest detail with the analogous portions of a tooth received from Professor Goldfuss, named by Agassiz *Galeus* (now *Corax*) *pristodontus*, apparently from the Maestricht beds. A comparison with the figures given in the "Poissons Fossiles" yields a like result. Some specimens in Mr. Lyell's cabinet, from the chalk of North America, approximate very closely to this species. Should they be identical, it will prove this to be one of the most

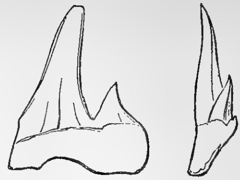
widely distributed fossil forms of fishes with which we are acquainted.

Corax *incisus* Eg. — A second species of Corax occurs in the Indian collection sent over by Mr. Cunliffe, of small size and very distinct character. It is rather smaller than the species of this genus generally are, corresponding in this respect with *Corax planus*, of which some imperfect specimens are figured in the "Poissons Fossiles" from an unknown locality. Our specimens are not perfect, but they are sufficiently so to prove them to be specifically distinct from all those figured and described by Agassiz. The principal cusp is conical, rather slender, and pointed. It is more upright and less falcate than usual. The antero-posterior diameter of the tooth is small, in this respect resembling *Corax planus*. The character of the marginal armature is peculiar. It is rather notched or crenulated than serrate, the subdivisions of the edge being blunt and irregular. The lateral cusp is smooth, and corresponds with its principal in the character of its dentelures.

Otodus ? *marginatus* Eg. — Several of the Indian squaloids are apparently referable to the genus Otodus. Of these, two have some resemblance to the common *Otodus appendiculatus* of the chalk formation; and although the characters of this species, as at present recognised, are wide enough to embrace an extensive variety of forms, yet they are sufficiently defined to exclude the Indian specimens. The larger species, of which I have found four specimens, is remarkable for the rapid increase of the antero-posterior diameter of the shaft as it approaches the base. The latter is thick and massive, with a deep depression on the outer surface. The cone in profile is regularly and distinctly incurved from the apex to the junction with the base. It is narrower than in most specimens of *O. appendiculatus*. The outer surface is smooth and rounded; the inner one is also smooth, and more arched than in any species I am acquainted with. A section, taken one third distant from the base, would represent the inner face of the tooth as nearly semicircular. The cutting edge is sharp, and so distinct as to have the appearance of a border, separated from the remainder of the shaft by a shallow groove. The lateral cusp is large, conical, and sharp, having more resemblance in these respects to this feature in the odontaspid teeth. The corresponding cusp is broken; but the fracture shows that, in all probability, the tooth was symmetrical.



Otodus *basalis* Eg. — A tooth sent to England by Mr. Cunliffe has a closer resemblance to *O. appendiculatus* than the species last described. Of the various forms comprehended in this species, one fossil most nearly approximates a tooth from the Maestricht quarries. Its peculiar distinctive features are, the larger size of the lateral cusp, the greater breadth and obliquity of the base, and the smaller proportions of the principal cone compared with the other dimensions of the tooth. When viewed in profile, the principal cone is straight and narrow, and the cusp from its inward slope forms an acute angle with the principal cone. Both surfaces are smooth and rounded; the inner are, as usual, rather more so than the outer. The tooth is slightly oblique, but not so much so as the Maestricht specimen. As this feature varies according to the position of the tooth on the jaw, it is of little value.



Otodus *nanus* Eg. — A single tooth in Mr. Kaye's collection, referable to the genus Otodus, differs from the other species of the same genus in its diminutive size. The central cusp is triangular, equalling in height the breadth of the base. It has a thick and stunted aspect, being equally convex on either surface. It is incurved, and slightly obtuse at the apex. The lateral cusps are short, wide, and blunted.

Otodus *divergens* Eg. — An unique specimen in Mr. Cunliffe's collection, although differing in some respects from the general characters of the genus Otodus, has notwithstanding more resemblance to this than to the squaloids of any other genus. The central cusp, from its sharp, flattened, and lanceolate form, resembles an Oxyrhina or Lamna; but the large development of the lateral cusps must exclude it from those genera. From Odontaspis it differs in the width and general character of the lateral cusps. The latter are exact miniature representations of the principal cusp, and are so placed upon the base as to slope outwards on either side. They have each a small supernumerary point on the outer shoulder. The tooth is slightly convex on both sides; the point is somewhat recurved; and the edges of all the cusps are remarkably sharp. This is a perfect and very interesting specimen.

Otodus *minutus* Eg.—The last specimen I refer to this genus is of small size, not exceeding the dimensions of *Otodus nanus* described above, yet of different form. The principal cusp is more lanceolate, and the antero-posterior diameter is infinitely smaller, compared with the height of the tooth. The profile is straight, not incurved as in *O. nanus*. The lateral cusp is small and blunt. A prominent ridge borders the enamel at its junction with the base.

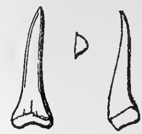
Oxyrhina *triangularis* Eg. — It requires specimens of unusual perfectness to enable the palæontologist to discriminate between the species of the genera *Oxyrhina, Lamna*, and *Otodus*. The Indian teeth,

being for the most part imperfect, it is a matter of great difficulty and uncertainty to decide to which genus many of them belong. The proposed arrangement of species must, therefore, be considered as a mere approximation, or rather, perhaps, as provisional, until more perfect specimens, or one more skilled in Fossil Ichthyology, shall clear up the obscurity. Several smooth teeth in the Indian collections are remarkable for their regular triangular form. They appear to have been destitute of lateral appendages. The base in this species is broad, equalling the total height of the tooth. The cone is flattened on the outer surface, and rounded on the inner. The enamel of the latter descends lower on the base at the sides than at the centre: the line of boundary thus represents an ascending obtuse angle. The teeth are more or less oblique, according to the position they hold on the jaw. It is one of the smallest species of the genus.

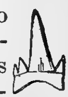
LAMNA *complanata* Eg.—The occurrence of a small lateral cusp in some of the specimens of this species marks it as belonging to the genus Lamna, although in other respects it would more properly be considered as an Oxyrhina. Its nearest analogies are with *Oxyrhina xiphodon* and *hastalis*. It differs from the former in having the outer surface more prominent, and the inner one more evenly rounded without the flattened character of the basal portion of the enamel. From the latter it differs in the less prominent contour of the inner surface. It is distinguished from both by the presence of the lateral cusp, in being infinitely smaller, and in its slender and elegant proportions. The transverse section shows the antero-posterior diameter to be exceedingly narrow—more so indeed than in any other species of the genus.

LAMNA *sigmoides*—It is difficult in a mere verbal description to make intelligible the minute distinctions which, in considering the characters of the fossil squaloid teeth, are the elements on which the species are eliminated. A single tooth sent home by Mr. Cunliffe recalls at first sight the well-known *Lamna acuminata* of the British chalk. It approaches also that species in size, being one of the largest of the Indian specimens, which, generally speaking, are of unusually small dimensions. In form it is intermediate between *L. acuminata* and *L. cuspidata*. It differs, however, from both in the sigmoid flexure of the cutting edge. There are no lateral cusps visible. In front it varies from the form of *L. cuspidata* in the greater breadth of the apex, and from *L. acuminata* in the parallelism of the sides in the middle region of the tooth. The outer surface is flattened until near the point, where it is slightly rounded. The inner surface is convex and prominent. Seen in profile, the cutting edge conceals the back of the tooth for two-thirds of its length; it then verges inwards until near the point, where it again tends slightly outwards. The

base is partially concealed by the matrix; but it appears to have been furcate, and of rather small size.



Odontaspis *constrictus* Eg. — A very large proportion of the Indian odontolites belong to the species now under consideration. Out of some dozen of specimens I have not, however, found one having the base sufficiently perfect to show whether it supported lateral cusps or not. If they were present, they must have been of very small size. Under this uncertainty it is impossible to determine whether this species should be placed under the genus Lamna or Odontaspis; but I am inclined, from the slender subulate aspect of the teeth, to refer it to the latter. At the time of writing this, I have not been able to compare the Indian specimens with figures of *O. gracilis* from the chalk and *O. subulata* from the lower greensand of Neufchâtel; but the descriptions given of these species lead me to infer a considerable resemblance in size and form with the Indian species, although the latter has a very distinctive feature in the cessation of the cutting edges before they reach the base, giving a constricted appearance to the shaft of the tooth. This character is well marked in *Odontaspis contortidens* of the Molasse; indeed our Pondicherry fossils are only distinguishable from this species by the absence of the striæ on the inner surface of the teeth.



Odontaspis *oxyprion* Eg. — The last species I propose to describe in this memoir is also frequent in the Indian collections. It belongs without doubt to the genus *Odontaspis*, and is very nearly allied to *O. rhaphiodon*. The comparison, however, is less accurate than I could wish, owing to my not being able to refer to Agassiz's plate on the subject; but one character establishes at once the distinctness of the Indian species, viz. the absence of striæ on the inner surface of the tooth. Some of the specimens of this species are in a good state of preservation, showing the form of the base and the lateral cusps. It is not impossible that more than one species may be included in this description, as some of the specimens are more convex than others on the outer surface, and less recurved at the point. The number and form of the lateral cusps also vary considerably; but there is a general resemblance which induces me for the present to include all under one denomination. In the form of the central cone they agree very closely with *Odontaspis rhaphiodon;* but the lateral cusps are larger, more elongated, and sharper at the points, and in these respects they exceed even the recent *Odontaspis ferox.* They are sometimes single, sometimes double, on each side, and occasionally single on one side and double on the other. The base is broader and less deeply notched than in *O. rhaphiodon.*

A considerable number of specimens remain to be examined; but most of them will probably belong to one or other of the species described above. Should any distinct forms be found, they will be treated of in a future memoir.

4. *On the Occurrence of a Bed of* SEPTARIA, *containing Fresh-water Shells, in the Series of Plastic Clay, at* NEW CROSS, KENT. By HENRY WARBURTON, Esq. M. P., F. R. S.

HAVING occasion, in the spring of 1843, to travel along the South Eastern Railway, I observed at the distance of about 200 yards to the south of the New Cross Station, on the western side of the cutting which there lays bare the junction of the London and Plastic Clays, and at the very foot of that cutting, what seemed to be a continuous bed of stone, forming a part of the Plastic Clay series.

I applied, in consequence, to Mr. Simms, a Fellow of our Society, (who, as one of the resident engineers, had ready access to every part of the line), to procure for me specimens of this bed; and he not only complied with this request, but also made a vertical section of the beds exposed in the cutting, extending from the base of the London Clay to the bed of stone in question.

The specimens which Mr. Simms procured contain, imbedded in the substance of the stone, two fresh-water shells, a Paludina and a Unio, which Professor E. Forbes has examined and described. The stone proved, on examination, not to form a continuous stratum extending to any distance, but to occur at intervals only; and to be, in fact, a bed of Septaria, of a texture considerably more earthy than the Septaria of the London clay usually are. These Septaria may be traced along the base of the railway cutting from the point already mentioned, south of the New Cross Station, to beyond the first bridge which crosses the railway south of that station, and rising, like the railway itself, at an inclination of 1 in 100.

The position of this bed of fresh-water Septaria, in relation to the London clay, will be best understood from the following section by Mr. Simms:—

	Ft.	In.
1. London clay, the lowest bed of which, from 10 to 15 feet thick, is of a blue colour.		
2. Rolled flint pebbles - - - - - - - - - -	1	10
3. Fine fawn-coloured sand - - - - - - - -	0	3
4. Lignite - - - - - - - - - - - -	0	$0\frac{1}{4}$
5. Fine fawn-coloured sand - - - - - - - -	2	0
6. Ferruginous sand, with fragments of oyster shells, and Cerithia -	0	4
7. Grey sand, with fragments of Cerithia - - - - - -	0	8
8. Strong black clay - - - - - - - - - -	0	10
9. Black clay and sand, with fragments of oysters and Cerithia -	0	9
10. Black sand - - - - - - - - - - -	0	4
11. Dark sand, with oyster shells - - - - - - - -	0	6
	7	$6\frac{1}{4}$
12. Calcareous stone, with fresh-water shells - - - - - -	0	6
13. Sand and stone in a rotten state, with oysters - - - - -	0	3
	8	$3\frac{1}{4}$

The following is the description of the shells, by Mr. E. Forbes:

1. *Paludina.*

A species with 5 ventricose whorls which appear to have been slightly striated by lines of growth; the largest perfect specimen measuring 1 inch in height by half an inch in greatest breadth of the body whorl.

I can find no character by which to separate this fossil from the existing *Paludina vivipara;* some of the southern varieties of which it closely resembles in external form. That species is very widely distributed, at present being common to a great part of Europe and Asia. I am not aware of its ever having been previously noticed as an older tertiary shell, but its allies, *P. achatina* and *P. unicolor*, are both recorded tertiary species, having a wide range both geologically and geographically; the identity of the living species with the fossils discovered by Mr. Warburton and Mr. Simms is thus rendered the more probable. I regard this species as quite distinct from the *Paludina fluviorum* of the Wealden, which was confounded with *P. vivipara*, a confusion which has led to several erroneous statements and reasonings.

2. *Unio.*

An ovate, very inequilateral, depressed species, wrinkled transversely, growing to a length of between 2 and 3 inches.

The extreme difficulty of determining living species of Unio must render us very cautious in giving an opinion on a fossil. The remains, though not imperfect of their kind, and certainly those of *Unios*, are not sufficient to warrant the bestowal of a specific appellation on them. They are, however, probably distinct from any of the recorded British tertiary species. E. F.

I have only to add in conclusion, that in the Paris basin, which lies to the north of Paris, in the Département de l'Aisne, fresh-water shells belonging to the same genera occur in the plastic clay series, accompanied by lignite; and among the fossils of one of these beds, M. D'Archiac enumerates four species of Paludina, and an undetermined species of Unio. Mons. Charles d'Orbigny also, in a section of the beds in the Paris basin, intermediate between the calcaire grossier and the chalk, near Meudon, enumerates plastic clay, lignite with Paludinæ and Anodontas, and a conglomerate containing fresh-water shells.

This point of correspondence between the plastic clays of England and France, viz. their containing several of the same genera, at least of fresh-water shells, besides Cyclades, which have been before noticed as common to the two, and Cerithia, and other shells, inhabitants of brackish water, I have thought of sufficient interest to make the subject of a notice to the Society.

May 1, 1844.

1. *Report on the* Fossils *from* Santa Fe de Bogota, *presented to the Geological Society by* Evan Hopkins, Esq. F.G.S. By Professor Edward Forbes, F.L.S.

The fossils from Bogotá presented by Mr. Hopkins are all remains of Mollusca. They are embedded in a very dark and compact limestone; and are all, apparently, from the same formation. They include 17 species, most of which are in very good preservation. Of these, 9 are described species, and are identical with fossils from the same neighbourhood, described in the memoir by M. Von Buch, "On the Fossils collected in America by MM. Humboldt and Degenhardt," in the paper intitled "Notice of the Oolitic Formations in America," by Mr. Isaac Lea, printed in the "Transactions of the American Philosophical Society for 1841," and in the account of the fossils collected in Columbia by M. Boussingault, given by M. Alcide d'Orbigny, in the Palæontology of his South American Voyage, published in 1843. All these papers have been consulted in the preparation of this Report.

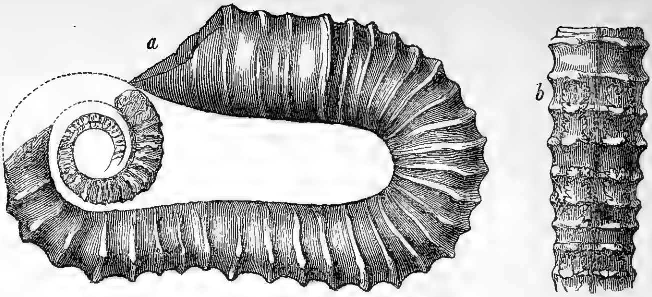
The formation in which these fossils were found has been referred by M. Von Buch to the Cretaceous era, by Mr. Lea to the Oolitic period, and by M. d'Orbigny to the Neocomian epoch of the Cretaceous era. The result of an examination of Mr. Hopkins's specimens, more especially of such as are new, bears out the view of their cretaceous origin first taken by M. Von Buch, and afterwards adopted by M. d'Orbigny. It is probable, however, from the number of forms approximating Gault species, that the last-named palæontologist has placed them too low in the Cretaceous series, when he refers them to the Neocomian, or, in other terms, the lower part of the lower greensand strata.

Accompanying the shells is a specimen of coal, stated by Mr. Hopkins to be found in the same formation. The species in the Society's collection are mostly Cephalopoda; they consist of 10 Ammonites, 1 Ancyloceras, and 2 Hamites; these are accompanied by 1 Rostellaria, 1 Venus, 1 Lucina, and 1 Inoceramus.

Descriptive List.

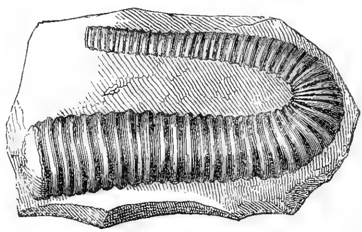
1. *Ancyloceras Humboldtiana.* (Orthocera Humboldtiana *Lea*, loc. cit. p. 253. pl. viii. f. i.)

This is apparently a good (though not quite perfect) specimen of the fossil described by Mr. Lea as an *Orthoceras*, from a fragment. The turns of both extremities are seen in Mr. Hopkins's specimen.



a. Side view, the outline completed by a dotted line.
b. View of the back, to show the form of the septa.

2. ? *Hamites Degenhardtii* Von Buch. l. c. f. 23, 24, 25.
3. *Hamites D'Orbignyana.* Nov. sp.



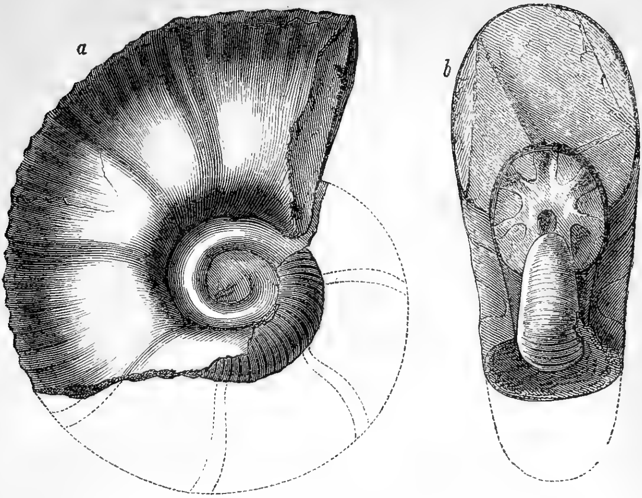
H. testâ tereti, transversim sulcatâ; sulcis numerosissimis, æqualibus, regularibus; interstitiis elevatis, angustioribus, acutiusculis.

Length of anterior portion	$1\frac{6}{10}$	unc.
posterior portion	$1\frac{4}{10}$	,,
Breadth of widest part	$0\frac{4}{10}$	,,

Of this Hamite there is a single specimen which exhibits most of the essential parts of the shell. It is cylindrical and tapering; the oral extremity appears to have been somewhat inflated. The surface is furrowed by numerous transverse sulcations, which are continuous to the back, though not in all cases equal; they are separated from each other by somewhat acute ribs. The shell bends with a sudden curve, and is then produced into a rapidly diminishing posterior extremity, running nearly straight and parallel with the oral portion.

4. *Ammonites Dumasianus* D'Orbigny, l. c. p. 69. t. ii. f. 1—2.
5. ——— *galeatus* Von Buch. l. c. pl. 2. f. 20.
6. ——— *Alexandrinus* ? D'Orbigny, p. 75. pl. xvii. f. 8—11.
7. ——— *Vanuxemensis* Lea ? pl. viii. f. 5.
8. ——— *Rhotomagensis* Sow. (Noticed also in the memoir by M. Von Buch.)

9. *Ammonites Hopkinsi.* Nov. sp.



a. Side view, showing the outline complete and a portion of the shell.
b. View showing the lobes in the septa.

A. testâ crassâ, umbilicatâ, transversim sulcatâ costatâque ; sulcis 6, subundulatis, marginatis ; dorso rotundato, transversè costato ; costis inter sulcos 5—8, rotundatis, lateraliter obsoletis ; aperturâ ovato-lunatâ ; septis —.

Diam. $2\frac{1}{2}$. Crass. $1\frac{6}{10}$ unc.

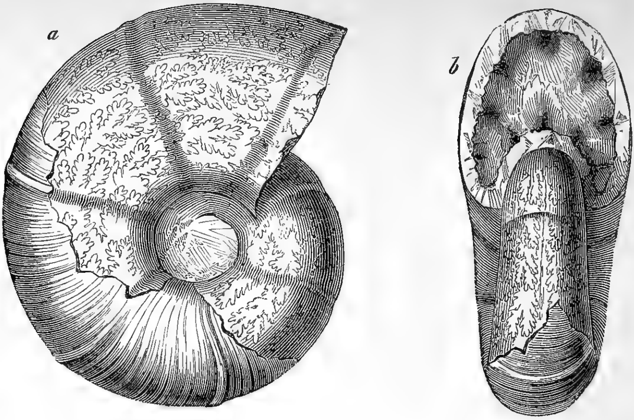
This fine Ammonite has an inflated shell, which appears to have been of considerable thickness. The outer whorl does not entirely conceal the others, but leaves a deep umbilicus which in the perfect shell probably exposed several of the inner volutions. The sides of the whorls forming the boundary of the umbilicus are steep, in consequence of sudden inflections of the shell. The middle of the whorls is flat and nearly smooth ; the back is rounded, and transversely sulcated, with rather broad, slightly undulated shallow furrows, which are separated into groups of from five to eight by distant, wider, and deeper furrows, which run in a curved manner entirely across the whorls. These sulcations, marking stages of growth, are very strong on the cast, but comparatively slightly marked on the external surface of the shell, showing that they are the marks of internal ribs. The mouth appears to have been lunate, and slightly elongate. It belongs to the section *Ligati.* It is very nearly allied to an Ammonite from the lower greensand of Southern India.

10. *Ammonites Inca.* Nov. sp.

A. testâ crassâ, umbilicatâ, radiato-striatâ, sulcatâ ; sulcis undulatis 6 ; dorso rotundato ; aperturâ lunatâ, latâ ; septis pinnatis, multilobatis.

Med. semi-diam. $1\frac{2}{10}$. Ult. anf. $1\frac{6}{10}$. Crass. $1\frac{4}{10}$ unc.

This species is nearly allied to the last, and resembles it in form, but differs in the absence of smaller sulcations between the greater furrows, which divide the cast of the outer whorl into six wide divisions, and which on the external surface of the shell were marked by raised ribs. These furrows and ribs proceed in an undulate and rotate manner from the umbilicus, which appears to have partially exposed the inner whorls. The sur-



Ammonites Inca.

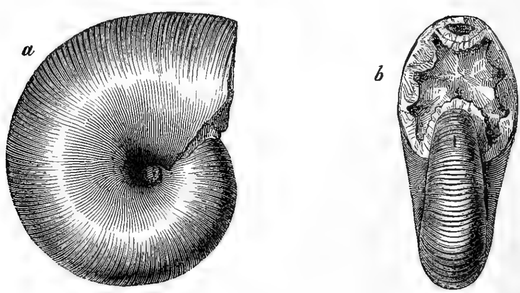
a. View of the side, showing the shell and the septa.
b. View showing the lobes of the septa.

face of the shell was finely, though irregularly, striated in an undulated manner, indicating fine lines of growth. The sides of the umbilicus are steep; the mouth is lunate, and broader than long.

The sutures of the chambers are well seen on a small specimen. The lateral lobes, of which four appear on the lateral portion of the outer whorl, are bilobate and pinnate, the pinnæ being denticulate. The dorsal lobe is short, linguiform, and denticulate at the sides.

Nearly allied to *Ammonites latidorsatus* Michelin, a gault species. Belongs to the section *Ligati.*

11. *Ammonites Buchiana.* Nov. sp.



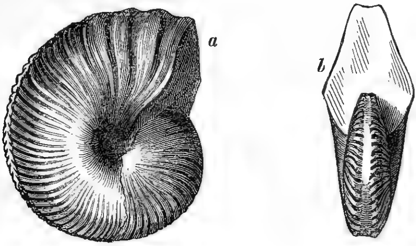
a. Side view.
b. View of the back.

A. testâ subdepressâ, subumbilicatâ, involutâ, dorso rotundato, costis transversis numerosissimis subundulatis, ad lateras obsoletis; circa umbilicum lævigatâ. Aperturâ lunatâ. Septis ——

Med. semi-diam. $1\frac{6}{10}$ unc. Crass. $1\frac{3}{10}$ unc.

The *Ammonites Buchiana* is a very beautiful species. The outer whorl almost completely envelopes the others, so as to leave only a small but deep umbilicus. The surface around the umbilicus is smooth for about half way across the whorl, where very numerous, regular, rather shallow, somewhat undulated striæ, or narrow sulcations, commence, with narrower interstices, and continue across the rounded back. The mouth is ovato-lunate; the septa appear to have been arranged in numerous phylliform lobes, the terminal divisions of which were ovate and large. Belongs to the section *Heterophylli*, but is rather an abnormal form.

12. *Ammonites Leai.* Nov. sp.



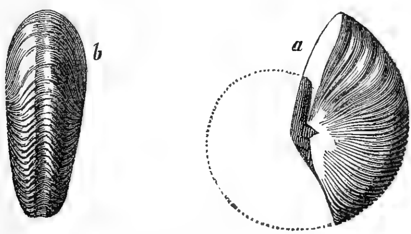
a. Side view.
b. View showing the form of the aperture, and the back of the whorls.

A. testâ compressâ, subumbilicatâ, involutâ, semicostatâ, costis numerosis, prope aperturam obsoletis, sulcis undulatis substitutis; dorso excavato-sulcato, sulco lævi, marginibus carinatis, dentatis. Aperturâ subtriangulari. Septis ——

Med. semi-diam. $0\frac{6}{10}$; m. crass. $4\frac{1}{2}$; lat. sulc. dors. $0\frac{3}{4}$ unc.

A very beautiful little Ammonite, quite perfect, and apparently full-grown. It is compressed at the sides, and flattened and furrowed at the back. The last whorl envelopes the others, and becomes somewhat dilated at the mouth. That half of it nearest the umbilicus is smooth, the remainder marked by numerous well-defined undulated sulcations, which become obsolete towards the mouth, where they are replaced by deeper and wider sulci, separated by flattened elevations of equal breadth. The angles of the dorsal furrow are rather acute, and are tuberculated by the raised oblique extremities of the costæ between the lateral sulcations. The centre of the back is slightly hollowed out, and quite smooth. The mouth is wide and triangular, though truncated at the top. The septa are not visible. Belongs to the section *Dentati*, and is nearly allied to several gault Ammonites.

13. *Ammonites bogotensis.* Nov. sp.



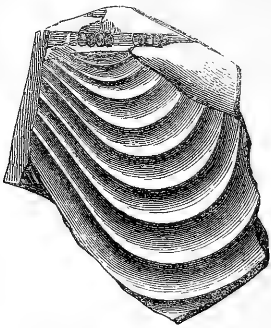
a. Side view; the outline of the complete shell restored.
b. View of the back.

A. testâ compressâ (subumbilicatâ?) radiato-striatâ, subsulcatâ, dorso plano subexcavato, sulco dorsali lato, lævi.

Lat. frag. $1\frac{2}{12}$. Crass. $0\frac{7}{12}$ unc.

There is only a fragment of this Ammonite in the collection. It presents, however, excellent distinctive characters in the outer whorl, which is compressed, and so large as apparently to have enveloped, or nearly enveloped, the others. It is marked with radiating striæ or rather furrows, which are unequal and slightly undulated. These are separated into groups by wider, distant, shallow sulcations. The back is flattened, slightly excavated, and bounded by an obsolete keel or angle at each side, over which the lateral striæ turn obliquely, but become obsolete before they reach the hollow of the centre, which appears to have been smooth. The aperture was probably ovato-lunate in form. Belongs to section *Dentati*, and is nearly allied to several gault species.

14. *Rostellaria angulosa* D'Orbigny, l. c. pl. xviii. f. 4.
15. *Lucina plicato-costata* D'Orbigny, l. c. p. 83. pl. xviii. f. *b*. 4.
16. *Venus chia* D'Orbigny, l. c. p. 82. pl. xviii. f. 9, 10.
17. *Inoceramus lunatus*. Nov. sp.



I. testâ suborbiculari, obliquâ, planâ, sulcis concentricis regularibus latis, interstertiis angustis elevatis acutiusculis.

The only specimen of this well-marked *Inoceramus* is imperfect. The characters of the surface are, however, well displayed, and a portion of the hinge is shown. The sulcations of the surface are lunate, broad in the centre, narrow at the sides, and very regularly formed. The intermediate ribs are narrow, and slightly or obsoletely ridged; they slope away into the furrows more suddenly anteriorly than posteriorly. The fragment measures $1\frac{1}{2}$ inch in length, by $1\frac{3}{10}$ in breadth.

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2. *Comparative Remarks on the Sections below the Chalk on the Coast near* Hythe, *in* Kent, *and* Atherfield, *in the* Isle *of* Wight. By W. H. Fitton, M.D., F.R.S.

My objects in this paper are to illustrate, 1st, two sectional elevations, showing the proportional thickness of the principal divisions of the strata at Hythe and Atherfield; 2dly, an approximate sketch of the cliffs from Atherfield to the east of Blackgang-Chine; and 3dly, a corresponding sketch of the section from the chalk hills above Folkstone, to the level of the sea at Hythe.

§. The Atherfield Section is a copy of a drawing made by Sir John Herschel, referred to in the fourth volume of the Geological Transactions *: I have engrafted upon it such farther information as has

* Second Series, vol. iv. p. 186.

been recently obtained, as well as the result of Mr. Simms's measurement; and shall now mention some of these additions, beginning at the junction of the Lower Green-sand with the Wealden, and referring for an account of the junction itself to the abstract published in the "Geological Proceedings," vol. iv. p. 198. The subdivision of the strata into groups is, of course, in a great measure arbitrary, and would, in all cases, probably vary, according to the views of different observers, and to the temporary condition of the cliffs, which are in a constant state of degradation and change.

§. Although the two lower beds immediately over the Wealden are not together more than 5 feet in thickness, it will be expedient to consider them separately, both on account of the great number of very remarkable fossils which they contain, and of their difference, both in composition and fossils, from the beds of clay immediately above,—which nearly resembles fullers' earth, and differs much in its characters from the sandy clay or mud immediately in contact with the Wealden. It is not improbable that these two lower beds at Atherfield may be the representatives of some more largely developed group at the bottom of the Green-sand in other countries.

The absence of strata corresponding to these lowest beds, in the clay immediately above the Wealden at Hythe, is remarkable; but the bottom of the series in Kent is hitherto known only from the specimens obtained from Mr. Simms's shaft. It is much to be wished that this part of the section may be brought into view by an open cutting, for which the vicinity of the town of Hythe affords many promising positions.

The list of fossils from the coast at Atherfield has received several additions since my last communication; among others many excellent specimens of *Perna Mulleti* have been obtained, by which some new points in the structure of that remarkable fossil are supplied. The whole collection of fossils from this place has been examined and named by Mr. Forbes.

§. With respect to the clay to which the name of "fullers'-earth" has here been assigned, I wish to correct a statement in my former paper (Geol. Trans. 2d ser. vol. iv. p. 196.), where it is said that "the "lowest stratum of clay immediately above the fossiliferous stone at "Atherfield *appears to be the equivalent of the fullers'-earth of Sur-"rey,*" and that the stone itself, about 2 feet in thickness, "*is appa-"rently the equivalent of the limestone very near the bottom of the "Lower Green-sand at Hythe.*" This clay, though it has many of the properties of fullers'-earth, is certainly not the representative of the substance which bears that name at Nutfield and Reigate, in Surrey; and the stone beneath is quite distinct from the Kentish Rag of the Hythe quarries. I was led into both these errors by an imperfect acquaintance with the bottom of the section at Hythe; by the (supposed) absence there of fullers' earth above the limestone; and by finding at Atherfield *Nautilus radiatus* (?), with Trigoniæ and other fossils of frequent occurrence in the Hythe stone quarries. The true place of the fullers'-earth, at Nutfield itself, is above the Kentish Rag, and considerably above the bottom of the Lower Green-sand.

The junction of the Lower Green-sand with the Wealden on the south of Nutfield was disclosed by the cutting for the railway near Robert's Hole Farm, as mentioned in my last paper. On the N. W. of this farm, a flexure or depression of the strata brings down one of the principal beds of fullers' earth to the level of the railroad, near the Redhill (or Reigate) station; and this was exposed, some months ago, in a bank immediately behind the original Station House* of the South Eastern Company.

I have hitherto seen no traces of this upper fullers' earth at Hythe; but at two intermediate points, viz. Tilburstow Hill, near Godstone, and the top of Mrs. Bensted's principal quarry, near Maidstone, fullers' earth appears with somewhat peculiar characters, above the mass of stone, which has been considerably disturbed at both places. A few feet (10 or 12) below this fullers' earth at Tilburstow†, portions of white or yellowish sand in a stemlike arrangement occur, precisely resembling what I shall presently mention as fallen from the upper part of the cliffs on the east of Whale Chine near Atherfield. If these appearances in Kent and Surrey mark the top of the limestone, they may possibly indicate a corresponding point in the Atherfield section.

§. A continued search has brought to light many specimens of fossils, among which are several new species, in a bed which seems to be immediately above the fullers' earth of Atherfield Point. They were described to me as occurring in detached masses or lumps in the sandy clay immediately under the lowest range of larger concretional masses which form the prominence of the coast at the "Crackers." The fossils are united by a medium which varies from a loose sand to a somewhat calciferous stone, or indurated fullers' earth. These lumps may, possibly, be the representative of the masses which are mentioned by M. Leymerie as occurring in the "*Argiles Ostréennes*," of the department of the Aube.

§. The "*Crackers*" is the name given to a projecting part of the coast, which owes its prominence to the presence above the level of the sea of two ranges of nodular masses, occurring in a bed of sandy clay about 18 or 20 feet in thickness, and at the junction of which with the sandy stratum next below the *Ammonites Deshayesii* was frequent. These nodules of sand and calciferous sand-rock are the only stone upon the coast which can be considered as representing the (Kentish) limestone of Hythe and Maidstone, &c.; and their distance from the bottom of the Lower Green-sand accords with this identification.

The vertical distance from the bottom of the Crackers to the

* This Station has since been removed to the junction with the Brighton Railway.

I find from the Railway Plan of the country near Redhill and Nutfield that Mr. Simms has estimated the height of two of the fullers' earth pits nearest to Robert's Hole Farm at 140 and 160 feet above the junction of the Lower Green-sand and Weald clay, which has afforded the *Perna Mulleti* and other remarkable fossils of Peasmarsh and Atherfield.

† See Account of Tilburstow. Geol. Trans. vol. iv. p. 138.

Wealden is about 59 feet, according to Mr. Simms; nearly the same thickness as of the corresponding portion of the section at Hythe.

§. The aspect of the shore from the Crackers eastward is diversified only by the presence of an undercliff, which varies in extent from the rapid destruction to which every part of this coast is subject. At *Atherfield-high-cliff*, between 500 and 600 paces from the Crackers, is a fossiliferous group, the top of which descends thence to the shore at a distance of more than 250 paces; and includes several remarkable ranges of *Gryphæa sinuata*, among which are very fine specimens with large Ostreæ; the lowest bed of this group also consists of a similar range, and immediately beneath are masses composed for the greater part of agglutinated shells of *Terebratula sella*, with another (plicated) species.

To compare the two sections at this point, let us suppose a limestone as thick as that of Hythe (about 130 feet), to be introduced in the place of the Crackers. This, from the inclination of the strata, would extend along the coast to a point about 300 paces east of Whale Chine; and would include the fossiliferous nodules of the Crackers at the bottom, and also, near the top, another nodular mass of strata which rises to the summit of Atherfield-high-cliff. The contents of this latter group are, as yet, imperfectly known; but the fossils hitherto found on this part of the coast are nearly the same with those of the quarries at Hythe.

The strata from hence to Whale Chine consist, generally, of a greenish sandy mud, including several ranges of Exogyra, with other fossils, one of which crosses the mouth of that chine, and is visible within the chasm itself, descending to the shore at a point very near the mouth of the next chasm on the east called Ladder Chine.

Another group, containing nodular concretions, is visible on the east of Walpen Chine, beneath what is called *Walpen high-cliff*: it first rises on the east about 350 paces from the chine, and extends to a distance answering to about 200 paces eastward. A second remarkable group containing Gryphæa rises between Walpen high-cliff and Cliff-end.

The beds above Cliff-end to the top of Blackgang-Chine have hitherto afforded few fossils; but in the corresponding part of the section, from Bonchurch to Shanklin, the upper beds are much better displayed, and deserve a new examination. They contain numerous casts, chiefly those of *Gervillia aviculoides*, *Natica*, *Rostellaria*, *Thetis minor*, *Terebratula*, *Trigonia alæformis*, *Turbo*, and *Venus*; and the shore immediately on the east of Shanklin-Chine exhibits, at low water, an extensive surface of a lower bed, almost entirely composed of large Gryphæa sinuata.

§. The distinction between the first and second subdivisions of the Lower Green-sand, pointed out in my description of the coast near Folkstone, is much less prominent near Atherfield than in Kent: but a group corresponding to the upper or ferruginous division (which Mr. Austen mentions as conspicuous also in Surrey) is clearly distinguishable at the farm of Walpen, where a continuous ridge of sand impends over the lower ground between that place and the coast. A great portion of the two promontories at Blackgang Chine belongs to this upper division; and if the interval between the bottom of the Gault within the chine and the retentive stratum over which the streamlet runs to the waterfall, be assigned to it, the thickness will be rather more than 200 feet, including some remarkable beds — one 12 feet, and two others about 17 feet each, in thickness — of fawn-coloured, or nearly white, sand, not in itself distinguishable from that of Hastings. No fossils from this division in the Isle of Wight have yet come to my knowledge. Its junction with the more retentive mass below appears to be marked by the breaking out of springs, as in the corresponding place near Hythe. The subdivisions of this group are detailed in the drawings.

On the coast of Kent, between Folkstone and Sandgate, this upper division of the Lower Green-sand contains more calcareous matter than at Blackgang-Chine, and even some concretions of compact limestone, with spongy siliciferous masses, very like the whetstone of Blackdown. [Geol. Trans. 2d Ser. iv. p. 118, 119.]

§. *The Gault*, hitherto estimated as no more than 70 feet in thickness throughout the back of the Isle of Wight, appears from Mr. Simms's measurement to be 146 feet thick near Blackgang-Chine. The lower part is at first view not easily distinguished, from its change of colour after exposure; but the lower line of boundary was accurately traced, on the east of the hotel, by Mr. Warburton, and on the west of it by myself, within the upper part of the chine on both sides. On the west of the hotel, just within the ravine, at the top, some of the characteristic Gault fossils, including Ammonites, have been found close to the bottom of the deposit; and similar remains have been obtained, as I am informed, at Puckaster.

The much greater prominence of the *Upper Green-sand*, which has here a thickness of 104 feet, is a very remarkable point of difference from the Folkstone section. This group in the Isle of Wight consists apparently of two divisions, as in Western Sussex, and contains fossils in great numbers.

§. On a general comparison of the sections of the Kentish coast and the Isle of Wight, the most prominent points of difference are, 1st, the almost total absence of limestone at Atherfield; and 2d, the great excess, at the latter place, in the thickness, especially, of the Lower Green-sand.—

	Atherfield.		Hythe.	
Thickness of Upper Green-sand - -	104	0	15	0
,, Gault - - - -	146	0	126	0
,, Lower Green-sand - -	752	11	406	6
Total - - - - - -	1002	11	547	6

So that, while the Gault in the two situations differs only 20 feet in thickness, the Lower Green-sand at Atherfield exceeds that of Hythe by 346 feet. There is also throughout considerable variation in mineral composition, and in aspect; but not greater than what appears, even in the Isle of Wight itself, between the nearly horizontal strata at Atherfield and Shanklin, and their continuation in the vertical strata at the Red-Cliff between Sandown and Culver. The distance in a direct line of the two sections we have just compared, from Atherfield to Hythe, is less than 95 miles; while that of their foreign equivalents is, — in the case of the Aube, about 285 English miles; from Atherfield to Neufchâtel is about 440 miles; to Hanover the distance is not less than 450 miles; and to the Crimea is 1650 miles. From the Neufchâtel deposit, which M. Dubois has emphatically identified with that of the Crimea, the distance is not less than 1300 miles.

§. Such being the strata in the two principal sections of our coast, let us next inquire what are their equivalents in other parts of the globe. This question has of late acquired new importance, from the proofs of the wide diffusion of the cretaceous system, and the almost surprising agreement of its fossils in very distant places.

A brief general statement concerning the *Terrain Neocomien* has been given by Mr. Murchison in his Address to the Geological Society at the Anniversary of 1843. It may be useful to bring together some of the descriptions of those distant deposits, though it would be difficult in a small compass to give even an abstract of the various papers on the subject published during the last ten years. I have therefore given some of the principal characteristics of the groups, following as authorities, — 1st, the original memoir of M. Montmollin, on the cretaceous deposit of Neufchâtel, from whence the term "Neocomien" has been derived; 2dly, that of M. Leymerie on the department of the Aube in France, accompanied by a series of plates; 3dly, M. Von Rœmer's elaborate work, on the fossils of the chalk formation in the North of Germany; 4thly, the account given in M. Dubois de Montpereux's work on the Crimea, of the cretaceous series in that region.

The deposit since called "Neocomien" on the Continent was first described by M. Auguste de Montmollin, in a paper published in 1835.* The author states that he first learned at Paris in 1828 that fossils collected by him in the vicinity of Neufchatel belonged to the lower part of the chalk formation, "the green-sand," although previously considered as a part of the Jura formation. The term "*Neocomien*" was applied to these strata by M. Thurmann, and subsequently recognised by M. de Montmollin, who had previously designated his discovery merely as the "Terrain cretacé de Neufchâtel."

The strata described by M. De Montmollin were unconnected with any superior groups; but M. Dubois subsequently discovered at Souaillon, traces of green-sand above the yellow limestone. The list of fossils from Neufchâtel was unaccompanied by plates; and it was not till those of M. Leymerie appeared, that any figured Neocomian fossils were known in this country, although many of

* Mém. de la Société de Neufchâtel, vol. i. p. 47.

those named by M. Montmollin belong to our green-sand. M. Leymerie, though he regards the aspect of the Neufchâtel series as quite distinct from that of the Aube, considers the two deposits as perfectly identified by their fossils. The limestone below the "*Marle bleu*" of Neufchâtel either does not appear in England, or is represented by the two lowest beds at Atherfield, so remarkably abundant in fossils. If this be the case, our fullers' earth at Atherfield and Hythe may represent the blue marl (30 feet in thickness), and our Kentish limestone (129 feet), at Hythe, may be the equivalent of the upper "yellow limestones," from 120 to 160 feet thick.

§. A very important extension of the tract occupied by the Neufchâtel deposit has since been made known by M. Jules Itier, in a memoir read before the Institute of France *; from the report on which it appears that the Neocomian strata in the department of the Aisne have a maximum thickness of 300 *metres;* which, the reporter adds, is far inferior to that of the same formation in the department of the Isère, and of the South of France. Among the fossils of this department, the most remarkable and characteristic is the *Chama ammonia* (*Caprotina* of D'Orbigny), from whence, or rather from its synonyme *Diceras*, the term "*calcaire à dicerates*" has been applied to some lower members of the chalk series, in what has been called the "bassin mediterranéen."

§. To any one familiar with the chalk districts of England, and those of France near the coast of the English Channel, it would be surprising if the series of beds below the chalk on the east of Paris were very different from that of the west. M. Leymerie's map of the department of the Aube appears to indicate the same series as that of England; yet it is difficult to identify his subdivisions at the upper part of the series with ours. His general divisions of the subcretacean groups are, *Argile-teguline* and *grès vert,* about 150 metres (about 490 feet); and *Terrain neocomien,* 50 metres (164 feet); the latter including three subdivisions, which seem to be the equivalents of part of our green-sands,—viz. *a. Argiles et sables bigarrées,* containing much iron ore; *b. Argiles ostréennes,* (about 25 metres); *c. Calcaire à spatangus,* about 13 metres (about 42 feet).

§. In confirmation of the evidence which proves the superposition of our English equivalent of the Neocomian to the Wealden group, it may be remarked, that the fishes of the latter deposit are considered by M. Agassiz as more intimately allied with the oolitic than with the cretaceous series; and a similar observation has been made by Professor Owen with regard to the Wealden reptiles. If, therefore, a marine equivalent of our Wealden should be discovered, analogy would lead us to expect in its fossils a character approaching to that of the Oolites, from which M. D'Orbigny regards the whole of the cretaceous species as perfectly distinct:—and for such a deposit the best name would probably be that of "*Ma-*

* Comptes rendus, &c. de l'Acad. 22 Août, 1842.

rine Wealden" (*Veldien Marin*) which would at once indicate its position, and its peculiar relations.*

§. The lower cretaceous series on the Continent, which probably bears the greatest analogy to ours, is that of Hanover, described by M. Von Rœmer. Though differing at the upper part from ours by the absence of the Gault, the cretaceous series at the bottom is well defined, reposing on a complete equivalent of our Wealden, with nearly all the characteristic fossils of Surrey and Sussex. It is not easy to identify the upper member, which M. Von Rœmer supposes to be the same as the upper part of our Lower Green-sand, but which contains a great variety of fossils, and possibly may include some higher portions of the chalk.

The "*Hils-conglomerat*" of Von Rœmer contains some fossils identical with those of our Lower Green-sand, and some with the Neocomian, which he distinguishes from that division. It is supposed to rest upon the lower clay of Hils (Hils-thon), but has not been seen in apposition with it. Lastly, the Hils-thon is identified by its fossils with the Speeton clay †, and seems to correspond exactly with the clay of Atherfield, Hythe, and Surrey. Having had the pleasure of seeing M. Von Rœmer in his own country during the progress of his work, and having mentioned to him the probable identity of our Atherfield clay with that of "Hils," I am glad to find (p. 132.) ‡ that he has adopted this identification. He has shown that the Hils-conglomerat and this clay are in Hanover distinctly superior to the Wealden (Wälder-thon); a fact of importance, coinciding with our own sections in proving that the Neocomian (or that part of it at least which is identical with the Hils deposits), cannot be contemporaneous with the Wealden, *upon* which it is found to repose.

The Hanoverian series is farther interesting to the English geologist, as demonstrating that the fresh-water deposits contemporaneous with our Wealden were not quite of such limited extent as has been supposed.§

No limestone like that of Kent has been found in Hanover; and

* It may be worth while to ascertain by exact search in the department of the Aube, whether traces of the Wealden itself do not exist there below the Neocomian strata of M. Leymerie. It is stated by M. Dufresnoy that he had seen such indications near Angouleme; and they exist, according to M. Passy, in the vicinity of Beauvais, Pays de Bray. (See Bulletin de la Soc. Geol. de France; and Geol. Trans. vol. iv. p. 327.)

† Mr. Austen has recently expressed the same view respecting this clay, on different and independent evidence. — See Proceedings of Geol. Soc. June, 1843, vol. iv. p. 196.; but Professor Agassiz had previously assigned its correct place to the Speeton clay, having stated its identity with the *Neocomian* clay of Neufchâtel, at a meeting of the Geol. Soc. of France, April 16. 1838. Bulletin, &c. ix. p. 262.

‡ The work of M. Von Rœmer here referred to, "Die Versteinerungen des norddeutschlichen Kreide Gebirges," was published in Hanover in 1841.

§ In the work of M. Geinitz, on the Fossils of the Saxon Cretaceous Hills, (Dresden, 1839 to 1842,) it is intimated that the Wealden occurs below the cretaceous series in that country.

M. Von Rœmer considers the "yellow (Neocomian) limestone" as inferior to his Hils-conglomerate and Hils-clay, which, however, contain, like our Atherfield strata, many of the characteristic Neocomian fossils.

§. The Neocomian of the Crimea was described in the Letters of M. Dubois, published in 1837 in the Bulletin of the French Geological Society *: the writer having been the first, as he states, to discover an analogue of the Neufchâtel Neocomian in the Crimea, which presents fossil species so much alike in form that it was impossible to distinguish them; the general aspect of the beds also being perfectly the same. The lower bed, however, (which M. Dubois calls *Neocomien* in his section,) may well be a calciferous expansion of the lowest beds at Atherfield. It is characterised by the *Terebratula biplicata* and *Exogyra Couloni* (which Professor Edw. Forbes considers as identical with *E. lævigata* of Sowerby), two of the most characteristic shells of the lowest limestone of Kent. Above this, and next in succession, are about 40 feet of schist, which may represent our gault; and between this and the "étage supérieur de la craie," is a series like the Upper Green-sand.

Beyond the Caucasus another Neocomian deposit exists at Koutaïs and at Kèreïte, with fossils including small Nerinæa and Diceras like those of Mont Venteux, Grenoble, but accompanied by many other of the more usual Neocomian species.

It is not surprising that a statement by a naturalist and traveller of such authority as M. Dubois, should have fixed the attention of the French geologists, who had previously been occupied with the Terrain Neocomien. Nor was it unnatural that M. Dubois himself, in recurring to his native country, should have looked no farther; even if he had been acquainted with the English works concerning the beds below the Chalk, where he might have found other evidence of a striking affinity to what he has described.

§. On a general view of the strata beneath the Chalk as they exist upon our own coast, it is evident, that, notwithstanding the local variations, the Lower Green-sand has a definite and distinct character; extending throughout from the Wealden to the Gault, and bounded naturally by those two groups, with their distinct and peculiar fossils: and it is apparent, also, that there is no natural connection between the Upper and the Lower Green-sand. The distribution of the fossils in the lower sands is very unequal; they are numerous at the lower part, rapidly diminish upwards, and (at present) seem to be nearly wanting at the top †; the same species, however, are carried through the whole, the upper fossils being a selection, as it were, from those below. It is in-

* Bulletin, vol. viii. p. 385 — 389.

† Among the fossils of these beds near Folkestone, where phosphate of lime occurs in detached masses, are the remains of an *Astacus*, a plicated *Terebratula*, stem-like concretions of *Siphonaria*, and fragments of an oyster or *Gryphæa*. (See Geol. Trans. vol. iv. pp. 117, 118.)

deed not improbable that this absence of fossils may be local, or apparent, arising only from imperfect search.*

It may be observed of all the supposed equivalents of the Neocomian beds, that while some species are very generally diffused, others (and apparently the greater number) are peculiar to each place. So that although some remarkable continental forms are wanting in this country, we have in return many which do not occur elsewhere. The recent examination of the Isle of Wight has brought to light several species new to the continental faunas as well as our own. †

§. There can now be no reasonable doubt that the *Terrain Neocomien* of Central France, illustrated by M. Leymerie, as well as that of Neufchâtel, represent the lower and middle portions of our sections at Hythe and in the Isle of Wight. We want, probably, many species of the Aube; — but we have long possessed a great number of the characteristic Neocomian forms, and are daily adding to the list. The great difference consists in the absence of calcareous strata below the clay of Atherfield — (the *Argiles Ostréennes* of M. Leymerie); and the general question seems to be reduced to this: — Whether the presence of a certain number of characteristic fossils in two distant places is sufficient to establish geological identity — where not only the species, and the numbers of the fossils, and the mineral composition of the strata is varied, but where one of the two objects compared is so very much superior in thickness and extent to the other, as the deposits of the south of Europe are said to be with respect to that of central France, — of England, — of northern Germany, — and even, it would seem, of Neufchâtel itself. I believe that Geologists generally will be in favour of the identification by fossils — even in this extreme case — and will be disposed to regard the greatest diversity of mass and composition as nothing more than accidents — so called perhaps because we are not able to account for them.

If, on the other hand, it be found that, in the south or elsewhere, the lower members of the so-called Neocomian (for the true Neocomian and the Lower Green-sand are unquestionably the same) become distinguished notably by fossils new in form and in great numbers, it would seem that the name of that portion of the deposit so distinguished ought to be changed; the upper strata remaining with the cretaceous groups, and the lower being regarded as something new and different from the Cretaceous system. Whether

* The place in the series of the Blackdown beds of Devonshire is still a subject of doubt. But if (which is not wholly improbable) they belong to the upper part of the lower green-sand, the fossils in that division will then be nearly as abundant as they are in the lower members at Atherfield, &c. The siliceous casts are so remarkable, that if a similar deposit exists in many other parts of this country, it is unlikely that they should have remained unknown. In the upper part of the sands near Folkestone and Sandgate there are spongy siliceous concretions very like the Devonshire whetstone, but in which shells are very rare.

† *Ammonites asper* is one of the species generally diffused on the Continent, which has never yet been discovered here.

the new deposit thus supposed to exist shall be considered as the representative of our *Wealden* is still another question, which it is not necessary to enter into at present.

§. In the mean time, every Geologist who doubts the possibility of any part of our Lower Green-sand assuming the form of limestone, and, in that condition, acquiring great development and importance, will do well to examine the quarries of the Kentish Rag on the south-east of Maidstone *; where the stone which in other portions of this tract is concretional, and irregularly distributed through masses of soft calcareous tuff, assumes the form of uniform and continuous strata of compact limestone, ranging horizontally through large spaces, and adapted, by its firmness and durability, to all the purposes of the architect and mason. In these same quarries, it is probable, abundant proofs of identity with the Neocomian beds will be found: and this within twenty miles of a tract where nearly the whole deposit is composed of sand.

The *Boughton Group*, like that of Hythe and Kent in general, may answer to the Upper Neocomian limestone; as the fullers' earth and other clays of Atherfield correspond to the blue marl of Neufchâtel. It is useless to press exact identification between such distant deposits to an extreme, since we constantly find diversity even in the adjoining quarries of a continuous country, while on the other hand, Geologists are frequently surprised by minute points of empirical resemblance in very distant places.

§. The author of this paper had long since stated the objections to which the name of *Lower Green-sand* is exposed †, but thought it expedient in 1835 to adopt that term, on the ground of its universal employment in England, and its very general reception on the Continent.‡ On this ground he still thinks that this name ought, for the present, to be retained. If hereafter a change be thought desirable, he conceives that the new denomination should be taken from the *Isle of Wight*, where this portion of the subcretaceous groups was first distinguished, and where the sections on the coast are remarkable for their distinctness; and if such a case should arise, he suggests the name of *Vectine* for the strata now called Lower Green-sand, from the ancient name of that island — *Insula Vectis* of the Romans.

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3. *On the Junction of the* Lower Green-sand *and the* Wealden, *at the* Teston Cutting. By F. W. Simms, Esq. F.G.S.

The Author in this communication mentions that the beds resting on the Wealden in this locality (near Teston turnpike, on the

* Especially at Boughton.

† Annals of Philosophy, London, 1824.

‡ Geol. Trans. 2d Ser. iv. p. 105.

Maidstone junction of the South-Eastern Railway), seem to be identical with the marine clays found at Hythe and at Atherfield in the Isle of Wight. He adds, " There is also a bed of stone, not a continuous bed, but in concretionary masses, just above the junction, from which I obtained fossils, and which, I consider, represents the Atherfield rocks. This bed is also similar to the blocks taken from the cutting in the vicinity of Red Hill, near Reigate." He states also, that the same junction can be traced from the Teston Cutting in the direction of Maidstone, to near the Farley Cutting through the Kentish Rag. The junction of the Wealden and greensand clays is at the bottom of the valley, near the banks of the river Medway.

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4. *On the Section between* Blackgang-Chine *and* Atherfield Point. By Capt. L. L. B. Ibbetson and Prof. Edw. Forbes, F.R.S.

The accompanying Table exhibits the succession of strata, presented in ascending order, from the Wealden to the top of the Upper Green-sand, in the Isle of Wight, between Atherfield Point and St. Catherine's Down. The measurements of the upper portion were ascertained by trigonometrical survey, by Capt. Ibbetson, during the years 1833—38, those of the lower portion during the winter of 1842–3.

The following observations refer to that portion of the section which includes the Lower Green-sand strata, visited by Capt. Ibbetson and Prof. Forbes in March, 1844.

Between the Gault, as seen near Blackgang-Chine, and the Wealden at Atherfield Point, there are sixty-three distinct strata, the total thickness of which is 843 feet.

§ 1. *Description of the Strata.*

The lowest of these is a brown clay 3 feet thick, the base of which, at the junction with the Wealden, abounds in remains of fish. Through this clay are scattered many fossils, none of which are peculiar to this lowest bed, but mostly such as run on through the fossiliferous clays of the Lower Green-sand. This is succeeded by a harder bed or rock of a sandy texture, 2 feet thick, characterised by the presence of numerous fossils, among which the most remarkable is the *Perna Mulleti*, peculiar to this bed.

The clays which succeed are fossiliferous at the lower part, but very slightly so in the middle, where they contain numerous crystals of sulphate of lime. The uppermost of these clay strata, called the *Lower Lobster-bed*, is an impure fullers' earth, abounding with fossils, the most characteristic of which are numerous remains of *Astacus* scattered here and there, and found in so perfect a state that no time could have elapsed between the death of the animal and its entombment in the strata, sufficient to permit decomposition to take place. These clays present a thickness of 99 feet.

The hard noduliferous bed which succeeds, termed the *Lower*

Crackers, is full of *Gervillia aviculoides* and other fossils, and a similar stratum immediately above (the *Upper Crackers*) abounds in fossils peculiar to itself; indeed it is in this bed that most of such of the species as are limited in their distribution, occur. The Crackers occupy a thickness of 18 feet.

A clay bed, 20 feet thick, having the properties of fullers' earth, and similar in appearance to that preceding the Crackers, succeeds: it is very fossiliferous, and, like the other, abounds in Crustacea, mostly of species identical with those in the *Lower Lobster Bed.* This is termed in the section the *Upper Lobster Bed.* Ammonites and several bivalves accompany these crustacea.

A dark sandy clay succeeds, and is very fossiliferous; the characters of the fossils do not for the most part differ from those in the lowest clays. It is 20 feet thick.

This is capped by a band of Terebratulæ (mostly *T. Gibbsii*) imbedded in the stratum of dark sand, 22 feet thick. The Terebratulæ are in immense abundance and accompanied by Serpulæ.

A series of beds containing zones of *Gryphæa sinuata* imbedded in dark sand succeed. The Gryphæa zones mostly alternate with rows of large nodules containing *Crioceras* and *Scaphites.* This assemblage of Gryphæa zones is interrupted in the centre by a bed of sandy clay, 34 feet thick, very fossiliferous, and in which a great many of the fossils of the lower clays reappear. These *Gryphæa* and *Crioceras* beds, with the included clays, have a thickness of 155 feet.

Thirty feet of dark sand, containing prolific zones of Terebratulæ, chiefly *T. biplicata*, succeed, and form the base of a new succession of Gryphæa bands imbedded in dark sand; but the Crioceras nodules are absent. Twenty-four feet is the extent of this uppermost series of Gryphæa zones.

Above this the beds become ferruginous, and are occasionally, though rarely, mixed with dark blue clay. Fossils in some parts are abundant, but mostly in the state of casts, and no new forms appear. A lignite bed occurs in the lower part of these ferruginous beds, the lignites being arranged in zones. There are also here and there rows of calcareous concretions, usually of an oblong shape, and mostly having a direction towards the S.E., like the lines of oblique bedding occasionally presented in this part of the series.

At the top of Blackgang-Chine waterfall, a series of indurated ferruginous sand rocks alternating with dark sandy clays appear. The sand rocks are composed of quartz grains, and exhibit lines of oblique bedding. They contain no fossils.

At the uppermost part of the Lower Green-sand is a series of thin beds, alternately ferruginous and sand, lying immediately below the gault. Casts of a *Solarium* (species unknown), and of an *Ammonite*, were found in these bands.

§ 2. *Grouping of the Strata.*

The 63 strata enumerated may be grouped under three divisions, from their general mineral character.

A. The lower assemblage of clays, mostly fullers' earth, abounding in fossils, and in which the *Perna* sand-rock and the Cracker nodules are exceptional strata, indicating temporary conditions.

B. The region of *Gryphæa sinuata* sands, in which the *Terebratula* bands and upper clays are exceptional strata. This region may be subdivided into three portions, the two lower containing Crioceras nodules separated by the clay, and the upper containing no nodules. The noduliferous part of the series, and that which is free from the nodules, have each a zone of *Terebratulæ* for a base.

C. The region of ferruginous sands, which may itself be divided into two or three sections, the lowest of which is fossiliferous.

§ 3. *Chemical Peculiarities of the Beds.*

A chemical analysis of the composition of the several strata was next given; the principal results of which, affecting the distribution of the organic remains, are the following: —

The beds which are most fossiliferous are those containing most carbonate of lime. In the ferruginous beds, whether upper or lower, there are no traces of lime; but large quantities of peroxide of iron. This is true as well of the fossiliferous as the non-fossiliferous parts. The gault which caps the iron bands at Black-gang-Chine contains but few fossils, and those occur rarely. On analysis it was found to exhibit no trace of carbonate of lime, but a little gypsum; whereas the fossiliferous gault of Folkstone and other places abounds in carbonate of lime.

§ 4. *Indications of Conditions under which these Beds were deposited.*

At the close of the deposition of the Wealden, there appears to have been a sudden depression of the bed of the great freshwater estuary, and an influx of the sea. The first effect of such an influx would be the destruction of the animals in the estuary not adapted for living in salt water; hence we find a total destruction of the Wealden animals, the remains of which accumulate towards the point of the junction of that formation with the Lower Greensand; a fact which indicates the nature of the change. Even the *Cerithium*, although belonging to a genus many species of which are capable of living in the depths of the sea, was destroyed — notwithstanding that its appearance, only in the uppermost beds of the Wealden, indicates that its presence there was due to the commencement of the very state of things which eventually destroyed it. That the depression was of some extent, though not, perhaps, of very many fathoms, is indicated by the nature of the animals which lived in the first-formed sea-bed, and which, when they died, were often imbedded in the fine and, probably, fast depositing mud, in the vertical position which it is the habit of the animals of such genera as *Pinna* and *Panopæa* to assume when alive. After this, a temporary change followed, when an influx of sand, mingling with the calcareous mud, caused a state of sea-bottom peculiarly favourable to the presence of animal life. In this way were called into existence a multitude of species which were added to those which had appeared before them. This was, in fact, such a state of sea-bottom as is now presented by great shell banks; but it does not seem to have lasted long, and new depositions of mud appear to have extinguished some forms, whilst others suffered by the change only in the diminution of their numbers. In the midst of this muddy epoch, a temporary and peculiar condition of sea-bottom, forming what are now called the Crackers, called forth the presence of numerous mollusca, at first of various species of the genus *Gervillia*, and afterwards of *Auricula*, *Cerithium*, *Dentalium*, and other univalves, which appear to have enjoyed but a brief existence (as species) in this locality, since similar conditions were never afterwards repeated. The greater number of the Gasteropodous mollusca of the English Lower Green-sand are found within this very limited range. At the close of the deposition of this great mass of clay there was for a time a great multiplication of the individuals of certain *Brachiopoda* which had commenced their existence in the lowest beds. Thus *Terebratula Gibbsi* suddenly appears in immense abundance, covering the bottom of the sea, and predominating over the animals among which it had previously been but thinly scattered.

This lowest zone of *Terebratulæ* marks the commencement of a new state of sea-bottom where sands predominated over the clays, each interval of deposition being usually marked by the presence of a layer of *Gryphæa sinuata*, the period of rest being almost always sufficient to enable the *Gryphæa* to attain its full growth. Other bivalves are found with it, but in comparatively small numbers, and not such as are of gregarious habits. During the whole of this period enormous *Cephalopoda*, including species of *Crioceras* and *Scaphites*, frequented these seas, and when dead formed the nuclei round which calcareous and sandy matter collected and formed nodules. The death of these animals seems to have been connected with the periodical charging of the sea with sediment; hence we find them usually alternating with the zones of *Gryphæa*, and forming irregular bands in the intervening sedimentary deposits.

In the midst of this epoch of *Gryphæa*, there is a sudden reappearance of the muddy deposits, during the predominance of which those animals adapted for such a sea-bottom, and which had survived the cessation of the deposition of the fullers' earth, again multiplied, but the species which had become extinguished were not replaced by representative forms. This, however, did not last long, the sand again predominating with its zones of *Gryphæa* and lines of Crioceras nodules.

A temporary multiplication of *Terebratula sella* suddenly marks a change in the zoological conditions—for the *Cephalopoda* disappear, although the zones of *Gryphæa*, which animal does not appear to have been affected by the change, (probably a change in the depth of the sea,) go on as before, there being, however, no alternating lines of nodules. It would seem that the sea began to shallow, probably from elevation of the sea-bottom, until at last the *Gryphæa* itself disappears, the bands exhibit traces of the influence of currents, and become more gravelly; lignites, indicating a shallow sea, become common, form belts in the ferruginous sand, and in one place a bed in the wavy blue sand, at a time when much iron was deposited. The deposition of the peroxide of iron appears to have been connected with the disappearance of the majority of mollusca, though *Trigonia*, *Thetis*, and *Venus* occasionally occur in considerable numbers. In the uppermost strata scarcely any animal remains are found, and every thing appears to indicate a shallow and barren sea, previous to a new state of things, when a fresh series of clays (forming the Gault) being deposited, the majority of the animal forms which characterise the clays of the Lower Green-sand disappear, and are replaced by distinct species, representative in time.

§ *Bearing of these Observations on the Neocomian Question.*

These statements regarding the distribution of organic remains and indications of mineral conditions, presented by the Atherfield section, lead to a few considerations which bear importantly on the question which has been agitated respecting the separation of the lower part of the Lower Green-sand as a separate bed under the name of "*Neocomien.*"

1st. It would appear that there is but one system of organic remains throughout the series of beds, entitled Lower Green-sand, in this locality, and that whenever similar conditions are repeated, the same species reappear.

2d. Throughout the series of beds examined, we find that when a species is extinguished by a change of mineral conditions, it is not replaced by a representative species.

3d. That the influences which determine the distribution of species throughout are mineral and local, and that these mineral — in a great measure, chemical — conditions enable us to divide the strata into groups, which groups, being from their very nature local, cannot be regarded as other than artificial, and have no claim to be numbered as subdivisions in time of the great series of cretaceous deposits.

A change of mineral conditions may determine the absence of certain species; but, unless when, under a repetition of similar mineral conditions, such species are replaced by representative species, or the general assemblage of species is replaced by representative and distinct forms, the change cannot be considered as indicating a great sectional division.

It appears to us, therefore, that the evidence of the Atherfield section maintains the unity of the Lower Green-sand; and that the accumulation of clays at its base can be regarded only as a local phenomenon.

Thickness and Description of Strata.

[Gault, with Fossils.]

No.		Thickness in feet.
64.	Iron band, fragments of fossils - - - - -	1
63.	Dark sand - - - - - - -	2
62.	Iron band - - - - - - -	1
61.	Dark sand - - - - - - -	2
60.	Iron band - - - - - - -	1
59.	Dark sand - - - - - - -	2
58.	Iron band - - - - - - -	1
57.	Iron clay and sand - - - - - -	12
56.	At the top, white sand; at the bottom, black sand and clay -	11
55.	Iron at the top, and sand - - - - - -	3
54.	Iron at the top, and dark yellow sand - - - -	4
53.	Yellow sand and clay - - - - - -	6
52.	Blue clay - - - - - - - -	2
51.	Yellow and white sand, very quartzose - - - -	15
50.	Above, white sand, tolerably solid at the top, clay and sand in the middle, and white sand at the bottom - - - -	19
49.	Black clay (perhaps lignite) with brown sand in thin laminæ, tolerably even, but in some parts wavy - - - -	17
48.	Yellow sand and blue clay, thinly laminated in some parts, wavy at the bottom, the sand white - - - - -	31
47.	A second white sand, tolerably solid - - - -	13
	(No. 31. crops out on the shore, a little to the west of Blackgang Chine.)	
46.	Blue sand and some clay - - - - - -	32
45.	A line of nodules at the top, and blue sand and some clay below -	33
44.	Third white sand, with tolerably solid yellow at the bottom. This stratum runs up from Rocken End - - - -	22
43.	Three sorts of black clay and sand - - - -	40
42.	Iron, fossiliferous, top of Blackgang-Chine Waterfall -	1
	(No. 24, (the Terebratula zone) crops out on the shore.)	
41.	Sand and clay varying from brown to black - - -	4
40.	Iron, fossiliferous - - - - - - -	1
39.	White sand, tolerably solid, yellow on the surface; near the top there are laminæ of pebbles; the bottom of it is in thin laminæ, divided by blue sand and clay - - - - - -	11
38.	Iron, fossiliferous - - - - - - -	1
37.	White sand - - - - - - -	10
36.	Blue clay and sand, the blue very conspicuous - - -	1
35.	Iron at the top, with fossils; dark sand below - - -	26
	(Nos. 22. and 23. nodules crop out on the shore.)	
34.	Iron at the top, fossiliferous, and dark sand below - - -	18
33.	Iron, fossiliferous, and grey sand below, much used for making mortar. Bottom of Blackgang - - - - -	28
	(No. 21. nodules crop out on the shore.)	
32.	Iron, fossiliferous, and white sand below - - - -	9
31.	Thin very wavy laminæ of black clay (or lignite) full of pyrites, with a layer of spongiform nodules near the bottom - -	25
	(No. 20. nodules crop out on the shore.)	
30.	Iron at the top, fossiliferous, with dark sand - - -	2

Thickness and Description of Strata.

No.		Thickness in feet.
29.	Iron, fossiliferous, with dark sand. Above the boat-houses, Ladder Chine - - - - - - - -	3
	(No. 19*a* crops out on the shore.)	
28.	*Gryphææ* at the top, with dark sand - - - -	8
27.	*Gryphææ* at the top, with dark sand - - - -	3
26.	*Gryphææ* at the top, with dark sand containing Terebratulæ, Echini, &c. &c. &c. - - - - - - -	4
25.	*Gryphææ* at the top, with dark sand - - - -	9
	(Nos. 15, 16, 17, 18, 19. *Gryphæa* and *Crioceras* nodules crop out on the shore.)	
24.	*Terebratulæ* at the top, with dark sand - - - -	30
23.	Nodules containing *Crioceratites*, a layer of *Gryphæa* under them, with dark sand - - - - - - -	7
	(No. 14. or *Scaphite* nodules, crop out on the shore.)	
22.	*Crioceras* nodules; a zone of *Gryphæa*, with dark sand - -	13
21.	*Crioceras* nodules, a zone of *Gryphæa*, with dark sand containing *Gryphæa* irregularly placed - - - - - -	3
20.	*Crioceras* nodules with Ammonites - - - - - -	26
19*a*	At the top black sand and clay, a zone of *Gryphæa* in the centre, with clay under, very fossiliferous - - - -	34
19. 18. 17. 16. 15.	*Crioceras* nodules with zones of *Gryphææ*, dark sand between them	38
	(Nos. 13. 12. 11. 10. crop out on the shore below these zones.)	
14.	Nodules containing *Scaphites; Gryphæa* zone under; *Ostrea carinata*, &c. at the top of dark sand; at the bottom layers of *Serpulæ, Terebratulæ*, &c. &c. - - - - -	16
	(No. 8 crops out on the shore below.)	
13.	Zone of *Gryphæa;* below red sand and clay, full of *Gryphææ, Ostreæ, Terebratulæ, Pectens, Serpulæ*, &c. &c. &c. very fossiliferous, and in some places divided into four zones of *Gryphææ* - -	22
	(No. 7. crops out on the shore.)	
12.	Layer of *Terebratulæ*, dark sand at the top, and a layer of small nodules and yellow sand at the bottom - - - -	22
11.	Dark clay, red at the top, and very fossiliferous - - -	20
	(No. 6. crops out on the shore.)	
10.	Upper lobster bed, dark sand at the top, fullers' earth in the middle, and sand at the bottom, very fossiliferous - - -	45
9.	Upper Crackers; nodules at the top, clay and sand, very fossiliferous	6
8.	Lower Crackers; nodules at the top, full of Gervilliæ, &c. &c., with brown sand and clay, fossiliferous - - - -	12
	(No. 4., or *Perna Mulleti* bed, crops out on the shore.)	
7.	Lower lobster bed, fullers' earth, very fossiliferous - - -	29
6.	The best fullers' earth with clay at the bottom, some fossils, but not very plentiful, and in some parts full of large crystals of sulphate of lime - - - - - - - - -	64
5.	Layer of small nodules, clay at the bottom containing fossils -	6

Thickness and Description of Strata.

No.		Thickness in feet.
4.	*Perna Mulleti* bed, with numerous *Gryphææ, Ostreæ*, &c. &c. very fossiliferous	3
3.	Clay, very fossiliferous, containing layers of fish-bones, teeth, &c. but regular	3

(WEALDEN.)

In the accompanying Table are given the ranges of such of the fossils of the above strata as were collected and noted by the authors on the spot.

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5. *Description of the Mouth of a* HYBODUS *found by* MR. BOSCAWEN IBBETSON *in the* ISLE OF WIGHT. By SIR PHILIP MALPAS DE GREY EGERTON. Bart. M.P., F.R.S., F.G.S.

THE present memoir is the result of the examination of an Ichthyolite discovered by Mr. Boscawen Ibbetson in the Isle of Wight, near the junction of the Lower Green-sand with the Wealden, and sent to me in the hopes that it might tend to show to which of the two formations this bed should be assigned. The evidence it affords on this question is neither direct nor conclusive, inasmuch as it is an undescribed species, and consequently any deductions beyond those based upon general affinities would be unwarrantable. In another point of view, however, this specimen is of high scientific value, as it sets at rest the long-mooted questions of the relative characters of the upper and lower teeth, and their general contour in the individuals composing the genus *Hybodus* so extensively occurring in the secondary strata. Mr. Ibbetson has had the rare fortune to bring to light the entire mouth of a fish of this genus. The left side is slightly crushed, but the other retains its natural form, and the greater portion of the teeth in both the upper and the lower jaw. The former measures 10 inches, and appears to have carried twenty-four teeth in the front series; the latter measures 7½ inches, and has nineteen teeth in series, one on the symphysis and nine on either side. Two rows of succession teeth are traceable behind the front series. The mouth is slightly open, and when seen in profile is more arcuate than in the recent sharks. The upper jaw has a broad notch for the reception of the thickened symphysis of the lower mandible. The teeth have a central cusp, rather hooked, and two secondary cusps on either side; the enamel is strongly plicated; the teeth only recently brought into use have the plicæ extending to the apex. The bases are wide, and have the rugose character so generally found in this genus. The lateral teeth present the same characters as the more central ones, but are rather smaller near the angle of the jaw.

SHOWIN THE SPOT) IN THE ISLE OF WIGHT.

RBES.

The object c ence their range in the lower beds of that formation, and that of the Cretaceous Series.

ations above or below the Lower Green Sand.

3. Lowest Clay.	nge.	14. Middle Clay.	Range.	15—16. Middle Gryphæa Sands.	Range.	19*a*. Upper Clay.	Range.
Panopæa mandibula	12	Cypricardia undulata.	14	Crioceras Bowerbankii.	15—29	Cardium ? imbricatorium.	19*a*
Panopæa plicata	12	Nucula spatulata	14	Scaphites giganteus.	15—29	Anomia radiata.	19*a*
Hemicardium Austen	12	Gervillia solenoides.	14—56	Nautilus radiatus	15—19	Arca securis	19*a*
Venus ? parva -		Lima elongata -	14—Glt.			Belemnites Sp. -	19*a*
Venus ? fenestrata	—29	Spatangus retusus.	14—29				
Arca Raulini -	12						
Nucula (scapha)							
Trigonia caudata							
Perna Mulleti -							
Gervillia aviculoide							
Ostrea carinata -							
Pecten 5-costatus							
Pecten obliquus -							
Pecten orbicularis							
Rostellaria Parkinso							
Rostellaria bicarinat							

To face page 414.

TABLE

SHOWING THE DISTRIBUTION OF LOWER GREEN SAND FOSSILS (AS NOTED ON THE SPOT) IN THE ISLE OF WIGHT.

BY CAPTAIN BOSCAWEN IBBETSON AND PROFESSOR E. FORBES.

The object of this table is to show that the majority of species composing the Lower Green Sand Fauna, as observed in the Isle of Wight, commence their range in the lower beds of that formation, and that the species assembled in the lowest beds include many common to the Lower Green Sand and other divisions of the Cretaceous Series.

Note. — The Figures refer to the Beds as numbered in the Table of Strata; the Roman Letters in the second columns to Formations above or below the Lower Green Sand. Names of Species within brackets have been applied since the Paper was read.

In the beds above 19*a* no species were observed to commence their range.

3. Lowest Clay.	Range.	4. Perna Band.	Range.	6—7. Lower Lobster Clay.	Range.	8—9. Crackers.	Range.	10—11. Upper Lobster Clay.	Range.	12—13. Lower Gryphæa Sands.	Range.	14. Middle Clay.	Range.	15—16. Middle Gryphæa Sands.	Range.	19*a*. Upper Clay.	Range.
Panopæa mandibula -	3—U.G.S.	Solen Warburtoni -	4—9	Corbula striatula	6—10	Cardium Ibbetsoni -	8—9	Astacus. No. 2. -	10—11	Modiola æqualis	12	Cypricardia undulata.	14	Crioceras Bowerbankii.	15—29	Cardium ? imbricatorium.	19*a*
Panopæa plicata -	3—U.G.S.	Panopæa (Neocomiensis)	4—14.	Gervillia linguloides.	6—10	Venus Orbignyana -	8—9	Pholadomya Martini.	10—20	Gryphæa conica	12	Nucula spatulata	14	Scaphites giganteus.	15—29	Anomia radiata.	19*a*
Hemicardium Austeni -	3—15	Astarte obovata - -	4	Ammonites Deshayesii.	6—10	Nucula obtusa -	8—U.G.S.	Cardium peregrinosum.	10—11	Terebratula oblonga.	12	Gervillia solenoides.	14—56	Nautilus radiatus	15—19	Arca securis	19*a*
Venus ? parva - -	3—57.	Venus striato-costata -	4—19*a*	Astacus. No. 1. -	6—10	Tellina vectiana -	8—9	Serpula Sp. -	10—20	Ammonites Martini.	12—29	Lima elongata -	14—Glt.			Belemnites Sp. -	19*a*
Venus ? fenestrata -	3	Corbis corrugata -	4			Gryphæa harpa -	8—14	Serpula Sp. -	10—15	Crinoidal stems	12	Spatangus retusus.	14—29				
Arca Raulini - -	3—19*a*	Cyprina angulata -	4—9			Dentalium cylindricum.	8—U.G.S.										
Nucula (scapha) -	3—29	Cardium (Cornuelianum)	4—14			Rostellaria glabra -	8—19										
Trigonia caudata -	3—U.G.S.	Thetis minor - -	4—U.G.S.			Rostellaria Fittoni -	8—9										
Perna Mulleti - -	3—4	Lithodomus (oblongus)	4			Tornatella marginata	8—9										
Gervillia aviculoides	(Ool.) 3—U.G.S.	Trigonia aliformis -	4—U.G.S.			Tornatella albensis -	8—9										
Ostrea carinata - -	3—Ch. M.	Trigonia dedalæa -	4—U.G.S.			Cerithium (Lallierianum.)	8—9										
Pecten 5-costatus -	3—Ch.	Gryphæa sinuata - -	4—29			Cerithium Phillipsii	8—9										
Pecten obliquus - -	3—U.G.S.	Hinnites ? Leymerii -	4			Cerithium turriculatum.	8—9										
Pecten orbicularis -	3—U.G.S.	Ostrea Leymerii -	4			Cerithium (Neocomiense.)	8—9										
Rostellaria Parkinsoni	3—Glt.	Plicatula placunæa -	4			Solarium sp. - -	8										
Rostellaria bicarinata -	3—14	Terebratula Sella -	4—41			Natica (Cornueliana)	8—9										
		Terebratula Gibsii -	4—41			Ammonites Hambrovii	8—9										
		Lingula truncata -	4														
		Natica rotundata -	4—9														
		Cidaris Sp. - - -	4—19														
		Astræa Sp. - - -	4														

The central teeth, also, are rather smaller than those immediately flanking them. The teeth of the upper jaw are precisely similar to those in the lower. In neither do we find any material increase of obliquity in the cusps as they recede from the centre. The cartilaginous alæ of the mouth are distinctly traceable; they increase in width rapidly from the symphysis of the lower jaw, and attain their maximum expanse at the angle of the mouth. Behind these are some traces of the hyoidal arch. It is probable from the appearance of the matrix which envelopes it, that with a little careful cleaning a considerable portion of the head might be disclosed. In its present condition, the only part of the cranial cartilages to be distinguished is a section of the prosencephalic cavity.

The geological inferences afforded by this specimen are briefly told. The species is new. The genus is undoubtedly Hybodus. This genus attains its maximum expansion in the Oolitic series, but it ranges from the Muschelkalk to the Chalk inclusive. The only evidence of its occurrence in the latter formation is a fragment of an Ichthyodorulite in the Mantell collection. The teeth have not yet been found in any strata more recent than the Wealden. As far therefore as the evidence goes, it leads to the supposition that a bed containing teeth of the genus Hybodus is most likely to be of an age anterior to the cretaceous system. In a zoological point of view, this specimen is of more importance, inasmuch as it fully corroborates the views advanced by Agassiz, "that most probably the Hybodonts differed little from the recent sharks in general aspect." It also authenticates the numerous species established by that distinguished naturalist from the characters of isolated teeth. We find in many of the recent sharks, in Carcharias for example, the discrepancy between the teeth of the upper and lower jaw so great, that it would be considered quite warrantable to describe them, if found detached, as different species. It was from a just appreciation of these difficulties that Agassiz has always professed his names and characters of the placoid teeth to be descriptive of specimens, and to be considered provisional as regards specific arrangement, until evidence should be found authorising or annulling the continuance of the titles as applicable to species. Mr. Ibbetson's specimen shows that in the genus Hybodus there was no difference between the teeth of the upper and lower jaw, and less variation, according to position, than in the recent sharks; consequently the descriptive characters given in the *Poissons Fossiles* will hold good as specific distinctions. The Hybodonts, then, of the secondary strata differed only from the sharks of the recent period in those modifications which adapted them to the circumstances under which they existed. The form of the mouth was nearly similar; from this we may argue a similarity of shape and an analogous arrangement of the fins to enable them to seize their prey. If they subsisted upon fish, which is most probable from the form of the teeth, we find in the denser structure and hard enamel coating of these organs, provisions to enable them to grapple with the Ganoid fishes of that period; while in the powerful fin bones with which they were armed, we see weapons of defence against the aggressions of the Piscivorous Saurians with which they were destined to coexist. I propose to name this species *Hybodus basanus.**

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6. Extracts were read from letters of M. Dubois de Montpereux to Mr. L. L. Boscawen Ibbetson, on the comparison of the Neocomian beds of the Caucasus and the Crimea with those of Neufchâtel, and from Professor Agassiz to Mr. Ibbetson, on the age of the Neocomian beds of Neufchâtel.

May 15, 1844.

W. J. Blake, Esq., of Danesbury, was elected a Fellow of this Society.

The following communications were made:—

1. *On some* Crustaceous Remains *in* Carboniferous Rocks. By W. Ick, Esq., F.G.S.

This communication accompanied two electrotype casts of the specimens alluded to. The one was found in the white ironstone measures at Ridgeacre Colliery, and the author states,—"I at first thought it might be the head and carapace of a new species of *Eryon.* except that the known species from the Solenhofen slate are much more deeply notched on the edges of the carapace, and the apparently spinous prolongation of the head and some other details do not agree. The white ironstone in which it was found is a bed in the lower part of the field below what is called the New Mine coal. It is the bed in which the finest remains of Megalichthys have been found."

"The other fossil is in an ironstone nodule. The form is not so well defined as in the first, and I dare not venture to guess to what it may be referred."

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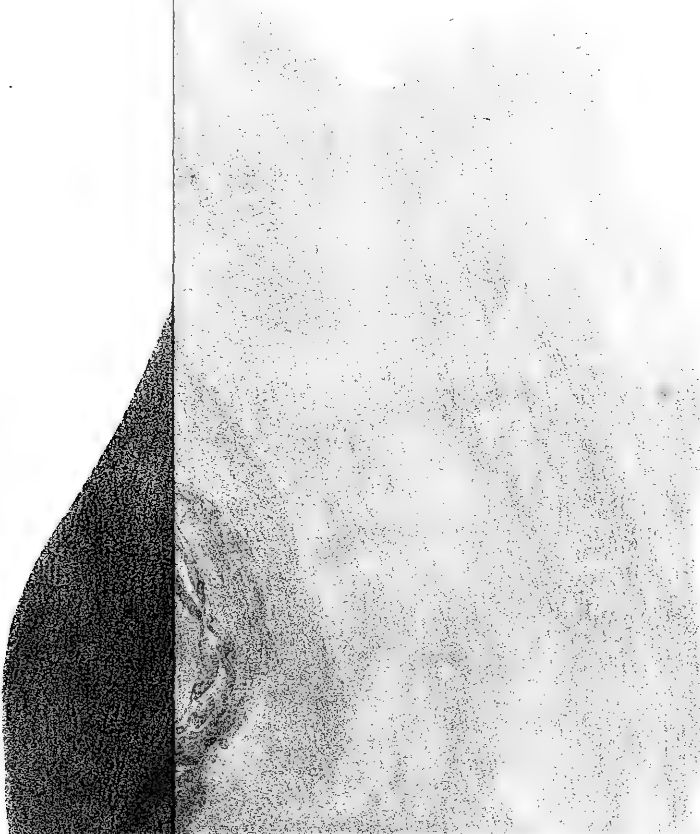
2. *On the probable Age and Origin of a Bed of* Plumbago *and* Anthracite *occurring in mica-schist near Worcester, Massachusetts.* By C. Lyell, Esq., M.A., F.R.S., F.G.S., &c.

A bed of plumbago and impure anthracite described by Professor Hitchcock in his "Geology of Massachusetts" is found interstratified with mica-schist near Worcester, forty-five miles due west of Boston. It is about two feet in thickness, and has been made use of both as fuel and in the manufacture of lead-pencils. It is much mixed up with the associated rock, has the touch and somewhat of the lustre of plumbago, and gives a streak on paper. It is occasionally iridescent like coal, contains pyrites, which is also found in the associated clay slate and garnetiferous mica-schist,

* The accompanying plate exhibits the appearance of the fossil embedded in the rock, and partially cleared.

Pl. IV.



Hybodus Basanus Eger.

both of which are impregnated with carbonaceous matter. This plumbaginous rock presents numerous polished surfaces or slickensides, on some of which are delicate parallel striæ, which reminded me so strongly of the finely striated leaves common in coal, that I had first supposed them to be of the same nature; and was thus induced to search very diligently, but in vain, for vegetable impressions. In the old mine of plumbaginous anthracite about two miles to the north-east of Worcester, the accompanying clay-slate and mica-schist, (the latter containing garnets and veins of asbestus), dip towards the north at an angle of between 30 and 40 degrees, and a railway cutting east of Worcester, and to the south of the old mine above mentioned, has finely exposed to view the mica-slate and clay-slate with some layers of quartz inclosing a bed of similar plumbaginous anthracite; some of which has the iridescence of peacock coal. Professor Hitchcock has traced this group of strata in a north-easterly direction 50 miles, to the Merrimac river, and the beds are continued with the same strike, in a south-westerly direction, for many miles. In their course they exhibit a great variety of crystalline strata, and the mica-slate sometimes alternates with gneiss.

The schists including plumbago, at Worcester, as above mentioned, are separated from the anthracite occurring on the borders of Rhode Island and Massachusetts, by a district of gneiss and hornblende slate about thirty miles wide. The anthracite of those slates is impure and earthy, but has been worked for coal at Wrentham, Cumberland, Mansfield, and other places, where, in the accompanying carbonaceous and pyritiferous slates, I collected numerous impressions of the most common coal plants, such as *Pecopteris plumosa*, *Neuropteris flexuosa*, *Sphenophyllum*, *Calamites*, &c. This earthy anthracitic coal, as well as the accompanying slates, contain pyrites, as at Worcester; and the anthracite exhibits the same glazed surfaces and slickensides; but it does not soil the finger like that of Worcester, and its specific gravity has been shown by Dr. Jackson and Professor Hitchcock to be less than that of Worcester, but greater than that of the anthracite of Pennsylvania. There are layers and veins of quartz in the slates and micaceous sandstones forming the roof of this anthracite, affording another point of analogy between this series and the quartziferous rocks at Worcester. I have also seen numerous specimens from the anthracite and bituminous slate of the neighbouring district of Mansfield, in which the usual coal plants were imbedded; but the slate was more crystalline. I was presented by Professor Hitchcock with a specimen of distinct mica slate from this neighbourhood, in which rounded nodules of granite and quartz rock are included; and in the contiguous parts of Rhode Island a conglomerate belonging to what has been called the greywacké formation has been observed by Dr. C. T. Jackson (Survey of Rhode Island, p. 70.) to pass downwards into mica slate. The rocks of the coal measures now under consideration are accompanied by a red sandstone, which I examined at Attleborough, a few miles from Wrentham before mentioned. There is a conglomerate subordinate to it, and it may, with all probability, be referred to the old red sandstone which occurs beneath the coal in Pennsylvania; although, in the absence of fossils, the disturbed state of the strata, and the frequent concealment of their outcroppings by a thick covering of drift, it is usually difficult to determine the exact order of succession. It is, however, important to observe that the whole of this series, which Professor Hitchcock now inclines to refer to the coal and old red sandstone, was formerly called greywacké, and styled the transition formation, in consequence of the semi-metamorphic condition of several of the rocks. Their conversion into crystalline strata, in the immediate neighbourhood of masses of granite and syenite, is often complete. But besides this kind of alteration, resembling the effect of dykes and veins of intrusive igneous rocks, there is evidence here, as in the Alps of the Canton of Berne and elsewhere, of a more extensive and general change by chemical or plutonic action, affecting, with greater or less degrees of intensity, dense masses of stratified rocks.

Although many impressions of plants have been found in this anthracite formation, on the southern borders of Massachusetts and Rhode Island no traces of shells or corals have been discovered. In like manner we find an absence of all fossils except vegetable remains, in the anthracite coal district of Pennsylvania, and no fossils of any kind in the subjacent conglomerates and red sandstones.

The strata of conglomerate at Brooklyn, near Boston, and the greywacké slates and sandstones of that neighbourhood, some of which pass into metamorphic rocks, and in which no plants or other organic remains have as yet been found, are doubtless referable to the same carboniferous and Devonian formations as those above described.

After traversing this region in several directions, it appeared to me very probable that the stratified rocks, containing the plumbaginous anthracite of Worcester, consisted originally of similar sedimentary strata, which have been so altered by heat and other plutonic causes as to assume a crystalline and metamorphic texture, by which the grits and shales of the coal have been turned into quartzite, clay-slate, and mica-schist, and the anthracite into that state of carbon which is called plumbago or graphite.

The progressive debituminisation of the coal of the United States, as we proceed from Pittsburgh to the eastern and more disturbed axes of the Alleghany mountains, as pointed out by Professor H. D. Rogers, lend support to this conjecture.* In the Rhode Island anthracite, which is less combustible than that of Potsville, Pennsylvania, the change seems to have been carried farther; the volatile ingredients of the original coal having been still more completely expelled. In the impure plumbago of Worcester, we may have the last step in the series of transmutation, where only 3 per cent. of gaseous matter remains, where all traces of fossil plants

* See Appendix.

and vegetable structure have been obliterated, and where the lithological character of the accompanying sedimentary rocks has been entirely altered. I may remark that the Silurian and Devonian formations, which are so largely developed in the United States, yield no beds of coal or anthracite which could by metamorphosis be supposed to become turned into such a carbonaceous stratum as that of Worcester.

I shall conclude by observing that the difference of strike between the mica-schist containing plumbago at Worcester, and the nearest carboniferous rocks of Rhode Island and Massachussetts, affords no argument against the theory of both having belonged originally to the same group of sedimentary strata. In New England, and in Nova Scotia, the coal-measures frequently deviate widely from the same strike in continuous districts, and the direction of continuous anticlinal axes in the Alleghany mountains, composed throughout of similar silurian and carboniferous rocks, has been shown by Professors W. B. and H. D. Rogers to vary more than 40° in different sections of that chain.

Appendix. — *Analysis of Specimens of* Bituminous *and* Anthracitic Coal *of the* United States, *and of the* Plumbaginous Anthracite *alluded to in the foregoing Paper.*

In the Transactions of the Association of American Geologists, 1840-42, p. 470., Professor H. D. Rogers traces the gradation in the proportion of volatile matter in the coal, as we cross the Appalachian basin from the S. E. towards the N. W. In the most southeasterly basins, where the coal is a genuine anthracite, he states that the quantity of gaseous matter, chiefly hydrogen, varies from 6 to 14 per cent., as, for example, in the anthracite coal-fields of Pennsylvania.

Secondly, further towards the N. W., in the Alleghany mountain of Pennsylvania, and the Potomac basin and others in Virginia, the proportion of volatile matter varies from 16 to 22 per cent.

Thirdly, westward of the Appalachian mountains, in the wide coal-field watered by the Ohio river and its tributary, the amount of volatile matter is from 30 to 40, and even 50 per cent. With a view of testing these results, I submitted to my friend Dr. J. Percy, of Birmingham, for examination, specimens of coal, first, from the Pennsylvanian anthracite of Lehigh and Mauch Chunk, in which the proportion of gaseous matter (hydrogen, oxygen, and nitrogen) proved to be about 5 per cent.; secondly, from Frostburgh in Maryland, a part of the Appalachian mountains further west, where the strata have only undergone a moderate degree of disturbance. In this coal, the proportion of volatile matter to the carbon and ash was found to be about 9½ per cent.; and, thirdly, in the horizontal and bituminous coal of Pomeroy, on the Ohio, the proportion of gaseous matter was determined to be about 19 per cent.

The theory of Professor Rogers is borne out by these analyses, but, as the chemical results are exceedingly different, the proportion of volatile matter being only half that cited by the American geologist, I think it right to append a letter which I have received from Dr. Percy, in order to show the details of his manipulations, and the pains bestowed by him on an analysis which, in the case of anthracite, is exceedingly difficult.

Letter from John Percy, M. D. to C. Lyell, Esq.

Birmingham, Feb. 17. 1845.

My dear Sir,

I have now much pleasure in transmitting to you, in a complete form, the analyses of the specimens of coal which you sent me. The ultimate analysis of coal requires considerable care, as it is difficult, by the ordinary method of combustion with an oxidising body, to effect completely the oxidation of all the carbon. In every instance I have used chromate of lead as the oxidising body, and have employed a degree of heat sufficient partially to melt the Bohemian-glass combustion tube, although defended by inclosing it in thin sheet copper. I have been particularly careful not only to mix, but to *triturate*, the coal powder and the chromate of lead intimately together. The coal powder has been dried in the oil-bath at a temperature ranging between 110° and 120° Centig. The analysis of coal consists of three parts; viz.

1. Of the determination of the carbon and hydrogen.
2. Of the determination of the nitrogen.
3. Of the determination of the ash.

The oxygen, of course, is found by deducting the sum of these from the weight of coal employed in analysis. As I have already stated, the carbon and hydrogen were found in the usual way by burning with chromate of lead, as in an ordinary organic analysis. The nitrogen was ascertained by Will's method, which consists in heating the coal with the mixture of soda-lime in a combustion tube; all the nitrogen is evolved in the form of ammonia, which is retained in the receiver, containing hydrochloric acid; the hydrochlorate of ammonia thus formed is converted into ammonio-chloride of platinum, from which the quantity of nitrogen is estimated. Lastly, the ash was found by incinerating in a platinum crucible until every speck of carbonaceous matter had disappeared.

I shall now proceed to give you all the data obtained by analysis: —

1. Pomeroy Coal, Ohio. Colour of the powder, deep snuff-brown.

1st Analysis.

4·878 grs. gave

Water,	2·46 = Hydrogen,	0·273, or	5·59 per 100.
Carbonic Acid,	13·74 = Carbon,	3·747, or	76·81 do.

2nd Analysis.

5·686 grs. gave

Water,	2·96 = Hydrogen,	0·328, or	5·76 per 100.
Carbonic Acid,	15·97 = Carbon,	4·355, or	76·59 do.

Nitrogen Analysis.

6·90 grs. gave

Metallic Platinum, 0·836 = Nitrogen, 0·118, or 1·71 per 100.

Incineration.

6·44 grs.	gave of Ash,	0·28, or	4·34	per 100.
2·26 grs.	do.	0·11, or	4·86	do.
Mean	- - -		4·60	do.

2. Mauch Chunk, or Pennsylvanian Anthracite. Lustre somewhat glistening; powder much blacker than that of the preceding variety.

1st Analysis.

6·92 grs. gave
Water, 1·50 = Hydrogen, 0·166, or 2·398 per 100.
Carbonic Acid, 21·44 = Carbon, 5·847, or 84·49 do.

2d Analysis.

6·02 grs. gave
Water, 1·33 = Hydrogen, 0·147, or 2·441 per 100.
Carbonic Acid, 18·75 = Carbon, 5·113, or 84·93 do.

3d Analysis.

6·127 grs. gave
Water, 1·41 = Hydrogen, 0·156, or 2·546 per 100.
Carbonic Acid, 19·11 = Carbon, 5·211, or 85·04 do.

Nitrogen Analysis.

I heated some of the coal on a test-tube with soda-lime. Red litmus paper was immediately turned blue; and, on holding the stopper of the hydrochloric acid bottle over the tube, dense white fumes appeared. The coal, therefore, contained nitrogen.

7·18 grs. gave
Metallic Platinum, 0·616 = Nitrogen, 0·0874, or 1·217 per 100.

Incineration.

18·17 grains	gave of Ash,	1·85, or	10·18	per 100.
6·75	do.	0·69, or	10·22	do.
Mean	- - - -		10·20	

3. Frostburgh, Maryland. Colour of powder, brownish black.

1st Analysis.

4·85 grs. gave
Water, 2·10 = Hydrogen, 0·233, or 4·804 per 100.
Carbonic Acid, 13·91 = Carbon, 3·793, or 78·20 do.

2d Analysis.

6·54 grs. gave
Water, 2·92 = Hydrogen, 0·324, or 4·954 per 100.
Carbonic Acid, 18·89 = Carbon, 5·151, or 78·76 do.

3d Analysis.

5·889 grs. gave
Water, 2·45 = Hydrogen, 0·272, or 4·618 per 100.
Carbonic Acid, 17·03 = Carbon, 4·644, or 78·85 do.

Nitrogen Analysis.

6·83 grs. gave of
Metallic Platinum, 1·145 = Nitrogen, 0·162, or 2·37 per 100.

Incineration.

14·27 grains gave of Ash, 1·66, or 11·63 per cent.
2·28 do. 0·27, or 11·84 do.

Mean - - - - 11·73

In the first analysis, both of the Mauch Chunk and the Frostburgh Coal, there is a very decided error in the determination of the carbon; and the difference in the per centage of hydrogen in the analyses of the last-mentioned coal is much greater than I should wish. In the following table, therefore, we will take the mean of the *second* and *third* analyses only of the two varieties of coal in estimating the per centage of carbon; and the mean of the three of each variety in estimating the per centage of hydrogen. We shall not then, I am sure, commit any serious error: —

	Pomeroy.	Frostburgh.	M. Chunk.
Carbon - -	76·70	78·80	84·98
Hydrogen -	5·67	4·59	2·45
Oxygen - -	11·32	2·51	1·15
Nitrogen - -	1·71	2·37	1·22
Ash - -	4·60	11·73	10·20
Total - -	100·00	100·00	100·00

4. Worcester Plumbaginous Anthracite.

I selected for analysis those small fragments which appeared to be most free from the associated rock. It had the touch and somewhat of the lustre of plumbago; it gave a streak on paper, and the mortar in which it was triturated became coated and polished, as if from common plumbago. Dried at 120° centig.

Analysis.

8·00 grs. gave of
Water, 0·670 = Hydrogen, 0·0744, or 0·926 per 100.
Carbonic Acid, 8·316 = Carbon, 2·268, or 28·350 do.

Nitrogen.

I found I had not sufficient of the same specimen to make a nitrogen analysis. I ascertained, however, that what remained of the other fragments contained nitrogen. On heating in a test-tube with the soda-lime mixture, ammonia was evolved, as proved by

1. Red litmus-paper being turned blue;
2. By the appearance of dense white fumes on holding the stopper of the hydrochloric acid bottle near the mouth of the tube;
3. And, also, characteristically by the smell.

Incineration.

6·745 grains gave of Ash, 4·625, or 68·569 per 100.

We have, then,

Carbon	28·350
Hydrogen	0·926
Oxygen*? / Nitrogen	2·155
Ash	68·569
	100·000

I also incinerated another portion, which evidently contained a much larger quantity of rock. Dried at 120° centig.

28·70 grains gave of Ash, 24·21, or 84·35 per 100.

We have, then, 15·65 per 100 of carbon, etc. The incineration was conducted during $2\frac{1}{2}$ hours. The colour of the ash was reddish-brown, due evidently to oxide of iron.

In the combustion I employed as much heat as I could obtain by wafting the charcoal with a piece of paste-board. The gas ceased to be disengaged *completely*, and the caustic ley rose rapidly in the bulb, and continued to rise after breaking off the drawn-out extremity of the combustion-tube. I immediately removed the charcoal. On cooling, the tube, as I expected, cracked slightly, the ley in the large bulb descended, and I was enabled to draw air through effectually in the usual way. After removing the sheet of copper, with which the tube had been enveloped, I found the glass melted in several places, and in one spot, about two inches from the drawn-out end, the glass had sunk down to the chromate of lead, and so intercepted the passage of air from the drawn-out point. Only a very minute quantity of carbonic acid could possibly have escaped absorption. I am thus particular in relating details, that you may exactly know what value to attach to the analysis, which I think must be very near the truth.

Postscript. — Feb. 26. 1845.

I subjoin the following analysis of Anthracite from the Lehigh Summit Mine, Pennsylvania. The ash is in *very small* proportion : —

1st Analysis.

6·93 grains gave of

Water, 1·717 = 0·1907 Hydrogen, or 2·75 per 100.
Carbonic Acid, 23·57 = 6·428 Carbon, or 92·756 do.

2d Analysis.

6·854 grains of coal gave of

Water, 1·55 = 0·172 Hydrogen, or 2·509 per 100.
Carbonic Acid, 23·23 = 6·335 Carbon, or 92·427 do.

Nitrogen Analysis.

7·014 grains gave of

Metallic Platinum, 0·46 = 0·0652 Nitrogen, or 0·921 per 100.

Incineration.

33·73 grains gave of Ash, 0·75, or 2·223 per 100.
16·89 do. 0·385, or 2·280 do.

Mean - - - - 2·251.

* I presume oxygen to have been present. Its presence, however, could only have been demonstrated by determining the proportion of nitrogen.

Analysis.

Carbon - - - - - - - - -	92·591
Hydrogen - - - - - - - -	2·629
Oxygen - - - - - - - - -	1·608
Nitrogen - - - - - - - - -	0·921
Ash - - - - - - - - -	2·251
	100·000

The heat employed was sufficient to melt the Bohemian combustion-tubes in several places, although protected by sheet copper.

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3. *On the Geology of* CAPE BRETON.* By RICHARD BROWN, Esq.

(Communicated by Mr. Lyell.)

I PROPOSE, in the following pages, to give a slight general sketch of the geology of Cape Breton, from notes made at various times, some so far as 15 years back, and collected more with a view to professional pursuits, than for the purposes of geological research.

The island of Cape Breton is separated from Nova Scotia by the Gut of Canso, and is about 120 miles in length from north to south, and 90 miles wide from Scatari on the Atlantic shore to Port Hood on the Gulf of St. Lawrence. A range of highlands, commencing at Cape North, continues to St. Ann's on the east shore, and to Margarie on the west shore, both distant from Cape North about 60 miles, and presents, with few interruptions, bold and precipitate cliffs to the ocean. These highlands attain their greatest elevation near the shore, constituting a table-land from 15 to 20 miles in breadth, and 600 to 1000 feet in height, in most places incapable of cultivation. Part of this table-land is covered with a stunted growth of spruce and fir trees, and the remainder is principally rocky and barren moorland, which affords a scanty supply of moss for a few herds of wild deer.

From Margarie to Port Hood the country is elevated, but undulating, being intersected by several small rivers running through valleys of great fertility. From Port Hood another chain of hills stretches towards Ship Harbour, the water shedding from the eastern declivity into the rich alluvial valley of the river "Inhabitants," which runs parallel with the Gut of Canso from north to south. These hills decline gently to the west, and from Port Hood to Bear Island, at the southern end of the Gut, form a low shore, which seems to suffer less than might be expected from the

* The memoir, by the same author, accompanied by a map, and published under this title in the previous pages of this volume (see *ante*, p. 269.), was chiefly intended to have reference to Mr. Lyell's observations concerning the age of the gypsum in Nova Scotia and Cape Breton. — ED.

action of a tide running, in many places, at the rate of from 6 to 8 miles per hour. In the northern part of the Gut, the strong eddies have deposited long narrow beaches of coarse gravel, ponds or lagoons lying between them and the shore, which is thus protected from further abrasion; whilst to the southward, where the strait is narrower and the tides are more rapid, the position of the strata, consisting of strong compact shales and hard sandstones, has contributed greatly to their preservation, the strike being E. and W., or directly across the course of the current.

Proceeding along the southern shore, from the Gut of Canso to Scatari Island, the coast is low and rocky, occasionally exhibiting sloping banks of clay and gravel, until we arrive at Louisbourg, where the rugged cliffs, composed of greenstone and metamorphic rocks, defy alike the abrading action of the waves of the Atlantic and the atmospheric influences of a climate subject to great and rapid changes. There is very little land fit for cultivation along this part of the coast for several miles inland; but superior soils are found in the interior, especially on the Miray and Grand Rivers.

From Scatari to Cape Dauphin, the shore presents a continuous mural cliff, varying from 20 to 100 feet in height, except at the heads of the several bays, where low sandy beaches are invariably met with. This cliff, composed of the sandstones and soft shales of the coal formation, is subject to great waste, the rapid encroachments of the sea being noticed by the most careless observers. There can be no question but that Flint Island and the northern head of Cow Bay, now separated by a channel two miles in width, were, at no very distant period, united. The land along this part of the coast is generally low, but undulating, until we arrive at the Granite Ridge, lying between St. Ann's harbour and the ship entrance of the Bras d'Or Lakes, which ridge terminates at Cape Dauphin.

Having thus sketched the appearance of the sea coast of the island, let us next turn our attention to the interior. In the very heart of the island, there exist two capacious salt-water lakes, with innumerable bays, creeks, and islands, each of them communicating with the sea by two channels, one of which is navigable for ships of the largest class. The Grand Lake is 40 miles in length and 20 in width, from the narrows to St. Peter's Channel. In sailing from the West towards the East Bay, we have a water horizon before us, although the land at the head of the latter bay is by no means low. The scenery of the lakes is exceedingly striking, the conglomerates constituting long ranges of undulating blue hills, rising behind one another in the distance; whilst the white cliffs of gypsum stand out in bold relief on the margin of the water. The shores of the lakes are thickly studded with the cottages of thriving settlers, and a narrow belt of cultivated land stretches along the water's edge, backed by the dark shades of the forest. All the numerous creeks and channels are navigable by large vessels; and some idea may be formed of the extent of these lakes from the fact, that there is no point in the island more than twelve miles distant from salt water.

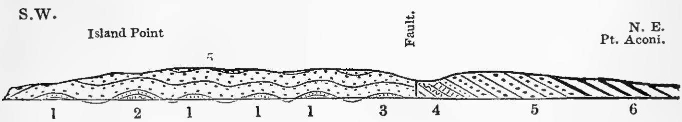
The rivers of Cape Breton, as may be supposed from an inspection of a map of the island, are inconsiderable. The principal are Miray, Margarie, Mabou, Inhabitants, and Grand rivers, discharging into the sea; and Baddeck, Wagamatcook, and Denny rivers, discharging into the Bras d'Or Lakes. Valuable tracts of alluvial land occur on the banks of all these rivers; and in beds of this kind on the Baddeck, a tooth and thigh bone of some large animal were found some years ago and sent to England. From the description given to me, I conclude that they belonged to the mastodon. They were found in the bed of the stream after a heavy flood, having probably been washed out of the alluvium which formed the banks of the river.

The bays and harbours of Cape Breton are numerous; many of the latter being surpassed by none on the whole coast of America in natural advantages. The principal are St. Ann's, the Great Bras d'Or Entrance, Sydney, Mainadieu, Louisbourg, Arichat, Ship Harbour, and Port Hood. Of these, Sydney is undoubtedly the best; and from its situation, in the very heart of the great coal field, is the most important. It is easy of access; free from rocks and shoals, and very capacious. After passing through the channel between the beaches (which is one mile wide, and 9 fathoms deep), it separates into two arms or branches, each of which is five miles in length, and averages one mile in width.

The coal formation is probably the most recent stratified group in the island; and it is certainly the most important, as it furnishes Newfoundland, Nova Scotia, Prince Edward's Island, and the United States with an abundant supply of coal, equal in quality to the best of that found in the Newcastle district. The coal field of Sydney, situated on the N.E. coast of the island, is the only one that has been sufficiently explored to determine its limits, and it extends from Miray Bay to Cape Dauphin, averaging about seven miles in width, and occupying an area of 250 square miles. As the general dip of the strata is north-east, or seaward, this great area of coal measures is probably the segment only of an immense basin extending towards the coast of Newfoundland — a supposition which is confirmed by the existence of coal measures at Niel's Harbour, 30 miles north of Cape Dauphin. The precipitous cliffs afford admirable opportunities for obtaining sections, but owing to numerous faults existing between Miray Bay and Low Point, the exact relations of the several seams cannot be ascertained so satisfactorily as in the district west of Sydney Harbour, which is free from any serious fault. The coal measures consist of beds of sandstone and shale, alternating with valuable seams of coal. In the natural section exhibited in the cliff stretching from Point Aconi to the commencement of the great sandstone or millstone grit, on the N.W. shore of Boulardrie Island, we have a horizontal distance of six miles, measured on the direct dip and rise of the strata, without a single fault or break; which, taking the average inclination at 10°, gives a perpendicular thickness exceeding 5400 feet. In this thickness are contained four seams of workable coal, ranging from 4 to 7 feet each, and several small seams of less than 2 feet. It may be satisfactory to the advocates of Mr. Logan's theory of the formation of coal, to learn that all the seams above mentioned, and in fact every one that I have examined in other parts of this coal field, rest upon fire-clay floors, containing leaves of Stigmaria. Vegetable remains, the same that are usually found in the coal fields of Great Britain, are also met with in great abundance; and occasionally trunks of trees, from one to two feet in diameter, are found both in vertical and in horizontal positions. Besides these, I have recently discovered fishes' scales, with teeth, fins, bones, and coprolites in a bed of bituminous shale, and in a thin seam of impure cannel coal.

The great sandstone or millstone grit upon which the coal measures repose may be traced along the southern border of the coal field of Sydney; but its thickness is variable, for it is compressed within very narrow limits at the western end, where the granitic ridge of Cape Dauphin rises abruptly behind the carboniferous limestone. The belt of limestone and gypsum which crosses Boulardrie Island about two miles to the S.W. of the crop of the coal measures, has apparently been brought up to the surface by a fault, since the same beds of limestone show themselves occasionally, cropping out from under the millstone grit, on both shores of Boulardrie to its S.W. extremity, as is represented in the following section:—

SECTION of the South-eastern Shore of BOULARDRIE ISLAND, 26 *miles*.



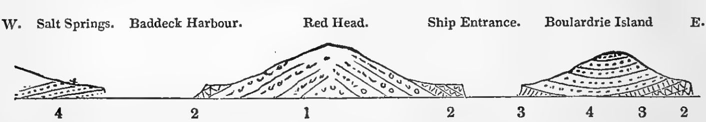
6. Coal measures.
5. Millstone grit.
4. Limestone, gypsum, and marls.
3. Limestone.
2. Limestone, gypsum, and shales.
1. Limestone and shales.

On the eastern shore of the Little Bras d'Or Lake, we have a good section of the millstone grit, from the crop of the coal measures to the mountain limestone at George's River, 2000 feet in thickness. The sandstones are generally coarse and pebbly; but some of the beds are compact and fine-grained, affording excellent building stone; false bedding is of frequent occurrence. A few beds of shale are interstratified with the sandstones; vegetable remains, such as *Calamites* and *Lepidodendron*, are abundant; and occasionally small patches of lignite are seen. The millstone grit preserves the same characteristics from hence to Miray Bay, where it comes into contact with a coarse conglomerate, and is thrown into a vertical position. One solitary *Lepidostrobus* was here found in the sandstone, being the only one yet met with in the island.

An extensive tract of millstone grit, with red shales and some thin limestones, commencing at Soldier's Cove, on the lake shore, seven miles to the eastward of St. Peter's, continues to the Gut of Canso; but I have not had an opportunity of tracing the northern boundary of these, except at the head of the West Bay, where limestone and gypsum show themselves. A few thin seams of coal, of no practical value, have been found in this tract; viz. at St. Peter's; at the mouth of the river "Inhabitants;" and at Carabacoo Cove, near Bear Island. It has not been ascertained how far the millstone grit extends up the valley of the river "Inhabitants;" but workable seams of coal are said to occur twelve miles above its mouth. A mass of trap protrudes through the grits and shales on the narrow isthmus which separates St. Peter's Bay from the lake, and there forms a conical hill, called Mount Granville, 600 feet in height. On its eastern declivity, beds of a coarse limestone are seen nearly on edge, but quite destitute of fossils. This trap is soft and crumbling, of a mixed green and white colour, and it resembles in every respect the mass of the same rock which bursts through the New Red Sandstone of Truro, in Nova Scotia.

On the western shore of Cape Breton, the millstone grit commences at the northern end of the Gut of Canso, and it underlies the coal measures which extend in a narrow belt from Port Hood to Chimney Corner, near Margarie. I have not visited this part of the island; but am credibly informed that valuable seams of coal exist at both extremities of this coal field.

One of the most characteristic features of the Cape Breton, as well as of the Nova Scotia coal field, is the constant association of extensive beds of gypsum and marls with the carboniferous limestone. These gypsiferous strata are nowhere more fully developed than in the Bras d'Or Lakes, where, most fortunately, the numerous creeks and inlets which ramify in all directions expose sections on their shores; and from these, at a future time, I trust I shall be able to collect a body of facts, that will clear up any doubts that may yet remain concerning the relative age and position of the gypsum and coal measures. In the vicinity of Sydney, gypsum appears at the head of the East Bay, and again, crossing the Boulardrie Island, following the course of the fault, as is shewn in the above section. Beyond this fault, the limestones, with the overlying sandstones, stretch out horizontally to the head of Boulardrie Island, the gypsum showing itself only at two places, viz. at Island Point and Big Harbour. The following is a section from Island Point to Baddeck:—



4. Millstone grit.
3. Limestone and shales.
2. Gypsum and marls.
1. Coarse red conglomerate.

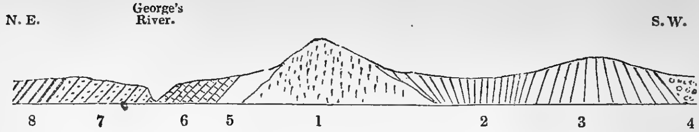
From this section, I think it is quite clear that the limestone and gypsum, dipping under the millstone grit of Boulardrie, emerge again, the former on the east, and the latter on the west side of the ship entrance, where we find this rock resting upon the conglomerate of Red Head. Crossing the promontory of Red Head, the gypsum is again seen on the east side of Baddeck Harbour, dipping apparently under the sandstone beds on the opposite shore. Further up the lakes, especially on the peninsula formed by Patrick's Channel and the river Denny, the gypsiferous strata spread out in every direction, sweeping round the bases of the lofty hills of the conglomerate, which constitute such prominent objects in the scenery of the lakes. These hills rise to the height of 400 or 500 feet, the strata of conglomerate being highly inclined, whilst the limestone and gypsum which occupy the lower ground, rarely rise 100 feet above the level of the lakes.

Salt springs are frequent in the gypsum districts; but the brine is generally weak, seldom yielding more than 7 per cent. of salt. Gypsum is also found on the shores of Aspey Bay, in the neighbourhood of igneous rocks, on the shores of St. Ann's Harbour, on the south side of Lennox's Passage, and at Plaister Cove in the Gut of Canso.

Underlying the gypsum and shales of the last-mentioned locality, we find an extensive belt of coarse conglomerate, which probably crosses the river "Inhabitants," and unites with the conglomerates of the river Denny and Ogomah Basin. In the opposite direction, it crosses the Gut of Canso, being separated from the igneous rocks of Cape Porcupine by a series of altered shales and grits of the greywacké formation; and it continues thence to the head of Chedabucto Bay.

Between Miray Bay and Louisbourg, the country is chiefly occupied by strata of fine-grained conglomerates, passing downwards into slates, and upwards, near their junction with the carboniferous limestone, into compact brown sandstones and hard red shales, analogous to the greywacké system of Europe. From Scatari Island towards Gabarus Bay, these rocks occasionally assume a crystalline texture, owing apparently to the presence of long ridges of greenstone trap interposed between the strata, which are generally vertical, or nearly so.

These parallel ridges of greenstone rise sometimes to a height of 20 to 30 feet above the general surface, and are frequently not more than 100 yards distant from one another; although it must be observed, that large areas of altered strata are met with where none of these trap rocks are visible on the surface. On the south shore of the Little Bras d'Or, similar strata of greywacké with altered rocks are also met with; but in this instance, the red granite which breaks through the limestone at George's River has changed the red shales and sandstones of the upper part of the greywacké series, and at the same time converted the limestone into white marble: the following is a section of the strata:—



8. Coal measures.
7. Millstone grit.
6. Mountain limestone.
5. White marble.
4. Conglomerates.
3. Greywacké slates.
2. Altered shales.
1. Small-grained red granite.

(Distance 8 miles.)

At Brack's Brook, we find the greywacké slates resting upon granite and porphyry, and extending to Soldier's Cove, where they meet the red shales and sandstones of the millstone grit series. Several small troughs of an apparently recent limestone may be here observed, lying unconformably upon the greywacké.

The conglomerate of Isle Madame seems to pass insensibly into a fine-grained greywacké slate, on the south side of that island.

Rocks of igneous origin occupy a very large proportion of the island of Cape Breton; and the lofty table-land in the northern part of the island is supposed to consist almost wholly of primary rocks. The high and narrow ridge lying between St. Ann's Harbour and the ship entrance of the lake, consists of fine-grained red granite and syenite; and at George's River, a similar granite protrudes through the limestone and greywacké as before mentioned. On the south shore of East Bay, granites and porphyries of various composition extend from Brack's Brook to the outcrop of the mountain limestone, a distance of ten miles, forming barren naked peaks, in some instances 800 feet in height. We find also here a beautiful porphyry, having a dark-green base, with large whitish crystals of felspar. The small island of St. Paul's, which lies about twelve miles east of Cape North, in the direct track of vessels bound up the St. Lawrence, and which has proved fatal to many a noble ship, consists of mica slate, gneiss, and granitic rocks, apparently stratified in thin beds, with an E. and W. strike, and nearly on their edges.

To show the connection of the strata of Cape Breton with those of Nova Scotia, I have continued the section across the Gut of Canso to the shales and sandstones of Merigomish. It will be seen that the conglomerates on the Nova Scotia shore, which succeed the greywacké and igneous rocks of Cape Porcupine, dip under the sandstones and shales of Tracadie (including some trifling seams of coal at Pornket), and emerge to the westward from beneath the gypsiferous strata of Antigonish, reposing upon and passing into the greywacké rocks of Antigonish mountain. The conglomerate again sets in on the western flank of Antigonish mountain, and is followed by the sandstones and shales of Merigomish and Pictou.

May 29, 1844.

W. M. Hen. Browne, Esq., of King Street, Covent Garden, and Geo. Loch, Esq., of Albemarle Street, were elected Fellows of this Society.

A communication was read by Professor Sedgwick, being in continuation of his Memoir "On the Geology of North Wales," read on the 29th Nov. 1843.* The notice of this paper is postponed for the present.

June 12, 1844.

R. T. Atkinson, Esq., of Newcastle-on-Tyne, was elected a Fellow of this Society.

The following communications were read:—

1. *On* Fluorine *in* Bones, *its source, and its application to the determination of the geological age of* Fossil Bones. By J. Middleton, Esq. F.G.S., late Principal of the College at Agra.

The accumulation of fluoride of calcium in fossil bones constitutes a very interesting and important subject of inquiry in reference to Geology, since it seems to involve the element of *time*, so interesting in all geological investigations. It was with a feeling of this importance that I some time ago commenced a series of investigations, which are not yet completed, in order to ascertain the proportion of fluoride of calcium in bones that had been preserved for various periods, with a view to infer, if possible, from the mineral condition, the relative ages of the specimens.

The bones hitherto examined by me with this view consisted of some from the Sewalik Hills, furnished to me by my friend Dr. Falconer, and some, for the permission to examine which I am indebted to the authorities of University College, London, in the chemical laboratory of which institution my investigations have been conducted. Among these last were the bones of a Greek, who had lived, it is supposed, about the time of the second Peloponnesian war (a coin of that period being found under the jaw of the skeleton), and a part of an Egyptian mummy in a remarkably perfect state of preservation. The Sewalik fossils were of the soft kind †, those imbedded in the clay in that locality, as they seemed better suited for comparison with bones of recent and known age and with those of early tertiary periods.

On examining these bones, I found that those from India con-

* See *ante*, p. 251.

† So named, I believe, by the gentlemen who found them, to distinguish them from those largely penetrated by oxide of iron or silica.

tained all of them nearly the same proportion of fluoride of calcium, viz. 11 per cent., while in the bones of the Greek the proportion was only a little more than 5 per cent., and in the mummy about 2 per cent. The difference in the two latter is accounted for, it would seem, by the circumstances of deposition, this being sufficiently evident from the appearance of the specimens; since the bone of the Greek has assumed a soft powdery character, tinged with peroxide of iron, the result of exposure to atmospheric and other influences, while that of the Egyptian exhibited all the structure of recent bone, having been preserved in a sarcophagus, and scarcely changed from its normal state.

From these results, and from having ascertained the presence of fluorine in the recent bones both of men and reptiles, I was led to suppose that the presence of fluorine must be due to some general condition, the same in ancient times as at present, for I could not believe that in this matter there could be any alteration in the laws of organic life, implying different proportions of the mineral at different periods. I was thus led to suspect that water might be the agent producing this apparent change; and this seemed to me to offer a ready solution of the whole problem. That there is a great tendency in fluoride of calcium to unite itself to phosphate of lime, is evident from the almost universal association of the two in nature; and thus, if the moisture constantly present at the earth's surface should contain the mineral in question, the bones might absorb it by simple exposure; a larger proportion being obtained, according as the bones had been longer exposed to its influence. Bearing this in mind, I was led to institute a series of experiments on aqueous deposits of different ages, and I found that, with one exception, — a pure but incompact stalactite of carbonate of lime, — fluorine exists in all, from the most recent deposit down to the old red sandstone, and that it is present in the older in larger proportion than in the newer beds. I think it is therefore beyond a doubt that it is present in water, though perhaps in very minute quantity; what its solvent may be I know not, but that it is so held in solution my own experiments have demonstrated; and if they had not, the simple fact that the blood conveys it to the bones, would, I apprehend, sufficiently refute any scepticism on the subject.*

It now remains for me to show, that the relative geological age of rocks may be estimated by the proportion of fluoride of calcium which they contain; and for this purpose I append the following results of my analyses in the cases of recent bone, the bone of a Greek already alluded to, a fossil bone from the Sewalik

* *Note by the President.* "I am informed by Professor Graham, that he is well acquainted with these researches of Mr. Middleton; that, previous to his return to India, Mr. Middleton ascertained the presence of fluoride of calcium in the deposit obtained by boiling the ordinary pipe-water supplied to the houses in London; and that there is reason to believe, from this and other observations, that the fluoride of calcium is held in solution by the carbonic acid usually present in water." — *L. H., April* 7. 1845.

Hills, and a bone of the Anoplotherium; the latter being given by Lassaigne: —

	Recent Bone.	Bone of the Greek.	Fossil Ruminant, from the Sewalik Hills.	Bone of the Anoplotherium.
Organic matter - -	33·43	9·97	—	
Phosphate of lime - -	52·11	70·01	78·00	37·00
Carbonate of lime - -	10·36	10·34	11·34	
Fluoride of calcium - -	1·99	5·04	10·65	15·00
Chloride of sodium - -	·60	} 1·15		
Soda - - - -	1·08		} a trace	
Magnesia - - -	·76	} 1·34		
Phosphate of magnesia -	·00			
Silica - - - -	—	1·68	—	35·00
Peroxide of iron - -		about ·25		
Alumina - - - -	—	—	—	10·00
Oxide of iron & manganese				3·00

In comparing together the quantities of fluoride of calcium in bones of different periods, we should be guided, I apprehend, by the proportion it bears, in each specimen, to the fixed basis of the bone, phosphate of lime, a substance which seems but little liable to variation in amount. The comparisons stand thus: —

	Phosphate of Lime.	Fluoride of Calcium.
Recent bone - -	52·11 - - -	1·99
The Greek's bone - -	70·01 - - -	5·04
The Sewalik fossil bone -	78·00 - - -	10·65
The Anoplotherium bone -	37·00 - - -	15·00

When the animal matter, entirely obliterated in the fossil bones, has been suppressed in the recent bones, we have: —

	Phosphate of Lime.	Fluoride of Calcium.
Recent bone - -	77·84 - - -	2·97
The Greek's bone - -	78·55 - - -	5·62
The Sewalik fossil bone -	78·00 - - -	10·65
The Anoplotherium bone -	37·00 - - -	15·00

If now, for convenience of computation, we represent the phosphate in each case by 100, we obtain the following ratios of the fluoride: —

Recent bone - - -	3·81
The Greek's bone - -	7·15
The Sewalik fossil bone -	13·01
The Anoplotherium bone -	40·54

Now, as the age of the Greek's bone is known to be 2000 years, we obtain, if my hypothesis be just, the following values, in time, of the above ratios of the fossil bones: viz. the Sewalik fossil, 7700 years; the Anoplotherium, 24,200 years.

2. Notice *of the* Raised Beaches *on the* Western Coast *of* Ross-shire. By J. G. Jeffreys, Esq.

(Communicated by the Rev. Professor Buckland, D.D.)

About two miles above Craig Inn, and eleven from the present termination of Loch Carron, there is a level platform extending for some distance in a parallel line with the valley up which the loch at present flows, elevated about 50 feet above the present sea level, and sloping at an angle of 45°, and its breadth seems the same as that of the present beach at its foot. Sixteen miles from the termination of the loch is a similar platform with the same direction and slope, but apparently at a higher level; and on the opposite side of the loch (which is about half a mile wide in that part) is a corresponding platform, similar in every respect to the other. This is outside the loch, about a mile below Strome ferry, which forms the entrance to it. Some miles further down the main channel of the sea, at a place called Plockton, the same appearances present themselves; and here the elevation is about 60 feet above high-water mark.

On examining this latter platform, I found underneath the superficial stratum of earth a bed of coral and shells two or three feet thick, and precisely similar to the beds which, as I ascertained by dredging, exist in the adjoining sea. The depth of the sea varied from three to upwards of a hundred fathoms.

At Applecross similar indications of a former beach are to be found, and also at Shieldaig near the mouth of Loch Torridon, and at Gairloch, on the same coast. In the former locality (Applecross) the platform or bank appeared to be almost entirely composed of coral and shells. In the neighbouring sea prodigious quantities of testaceous and calcareous mud appear to be accumulating.

I would further remark that the platforms in question do not appear to have been formed by drift, or by the ordinary action of the winds and waves, because their base is beyond the reach of any tide, and at the mouth of Loch Carron they are situated on both sides of the channel, and are consequently exposed to different winds and currents of the sea. The whole appearance seems referable to a sudden elevation of the land by means of some subterranean convulsion.

It is worthy of remark, that on the eastern coast of Scotland, particularly on the Moray Frith, trunks of trees are found embedded in the sands at low water, thus showing a subsidence or depression of the land on that side.

3. *On the Cliffs of* NORTHERN DRIFT *on the Coast of Norfolk, between* WEYBOURNE *and* HAPPISBURGH. By JOSHUA TRIMMER, Esq. F.G.S.

IN this paper the author proposes to describe certain changes that have taken place in these cliffs, comparing the appearances they present with those of raised beaches in North Wales.

With regard to the former subject, he notices first, the condition of a pinnacle of chalk at Old Hythe Point. The cavity at the summit of this pinnacle is now exposed to a greater depth than in Mr. Lyell's drawing*, and the sand and gravel with which it was filled are removed. No vertical strata of sand to the N.E. of the pinnacle are now visible, and these must have been removed by denudation. Mr. Lyell's statement that this pinnacle is separated from the great mass of the chalk by the crag deposits is, in the opinion of the author, confirmed by the position in which the chalk rests.

Of the protuberances of chalk near Trimmingham, the northern and middle seem now little changed, but the southernmost has undergone some alteration. Its length is still the same as when visited by Mr. Lyell, but it is reduced to nearly half its height, and the waves have washed away a portion of the overlying gravel at one extremity. The next fall of the cliff will probably bury this end of the protuberance entirely. The chalk inland seems tilted, and is covered with a breccia of the crag.

About a quarter of a mile east of Cromer, the author met with a bed of peat, resting on pyritous silt and gravel, and resembling a peat bed at Mundesly, and the stem of a small fir tree was here observed in a vertical position. Between Mundesly and Trimmingham he observed other instances of peaty beds associated with the same kind of gravel, and he endeavoured to determine whether the *till* and the freshwater deposits were contemporaneous. This he decided in the affirmative, at least for the upper portion of the freshwater beds, since at Cromer he found, at the height of 20 feet from the beach (about 300 yards west of the jetty), several bands of black peaty mud, a few inches thick, alternating with laminated blue clay, derived from an adjoining mass of the unstratified till, which elsewhere overlies the freshwater beds.

At Runton, near the Gap, the freshwater beds are covered by a regular marine deposit of the crag. A black peaty bed, about 4 feet thick, containing shells of *Cyclas*, *Planorbis*, *Helix*, and fragments of *Anodon*, together with some vegetable remains, rests on a ferruginous sand, containing *Anodon*. The peat is covered by a bed of gravel about a foot thick, containing *Fusus striatus*, *Tellina obliqua*, *Mya arenaria*, and *Natica helicoides*, and some of the shells of Mya exhibit the valves united, but they are too fragile to

* See Phil. Mag., May, 1840.

be readily extracted. There is here no mixture of fluviatile and marine remains, so that this instance offers evidence of submergence and subsequent elevation. The marine gravel is covered by laminated blue clay, derived from adjoining till, and it passes upwards into yellow silt and sand, the lamination of which is much contorted.

Till. The unstratified blue clay on the Norfolk coast alluded to under this name, resembles, in colour and composition, that which is found on the coast of North Wales and the east of Ireland, differing only from these deposits in the nature of the imbedded fragments. These seem to have been all of them transported from the north, and they are heaped in irregular hummocks, the height of the cliffs depending on the amount of this material. The till does not seem to pass by any gradation from the freshwater deposits, nor is the surface of the latter disturbed at the contact as if the sea-bottom had been ploughed up by the passage of icebergs. The contorted strata (accurately described by Mr. Lyell) are always either above or between the masses of till.

The transported blocks dispersed through the till consist of granite, gneiss, mica-slate, and trappean rocks, often in an angular state, and not rubbed. Some fragments, however, show scratches and other markings like those attributed to the grinding of a glacier, and the author states that he had already observed scratches on boulders in Caernarvonshire, and alluded to them as characteristic of the epoch, before such markings were attributed to the action of ice.

Notwithstanding the distance which separates the till of the coast of Norfolk from that of North Wales and Ireland, the author recognises a common character pervading the whole, which he attributes to their having had a common origin, being derived from the north, and he considers that the cause of the deposit of this boulder clay covered with sands, loam, &c. of a yellow colour, seems to have acted but once, the same appearances not recurring. There is still, however, one striking difference observable in the two localities, since the Norfolk beds are much contorted, while this is not the case in North Wales. These contortions are referred by the author to the movements connected with the final upheaval of the coast; but since, where the contortions are most violent, the underlying chalk is undisturbed, as between Sherringham and Weybourne, he supposes that the till has exercised some influence in producing these singular appearances.

The author observes, in conclusion, that these deposits on the cliffs, produced by the northern drift, ought to be carefully distinguished from ordinary raised beaches, the phenomenon in the former case having been produced by the submergence and subsequent elevation of land which had been long existing in that state. He does not pretend to decide the extent of the submergence.

June 26, 1844.

John Shaw, Esq., M.D., of Hop House, Boston, Lincolnshire, was elected a Fellow of this Society.

The following communications were read:—

1. *On the* Stonesfield Slate *of the* Cotteswold Hills. By the Rev. P. B. Brodie, M.A., F.G.S., and James Buckman, Esq., F.G.S.

The district alluded to in this memoir is situated to the east of Cheltenham, and includes the Cotteswold Hills, which divide the county of Gloucester from parts of the neighbouring counties of Oxford, Worcester, and Warwick.*

The formations occurring in this district are the following:—

Great Oolite	7. Clays representing the Bradford clay, or those dividing the beds of the great oolite in Wiltshire.
	6. Stonesfield Slate and ragstone.
Inferior Oolite	5. Fullers' earth.
	4. Inferior oolite.
Lias	3. Upper lias shale.
	2. Marlstone.
	1. Upper shales of the lower lias.

1. *Upper Shales of the Lower Lias.* These consist of blue argillaceous deposits, sometimes, especially towards the top, intermixed with clays of an ochreous yellow colour. The following are amongst the most characteristic fossils:—

Belemnites elongatus	Pinna lanceolata
Ammonites Henleyi	Lima antiquata
Crenatula ventricosa	Arca Buckmanni
Cardinia (*Pachyodon*) attenuata	Terebratula rimosa
Modiola cuneata	Trochus imbricatus

And some undescribed species of Gervillia, Arca, and Spirifer. The beds below the above present the usual lower lias fossils.

2. *Marlstone.* A hard sandy stone, blue when first quarried, but weathering of a brown colour. It forms the terraces seen on the first ascent to the Cotteswold Hills. These terraces, however, being covered with grass, the rock is best studied in outliers, such as are found at Churchdown, Dumbleton, &c., where the stone is quarried for road-making. The following fossils are peculiar to the marlstone in this neighbourhood:—

* See a paper "On the Structure of the Cotteswold Hills, and Country around Cheltenham," by Roderick I. Murchison, Esq., read the 14th March, 1832, and published in the Proceedings of the Geological Society, vol. i. p. 388. It was afterwards printed as a separate tract.

See also a "Report of a Survey of the Oolitic Formations of Gloucestershire," by William Lonsdale, Esq., read the 19th of December, 1832, and abridged in the same volume, p. 134.

Ammonites heterophyllus	Pinna affinis
spinatus	Spirifer (two new species)
Stokesi	Terebratula tetraëdra
Gryphæa gigantea	acuta
Pecten æquivalvis	bidens
Cardium truncatum	

3. *Upper Lias Shale.* A blue argillaceous deposit containing septaria. It is recognised on the hills by exhibiting a line of drainage; and is traversed by a thin seam of fissile limestone, containing remains of fishes, insects, and shells described lately by one of the authors. The following are the prevailing fossils:—

Ammonites Strangewaysi	Inoceramus dubius
Walcotti	Plicatula spinosa
annulatus	Nucula claviformis.

4. *Inferior Oolite.* The lowest bed of the inferior oolite in this district is a pisolitic rock, composed of rounded or flattened grains about the size of peas, cemented by a calcareous paste, and containing fragments of Pentacrinites, &c. *Cidaris subangularis* and *C. coronata*, *Pecten lens* and *Avicula contorta*, are the chief fossils of this bed.

A roestone of a yellowish-white colour succeeds this pisolite, and it is found to exhibit numerous small shells on careful examination under the microscope. The average thickness of this bed is 15 feet; and the following fossils are found in it, besides the microscopic ones:— *Cardita similis*, *Plagiostoma duplicatum*, a *Nucula*, a *Cucullæa* (M. C. t. 549. fig. 3.), *Patella rugosa*, and *P. nana*.

Overlying the roestone is a thick bed of white freestone worked in large blocks. This rock is about 25 feet thick, and is a fine-grained oolite intermixed with comminuted fragments of shells. It is overlaid by about 10 feet of oolite marl, resembling chalk, and having an uneven fracture. At Leckhampton and other places it abounds with fossil shells; but at Crickley and Birdlip, to the S.W. of the Cotteswold, it puts on the character of a coralline rock. The following list of fossils includes those most characteristic:—

Astræa agaricites	Astarte elegans
Madrepora limbata	Pinna tetragona
Agaricia lobata	Terebratula fimbria
Meandrina explanata ?	Natica macrostoma
Tubipora ?	hemispherica
Plagiostoma læviusculum	Nerinæa fasciata

A Gryphite grit, a rough kind of stone, separated from the oolite marl by about 4 feet of flaggy oolite, next succeeds. It abounds with the shells of *Gryphæa dilatata* in its lower part, and the overlying beds of marl and compact stone are partly composed of immense masses of *Trigonia costata* and *T. clavellata*. Besides these the rock contains the following species:—

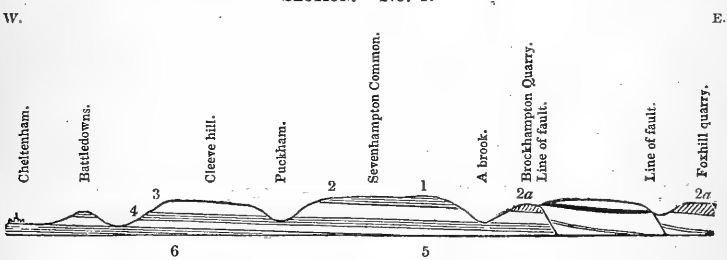
Trigonia striata	Terebratula concinna
Mactra gibbosa	spinosa
Amphidesma securiforme	resupinata
decurtatum	maxillata
Pholadomya ambigua	and six others
lyrata	Cirrus carinatus
Modiola (four species)	Melania striata
Cucullæa oblonga	Nautilus truncatus
Perna mytiloides	Ammonites Parkinsoni
Pecten vimineus	Browni
Terebratula perovalis	corrugatus

These beds are capped with a band of sand and clay containing nodular masses of oolitic stone, and a great number of *Clypeus sinuatus*.

5. *Fuller's earth.* This is a yellow argillaceous deposit, which seems to be about 10 feet thick, but it presents few points of interest. Its outcrop is marked by a line of springs.

6. *Stonesfield slate.* This is the bed which it is the object of the present memoir chiefly to describe.*

Section. No. 1.



6. Lower lias shales.
5. Lias marlstone.
4. Upper lias shales.
3. Inferior oolite.
2a. Fuller's earth.
2. Stonesfield slate and ragstone.
1. Beds of clay.

The first quarries of this flagstone described are situated on the top of a hill at Sevenhampton common, and the rock is generally very rich in organic remains. There are here three quarries at which the slate is worked, within the distance of half a mile from one another. One of them exhibits about 15 feet of coarse fissile ragstone, containing fossil remains of fishes and some shells, and passing downwards into the true Stonesfield slate. In another this ragstone, of about the same thickness, is occasionally intermixed with slabs of hard slate having blue centres, and there is then about 4 feet of true fissile Stonesfield slate, the upper slabs of which are used for tiling; but the lower part is sandy.

* The authors consider that the beds so called were only partially known to Mr. Murchison, and they disagree with some of Mr. Lonsdale's conclusions.

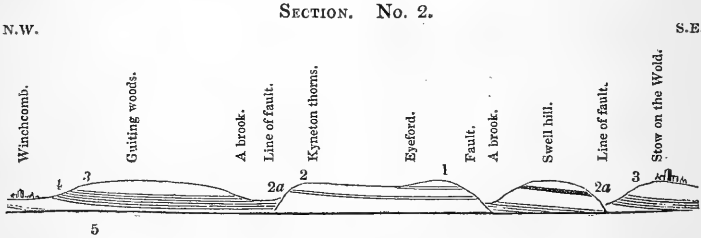
Numerous fossils have been obtained from this quarry, and the most perfect remains of plants have been found. These, as far as can be ascertained at present, consist of *Coniferæ* (two species, one of which greatly resembles the *Thenytes*, if it be not a new species); *Palmæ; Cicadeæ; Liliaceæ;* and two species of ferns; besides leaves of plants of too anomalous a kind to be determined. Stems of trees, much broken, occur in considerable quantity. Silicified wood of a coniferous tree has also been obtained from the above quarry. The third quarry exhibits little difference, except in the better marked subdivisions of the overlying beds, but the wing cases of beetles, and sauroid and fishes' teeth, are more frequent.

The next place at which the Stonesfield slate is worked seems to have been laid bare by a fault. It is about half a mile from Brockhampton Hill (see section above), and appears in a valley surrounded on all sides by hills which are capped with inferior beds. From this spot the beds of Stonesfield slate run in a N.W. direction; and at Kyneton Thorns and Eyeford are many quarries from which the slates are extracted for roofing.* The following is the sequence exhibited at one of the best quarries:—

3.	Rubble and superficial detritus - - - -	3 to 4 feet.
2.	Ragstone, not very fissile - - - - - -	13 „
1.	Stonesfield slate, a compact sandy stone, very fissile, especially after exposure to frost - - - - - -	5 „

A new species of *Asterias*, and a species, also new, of *Pollicipes*, were found beautifully preserved in the quarries at Eyeford. *Belemnites canaliculatus* and *B. fleuriansus*, some remains of plants, the teeth and palates of fishes, and a tooth of Megalosaurus, have all been obtained from this locality.

Section. No. 2.



(*For a description of the strata, see Section No.* 1.)

The eastern edge of the Stonesfield slate of the Cotteswolds exhibits the ragstone much thicker, and of a coarser kind. The quarry at Upper Swill, near Stow on the Wold, seems to show

* From one quarry alone 120,000 roofing slates are obtained in the course of a season. The work is thus conducted:—At the latter end of the year a quantity of stone is raised from the quarry, and spread over the surface of the ground. Being thus exposed, it loses the bluish tint presented when first quarried, and becomes light-coloured; this change, the result of weathering, rendering the slate more readily separable into tiles. The best tiles are said to be made from the middle of the beds.

marks of the fault already alluded to. From this quarry large reptilian bones and fishes' teeth have been obtained, and other fossils, such as *Clypeus sinuatus, Plagiostoma cardiforme, Pecten vagans, Ostrea acuminata,* a *Nerita,* and other shells. Not far from this, at a place called Wagboro' Bush, is a quarry not now worked, but the fossils from which are considered by the authors to identify the rock with the well-known beds at Ancliffe. These fossils are *Nerita spirata, N. minuta, Actæon cuspidatus, Nucula mucronata,* a *Corbula,* and a *Cerithium.*

The district described in the preceding account of strata has been subject to disturbances, the result of which has been the production of several lines of faults. One of these is represented in the preceding diagram. (Section No. 1.)

The beds from Cheltenham across the hills preserve their regular order and dip (seldom exceeding 10°); the upper beds of the inferior oolite marking the highest points of the Cotteswold range. From Brockhampton the higher ground proceeds about a mile and a half in a northerly direction to Charlton Abbotts (which is higher than Brockhampton Common): it then turns suddenly to the east, bounding Kyneton Thorns, which is situated in a fault valley extending from Kyneton to Eyeford.

The line of fault from Brockhampton is continued for about a mile to the south, where it takes a sudden turn, and is continued in irregular lines to the south-east, joining the eastern line at Stow-on-the-Wold.

There are other minor faults in the district, but they do not affect the Stonesfield slate formation.

There is evidence of denudation in the district under review, the upper clays being frequently absent: besides that the slopes of the hills are more or less covered by waterworn debris, and smaller deposits fill up hollows in the valleys to the depth of 20 or 30 feet.

The Authors conclude with the following general summary:—

"From the foregoing examination of the upper beds of the Cotteswold Hills, we are led to the following conclusions:—

"1st. That the Stonesfield slate occupies a considerable extent in the Cotteswold range of hills, as we have traced it over a district which would scarcely be enclosed within an area of fifty miles; and that this formation, as it occurs in this part of the country, is identical with that at Stonesfield, both in its lithological and zoological characters; indeed it is clearly traceable, with few interruptions, from Sevenhampton, within five miles of Cheltenham, to Stonesfield near Blenheim in Oxfordshire.

"2dly. That the Stonesfield slate in the district above described is so intermixed with the ragstone, particularly at the edges of the formation, as to be scarcely, if at all, separable from it, and (as has been shown) this ragstone presents fossils of a like character with those of the great oolite. We are thus led to adopt the conclusion, that the Stonesfield slate is part of the Great oolite formation, or at least not sufficiently distinguishable from it, to entitle it to rank as an independent formation; but, inasmuch as the Great oolite very much thins off where associated with Stonesfield slate, it would appear that the Stonesfield slate and its accompanying 'ragstone' were deposited by the same sea which formed the Great oolite itself, and that it partly owed its origin to certain mixed conditions, arising from the influx of rivers into an ocean interspersed with numerous scattered islands, abounding in a luxuriant vegetation, and inhabited by numerous terrestrial animals; and this opinion seems more probable from the quantity of plants which occurs throughout the Stonesfield slate beds, and also from the relics of land animals, such as the Didelphis and Pterodactylus.

"We also find that the Great oolite thins outs towards the northern end, whilst the Inferior oolite thins out in like manner towards the southern end of that long chain of hills of which the Cotteswolds form a part.

"3dly. If the beds just referred to belong to the Great oolite, it is just possible that the clays by which they are super-imposed in this district, may be the equivalent, or a sort of representative of the Bradford clay, judging at least from their position and the analogous fossils which they contain. Or, supposing this to be incorrect, we venture to conclude that these clays are the equivalent of certain clay-beds containing Apiocrinites, which in Wiltshire separate the freestone from a lower stratum of freestone of a coarser texture."

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2. *Description of a* FOSSIL RAY *from* MOUNT LEBANON (Cyclobatis oligodactylus). By Sir PHILIP GREY EGERTON, Bart. M.P., F.R.S., F.G.S.

I AM indebted to the liberality of Professor Edw. Forbes for many valuable specimens of fossil fishes, procured by Capt. Graves from the Lebanon range; and amongst the number, for the subject of the present memoir, one of the most interesting and remarkable ichthyolites ever brought to light by palæontological research. The cases of the discovery of fishes belonging to the placoid order, in a condition at all approaching to completeness, are exceedingly rare. The destructible nature of the endoskeleton, and the loose attachment of its component members, attest the probability that decomposition would complete its work ere these records could be engrossed in imperishable characters. That this order was nevertheless extensively represented from the earliest fossiliferous period to the present time, is manifest from the frequent occurrence of the palatal tritores, teeth, and defensive fin bones of the Cestracionts, Hybodonts, and Squales; and of the dental apparatus, caudal weapons, and dermal tubercles of the Rays.

The specimen presented to me by Mr. Forbes is a remarkable exception to the general rule, the parts being perfectly preserved, so far as they are exhibited by the fracture of the matrix. The fish is in its natural position *ventre à terre.* The dorsal integuments being removed, the skeleton is distinctly exposed as seen from above. The outer margins of the pectoral fins, and the caudal vertebræ from the termination of the ventral fins, are deficient. The preservation of the claspers proves it to have been a male, and (to judge from the development of these organs) of mature age. It corresponds in size with the unique specimen of *Asteroderma* from the Solenhofen oolite in the collection of the Society, but has little resemblance in other respects to that genus. The negative facts of the absence of all trace of dermal armature, as also of the caudal ribs described in the "Poissons Fossiles," would sufficiently distinguish it; we have, however, the positive evidence of the structure of the vertebral column, which is that of a true ray, without any approach to the squaloid character displayed in *Asteroderma.* As compared with the recent genera, the circular form of the head eliminates the Lebanon Ray from all save the Torpedos. From the latter family it is distinguished by the smaller number and greater length of the rays of the pectoral fins, by the smaller size of the ventral fins and the tail, as also by other characters, which will be sufficiently manifested in the sequel. The aspect of this fossil is very singular: it may not inaptly be compared to the figure 8, surrounded by a circular border of long divergent rays. The generic name of *Actinobatis* at first struck me as conveying a good idea of this peculiarity; but, finding that Agassiz had already appropriated this title to a fossil ray of which some dermal tubercles have been found at Plaisance, I have substituted the name *Cyclobatis,* which expresses equally well the most striking character of this singular fossil. The anterior or cephalothoracic cavity is circumscribed by the carpal bones carrying the fin digits, which join the rostral cartilage at an obtuse inverted angle. The mouth extends nearly from side to side; the teeth are only seen near the symphysis of the jaw, where they are small and discoid; the tympanic pedicle, extending from the angle of the jaw to the cranium, is broad and strong. The cartilages of the head are crushed; but the cranial cavity appears small, as also the orbits. Traces of the branchial apparatus are preserved; but the number of the arches cannot be decyphered. The cartilages composing the thoracic girdle, which forms the fulcrum for the action of the pectoral fins, are broad and strong. The anterior carpal ossicles are also largely developed, being at least a third broader than in a recent ray of similar size. These dimensions are continued until they abut against the anterior part of the head. The posterior prolongations of the carpal apparatus diminish in size as they recede from the thoracic girdle, and terminate at the insertion of the last pectoral digit a little behind the pelvic arch. The pectoral fins are very remarkable, and contribute chiefly to the peculiar characters of this ray.

They extend anteriorly to the nasal cartilages, completely surrounding this portion of the cephalothorax: the distal margins exceed those of the ventral fins. The component digits are 47 on each side. They increase in length and breadth as they recede from the head, the terminal ray being the largest of the series. In the recent rays the pectoral digits number from 80 to 100, and in the torpedos nearly 60.

The arrangement of the fin rays in *Cyclobatis* resembles that of the recent rays, radiating in regular gradation from the centre to the extremities, but the smaller number of the digits causes their divergence to be greater, and the interspaces consequently of larger extent. The actinated appearance of these organs is due to this peculiarity, which has suggested the title of *oligodactylus* for the species. The form of the phalanges is intermediate between that of the rays and that of the torpedos, combining a greater length and denser structure than we find in the latter, with breadth and thickness exceeding the comparative dimensions of these parts in the former. The digital articulations are more distant and fewer in number than in the recent genera. The fork occurs at the sixth articulation,—in the recent genera not before the tenth. The phalangeal ossicles do not contract in diameter between the articulations; they have a projecting longitudinal midrib, from whence they slope off to the margin, so that a transverse section would show a lozenge-shaped outline. The coarse granulated structure of these bones is distinctly traceable, causing a jointed appearance between the articulations. The abdominal cavity, or that portion behind the thoracic girdle, is nearly as large as the anterior or cephalothoracic, and in this respect differs most remarkably from the torpedos, where the anterior area is at least twice as large as the posterior. In form it is slightly oval; the pelvic arch differs from that of all the recent rays I have had opportunities of consulting, in the development of two elongated styloid processes, from the horns of the transverse pubic cartilage, and extending forwards over two thirds of the abdominal cavity. This structure recalls vividly the marsupial bones of the Australian mammals. The transverse cartilage of the pelvis sends out two broad processes, extending backwards for the attachment of the ventral fins. The proximal digit on either side is unusually large; it extends laterally at right angles to the spinal column, and at the first articulation forms a second right angle; the remaining phalanges being directed backwards, parallel to the spinal column. This digit is detached from the remainder of the ventral fin, and is inserted considerably nearer the transverse cartilage. The other fin rays are six in number on each side: the first is considerably smaller than the succeeding five, and curves outwards. The remainder agree in character with the pectoral digits. The tarsal bones which support the ventral rays, are considerably smaller than in the recent Skaits, in accordance with the smaller number of these bones, which in the latter species range from fifteen to twenty. The impressions of the claspers show these organs to have been comparatively large, and of complicated form. The whole of the pelvic apparatus, with its appendages, as compared with the rays of the present period, presents remarkable modifications. The small size of the ventral fins is conclusive evidence against the supposition that these differences could have relation to locomotion. If we seek to explain them with reference to the internal structure of the animal, the absence of the soft parts deprives us of the means of arriving at any satisfactory results. Analogical considerations, however, would suggest the idea, that the peculiar features of these parts have some relation to the generative system. The vertebral column corresponds with that of the recent rays in the form and character of the vertebræ, and has no approximation to the squaloid type found in the fossil ray from Solenhofen, in the Society's collection. The anteroposterior dimensions of the vertebræ are rather greater than in a specimen of raia of similar size with the fossil: the extremity of the tail is deficient, but judging from the rapid contraction of the caudal vertebræ preserved in the specimen, this organ must have been small and powerless, presenting a remarkable contrast to that of the torpedos. There is no trace of the existence of a defensive weapon; nor, indeed, would the proportions and form of this part of the specimen lead one to infer that this fish could have been provided with such an organ.

To recapitulate the features of this remarkable fish, we have a small ray, much resembling those of the present period, but entirely surrounded by a broad flexible cartilagino-membranous fin, the skin smooth, the teeth and eyes small, the tail slender, and no trace of dermal spines, tubercles, or defensive weapons. It is impossible to resist a speculation, as to how an animal apparently so destitute of the means of offence or defence could have existed. We find in the recent rays various provisions adapted to these ends. *Trygon* and *Myliobatis* are armed with weapons so powerful and deadly, that they have been adopted by savage nations for the armature of their war spears. Other genera have the nasal cartilages prolonged in the form of a cut-water, to enable them both to evade by flight those enemies they could not encounter in single combat, and to overtake the smaller fishes on which they subsist; and most of the recent forms have their integuments studded with spines or osseous plates, forming a species of defensive armour for the body, while a similar armature on the long and flexible tail renders this organ an effectual weapon for keeping intruders at a respectful distance. Our fossil possessed none of these advantages: the large development and anterior extension of the pectoral fins must have rendered the locomotive efforts of *Cyclobatis* little more effectual than the systole and diastole of a Medusa. The safety of the fish, then, could not depend upon flight. But these organs, however ill adapted for speed, are admirably formed for concealment, and when applied to the sand at the bottom of the ocean, would act as the leather suckers with which mischievous boys draw up the paving-stones in the streets, retaining the fish stationary, while the smoothness of the skin would present no obstacle to the passers by, and possibly its colour may have contributed to render the concealment more effectual. The position of the mouth forbids the idea that this ray buried itself in mud, as the lophius and other predatory fish are known to do. The difficulty of defence being thus surmounted, we have still to devise how this fish procured its subsistence. It may be that it fed upon some of the smaller and more helpless denizens of the deep; but at the same time I am inclined to believe, from a comparison of the oral apparatus with the recent forms, that its food was not dissimilar. Some of these forms, too, if found in a fossil state, would cause the zoological reasoner full as great embarrassment as the subject under discussion, from the absence of the ordinary provisions for self-preservation so familiar to all. Yet the Creator of the Universe has not formed them helpless; so far otherwise, he has endowed them with a subtle armoury, more powerful than the dental chevaux-de-frise of the marauding shark, — more deadly than the serrated lance of the fireflare, — more effectual than the speed of the dolphin, or the aerial excursions of the flying-fish. I allude to the electric apparatus of the Torpedo. The Lebanon Ray in many points of structure has presented analogies with this genus; and although, in the absence of all positive evidence to the fact, it would not be justifiable to infer that it was provided with a similar organ, yet I do not conceive that in drawing attention to this consideration in the passing allusion I have made above, I have overstepped those bounds of probability which ought to be rigidly observed by every observer in the rich and inexhaustible field of nature.*

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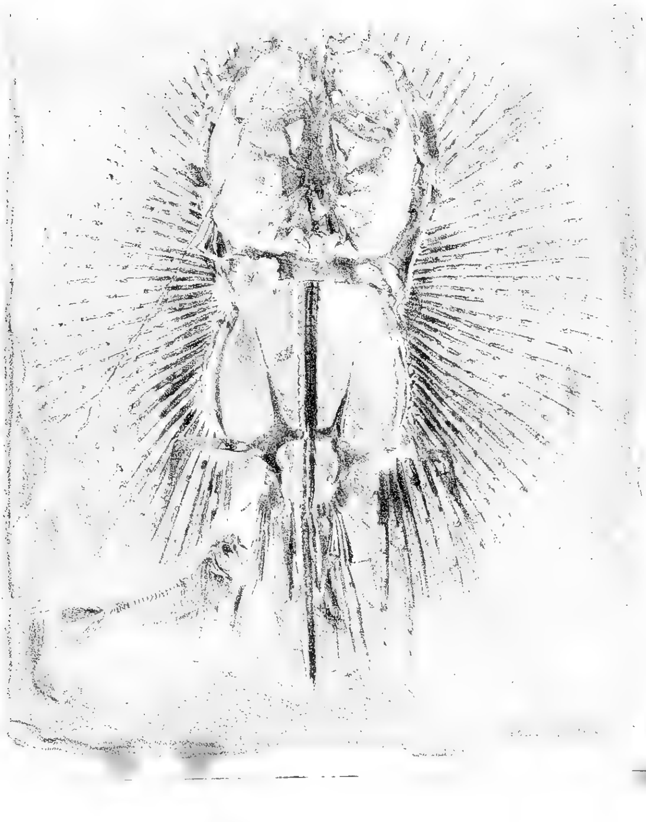
3. *On some New Species of* Fossil Fish, *from the Oxford Clay at* Christian Malford. By Sir Philip Grey Egerton, Bart., M.P., F.R.S., F.G.S.

Through the kindness of Lord Northampton and Mr. Pratt I have had an opportunity of examining several specimens of fossil fish found with the beautiful Ammonites and Belemnites already described by Mr. Pratt and Professor Owen, in the Oxford clay, at Christian Malford, near Chippenham. Some of these ichthyolites are in an excellent state of preservation; others are mere fragments. Those genera I have been able to identify belong to the Lepidoid and Sauroid families of the Ganoid order of Agassiz, viz. *Lepidotus*, *Leptolepis*, and *Aspidorhynchus*. These three genera

* In the accompanying plate, fig. 1. represents this fossil of its natural size, and fig. 2. is a magnified view of part of the jaw.

1



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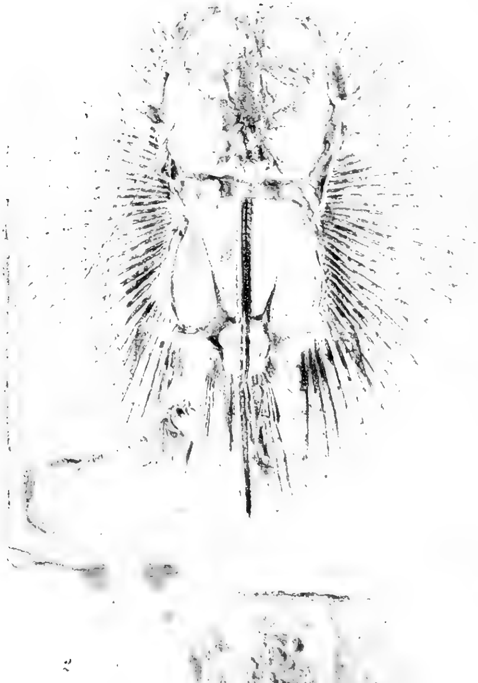


2

Cyclobatis oligodactylus Egerton

are found also associated with Ammonites and Belemnites in the lithographic stone quarries of Germany. The species appear all to be new.

Ganoid Order.

Lepidoid Family.

Lepidotus macrochirus, Eg.

I have only seen one specimen referable to the genus *Lepidotus;* it is, however, the finest ichthyolite yet discovered in this locality. The fish reclines on its back, and presents the whole ventral surface to the spectator. The head bones are rather dislocated, by which accident an advantageous view of the teeth is obtained. The two large bones of the horns of the hyoid bone are seen *in situ.* The pectoral and ventral fins are well displayed; the anal and caudal are crushed and indistinct. As compared with the species of this genus already described by Agassiz, this Lepidotus has the nearest affinity to *Lepidotus semiserratus* of the Whitby lias: it differs in the narrowness of the head, the larger size of the pectoral fins, and the marginal armature of the scales. The form of the lower jaw is well shown. The teeth are numerous, both in the upper and lower jaws, as also on the palate; they are in the form of acute cones, on constricted pedicles. The teeth on the palate are larger than those on the maxillary bones. The pectoral fins are large and strong. The rays are twenty or twenty-one in each fin, single for about half their length, then articulated; the articulations being frequent, and the ossicles small. The rays dichotomize so frequently as they recede from the base, that the extremity of the fin has a finely fimbriated appearance. The ventral fins are small, but the rays composing them are strong, apparently about eight in number. The scales have the thick enamelled surface so characteristic of the genus. The posterior edges of the flank scales are deeply notched or scalloped; this feature is traceable in other parts, although the number of notches in the caudal region is reduced to two or three. The gradual change of outline from the oblong to the lozenge shape as the scales approach the belly and tail, obtains as in other species of this genus. The arrangement of the scales of the vent has not hitherto been described in this genus. Indeed, no specimen with which I am acquainted exhibits these details; and yet we can scarcely imagine them peculiar to the species under description, but as common to the genus. In front of the anal fin, we find a pair of scales of large size; these are overlapped by a single scale considerably larger, and the anal orifice is situate under the middle of the posterior edge of the latter, coincident with the line of junction between the former. These three scales are quadrangular, and deeply notched on their free margin. Having had only a brief opportunity of examining the specimen above described, the details are not so complete as I could wish; they are, however, sufficient to show that this Lepidotus of the Oxford clay is not referable to any of those species already described by Professor Agassiz.

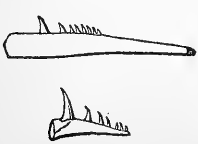
Sauroid Family.

Leptolepis macrophthalmus, Eg.

Lord Northampton possesses a specimen, nearly perfect, from the same locality as the preceding, referable to the Sauroid genus *Leptolepis*. It differs from the other numerous species of this genus in the long, slender, and superlatively elegant form of the body, as also by the large size of the orbit. The length of this fish is $5\frac{1}{2}$ inches, depth at the dorsal fin $\frac{9}{10}$ of an inch. The head is small, and its constituent bones thin and smooth. The mouth also is very small, and opens upwards; the orbit very large in proportion to the size of the head. The spinal column is composed of about 40 vertebræ, the terminal ones decreasing rapidly in size, and tending upwards: the ribs and vertebral spines are slender. The pectoral fins are composed of ten or twelve rays each; of these the anterior ones are strong. The ventral fins are comparatively large; they are situate nearly in the centre of the body, and have twelve rays in each. The dorsal fin is small, and immediately opposite the ventrals. The number of rays in this fin is not discernible. The anal fin is also small, and situate about half way between the ventral and caudal fins; the latter organ is symmetrical: the upper lobe has eight rays springing from the terminal vertebra, and has three or four fulcral rays on its upper margin. The lower lobe has from eight to ten rays. The scales are small and thin, finely sculptured with concentric striæ, as in *Leptolepis dubius*, and other species of this genus. This fish appears not uncommon in the Christian Malford deposit, as I have seen several specimens in the collections of Lord Northampton and Mr. Pratt, to whose liberality I am indebted for the specimens in my own cabinet. The latter gentleman has also presented me with two specimens which appear to constitute another species; they are not, however, sufficiently perfect to enable me to separate them definitively from the species already described, and the most striking differences appear to be, the greater size of the fish, and the stronger proportions of the ribs. The opercular bones are large, and the pre-operculum is sculptured with shallow radiating grooves. The fins are indistinct or wanting in these specimens; and the scales are wholly absent. I designate this fish by the provisional appellation of *Leptolepis costalis*.

Aspidorhynchus euodus, Eg.

The evidence of the occurrence of this remarkable genus, associated with the forms described above, consists of a few detached scales, and two fragments of jaw, one belonging to Lord Northampton, and the other to Lord Enniskillen. The scales present the peculiar characters found in the other species of the genus, and



leave no doubt as to the correctness of the generic identification. The teeth differ so far from the continental specimens as to indicate a distinct species. The jaw is furnished, as in the recent Lepidosteus, with teeth of various sizes, the larger ones projecting at intervals, the smaller ones filling the spaces between the principal ones. These teeth are remarkable for their strength and falcate shape. The bases are broad, and as the shafts taper to the apices they incline gently backwards: the result of this arrangement is a most formidable array of prehensile weapons, well adapted to secure the prey of these destructive fish, notwithstanding the obstruction of the ganoid scales with which they were invested. The specimens as yet brought to light of this fish are insufficient to show any further details of the species; it is to be hoped, however, that ere long, the riches of the Christian Malford deposit will be more fully explored. As far as our information extends, the association of forms there found is a natural one. The strong conical grinders of the Lepidotus are fully equal to contend with the shells of the Ammonites and the Mollusca; the sharp bristling teeth of the Leptolepis would find a suitable prey in the soft parts of the Belemnites, while they in their turn would find it difficult to elude the swift course and murderous jaws of the Aspidorhynchus.

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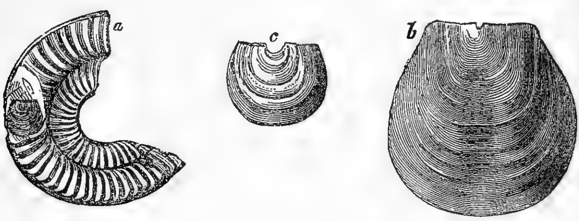
4. *On certain Calcareo-corneous Bodies found in the outer chambers of* Ammonites. By H. E. Strickland, M.A., F.G.S.



a. A portion of the broken shell of an Ammonite, with the calcareo-corneous body *in situ*, reduced to one-fourth natural size.

b. The body in (*a*), of the natural size.

c. Another similar body of a different species, also of the natural size.

In 1841, Miss Anning, of Lyme Regis, drew my attention to some black-coloured substances which she had occasionally met with in the interior of the *Ammonites Bucklandi*, and which she considered to indicate the presence of an ink-bag in the animal of the Ammonite, corresponding to that of the *Sepiidæ*. From these and other specimens, it appeared to me evident that these substances had constituted, not an ink-bag, but a laminar appendage to the animal, adapted to discharge some unascertained function. The specimens presented the appearance of a very thin concave shell, glossy on its outer surface, with irregular concentric undulations, crossed by longitudinal striæ and fine irregular oblique wrinkles. In the middle of the external margin is a large undulation or sinus. The inner surface, as exhibited by its cast, is of a dull black, the outer surface of the shell being of the colour of horn. Miss Anning informed me that these bodies generally occur about the middle of the outer chamber of the ammonite, whence they are obtained by breaking the fossil ; but as this process more frequently destroyed than exposed the object of search, I was unable, during my stay at Lyme Regis, to procure any tolerably perfect specimens, or to arrive at any satisfactory conclusion as to their nature.

In 1843, my attention was again called to the subject by finding in a bed of lias limestone, at Temple Grafton and Bickmarsh, near Bidford, in Warwickshire, (a bed remarkable for the variety of fish, plants, insects, and Crustacea which it contains,) several anomalous bodies whose characters were difficult to define. These substances are of a nearly semicircular form, very thin, slightly concave, presenting a small notch at the middle of the straight side, and having their surface covered with irregularly wrinkled lines of growth, concentric to the notch above mentioned. From the same point of departure also proceed fine radiating lines, visible only with the help of a lens. The colour is usually black, but they sometimes present a browner tint, as if from a mixture of calcareous and carbonaceous matter. The usual diameter is from half to five-eighths of an inch. (See figure *c.*)

In speculating on the nature of these bodies, although the black colour seemed to indicate a vegetable origin, yet the concentric lines of growth appeared so evidently allied to the structure of Molluscous shells, that I could not hesitate to seek for their affinities among the latter class of animals. Indeed, the general aspect is so much like that of an *Orthis*, that had they been found in a Palæozoic rock, I should probably have referred them to the *Brachiopoda.* But on closer examination it was evident, that these bodies were very little, if at all, calcareous, and that though their mode of growth was similar to that of shells, yet their composition was, in great measure, corneous, and probably elastic, like the plate in the genus *Laplysia.* It seemed, therefore, likely that they were part of the internal organisation of some mollusc, and on comparing them with the bodies before mentioned, as occurring in the Ammonites of Lyme Regis, it seemed not improbable that they were of a similar nature. Now the bed of lias in which these substances occur, contains two species of Ammonites, the *A. planorbis*, Sow., and another allied to *A. Conybeari;* and the dimensions of these Ammonites are such as would very well permit the bodies in question to be contained in their outer chamber. The form, too, of the bodies, is nearly that of a transverse section of the chamber of the Ammonite, so that they might easily close it in the manner of an operculum. From these considerations, the most probable supposition seemed to be, that the detached substances in the Bidford lias were portions of the animals of the Ammonites which occur in the same stratum.

This conjecture has been recently verified by finding a very interesting specimen. It is a species of Ammonite, allied to *A. Turneri*, Sow., but, as yet, I believe, unnamed, which occurs in a bed of clay, at Defford, Worcestershire, near the middle region of the lower lias. By a fortunate fracture, this specimen exhibits, imbedded in the stone which fills the outer chamber, a substance evidently identical in its nature with those just described. It lies with the convex surface outwards, and the straight side turned towards the mouth of the shell. The portion exposed to view is the cast of the interior surface, which is somewhat irregularly waved, but exhibits distinct concentric lines of growth. The whole of this inner surface is black like the Bidford specimens, but portions of the substance itself, which still adhere to the cast, are white and calcareous, showing that in this species, at least, the body was of a shelly nature. The slight portions which remain of the outer surface of this thin calcareous plate exhibit fine lines, radiating rather irregularly from the centre of the straight side, in which there is a very small but deep emargination or notch. (See the figure *b.*)

Judging from the specimens thus repeatedly obtained within the outer chamber of several species of Ammonite, there can be no reasonable doubt that these bodies were appendages of the cephalopodous mollusc which inhabited those shells. I leave it to more expert comparative anatomists to pronounce as to the precise nature of these corneo-calcareous appendages, which were possibly the representatives of the horny girdle described by Professor Owen as occurring in the recent nautilus, and which aids in the attachment of the animal to the shell. They may also possibly be the equivalents of that "ligamento-muscular disc," which protects the head of the recent nautilus.

These singular bodies may perhaps throw light on the nature of that much-disputed fossil the Trigonellites or Aptychus. I am aware that Professor Forbes has recently seen some reason for referring the latter fossil to the existing Holothuriadæ. But as this supposed affinity is as yet far from being demonstrated, I may be allowed to remark that the two valves of Trigonellites, when expanded, closely resemble in appearance the univalve disc which I have been describing; and when we recollect that Trigonellites have hitherto only been found in formations which also contain Ammonites, and that they have in several instances been found in the interior of Ammonites precisely as in the case of the bodies before us, there is, I think, a fair presumption that these singular bodies are allied in origin and in function to the remarkable fossils here described.

On referring to a paper communicated by M. Voltz to the Natural History Society of Strasburg, which will be found in the *Mém. de l'Institut* for 1837, p. 48, it appears that he was acquainted with fossils similar to those before us, and that he also considered them to be allied to *Trigonellites* or *Aptychus*. He divides the Aptychi into three groups, *A. cornei, imbricati,* and *cellulosi,* the former of which differs from the two latter (which are *calcareous* and *bivalve,*) in being *corneous* and *univalve,* both which characters are applicable to the fossils which I have above described. He supposes that in the corneous species a certain degree of motion was effected in the two halves of the body by means of its own elasticity, while in the calcareous groups the same end was obtained by means of a bivalve structure. He enumerates five species of the corneous group, all of which are from the lias and inferior oolite, and which, like the imbricate and cellulous species, are occasionally found in the interior of Ammonites, occupying a symmetrical position, and corresponding in their dimensions to the shell in which they are found. From these and other reasons, M. Voltz regards the whole of this group of fossils as appendages to the animals of Ammonites, a view which is confirmed by the facts adduced in the present communication.

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5. *Notice concerning the Tertiary Deposits in the south of Spain.* By James Smith, Esq., of Jordanhill, F.G.S.

In the bay of Gibraltar, immediately to the north of the plain which separates the fortress from the Spanish territory, we meet with a series of low swelling hills of yellow rubbly sandstone, the beds dipping to the S.W. at an angle of 12°, and abounding in marine tertiary fossils. Of these fossils, there is only a small variety, and of many of the species I could only find casts; but these were sufficient to furnish an important link, connecting distant deposits; for upon comparing them with the specimens in the Society's Museum, illustrative of Col. Silvertop's account of the tertiary formation of Murcia and Grenada, and Lieut. Spratt's paper on the Geology of Malta, I find that the three deposits are identical.

I have also observed tertiary beds at Cadiz, and between Xeres and Seville, which, I am satisfied, belong to the same deposit; and Mr. Sharpe, in his paper on the Geology of Lisbon, has assigned reasons, with which I entirely agree, for considering that the tertiary beds of the Tagus coincide with those of the south of Spain.*

In a communication respecting the age of the Lisbon tertiary beds, I stated the grounds which led me to conclude that it was nearly the same as that of the Bourdeaux deposit, and I may now add, that I consider it more ancient than the Touraine Faluns, or older crag.† It will be seen, from the report of Professor

* Geol. Transactions, 2d series, vol. vi. p. 113.
† Geol. Proceedings, vol. iii. p. 492.

Forbes on the Malta fossils*, that he has arrived at the same conclusion with respect to their age.

Professor Agassiz, who examined my collection of Lisbon shells, considered that they were of the same age as the Molasse of Switzerland.

The whole of these deposits, therefore, may be placed in the Miocene or middle division of the tertiary system; a formation of prodigious extent, which appears to have comprehended the whole of the southern portion of the European continent, from the shores of Portugal to the Morea, and from Switzerland and Vienna to Malta and the Straits of Gibraltar.

* Geol. Proceedings, vol. iv. p. 232.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY OF LONDON.

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November 6, 1844.

The following communication was read: —

Observations *on the* Geology *of some parts of* Tuscany. By W. J. Hamilton, Esq. M.P., Sec. G. S.

One of the principal physical features of the district under consideration in the present memoir, is the existence of three distinct mountain ridges, extending from N.W. by N. to S.E. by S., and parallel to the direction of the main chain of the Apennines. All these ranges belong to the *Scaglia*, a representative of the cretaceous series which is known to prevail extensively throughout Greece, the Morea, the Ionian Islands, Asia Minor, and the South of France.

I cannot pretend to define the limits of these different ranges, or even to point out their exact number and geological contents, having only been able to visit a small portion of them; but the following are the principal lines occurring in the district which came under my consideration.

1st. The first line, commencing between Pistoja and Prato, passes through Castello and Fiesoli, and keeping to the N.E. of Florence, descends in a S.E. direction to Arezzo, Castiglion Fiorentino, Cortona, &c., when it passes to the N.E. of the Lake of Thrasymene.

2d. Commencing to the S. of Pistoja in the Monte Albano, the second line crosses the Arno, between Signe and Empoli, and passing through Galluzzo and L'Impruneta, extends through San Martino, San Donato, Incisa, Levane, to the hills of Chianti, and thence to Monte Cetona.

3d. The third line, more to the S.W., may be said to commence with the hills of Monte Pisani, near Pisa ; thence crossing the Arno, it continues along the line of hills which separates the valleys of the Era and the Elsa, passing between Volterra and Poggibonzi until it reaches the mountainous district, in which are the quarries of Sienna marble, ten or fifteen miles S.W. of that city.

Perhaps a 4th parallel line may be traced further to the S.W., commencing with the hills of Monte Rotondo, near Leghorn, and passing through Monte Catini and Monte Cerboli, until it loses itself in the complicated system of the Maremme.*

It is still a question for further investigation how far the crystalline limestone near Sienna, and in which, to the W. and S.W. of that town, are the quarries of Sienna marble, is to be considered as a district of older formation. It is probable that a transverse chain of elevation, marked by rocks of a more crystalline character, will hereafter be distinguished extending from N.E. to S.W., *i. e.* from the Monte di Chianti, through Monte Maggio, N. of Sienna, to the district in which the quarries occur.

The valleys between these different ranges are generally filled with tertiary deposits of various characters, some of a mere local nature, while others extend over a considerable tract of country, to which they impart a singularly dreary appearance, being almost entirely devoid of vegetation and altogether unsuited for cultivation.

The various formations of Tuscany may be described in the following ascending order: —

A. Stratified Rocks.

I. Secondary formation.

II. Tertiary formation:
- 1. Tertiary marine.
- 2. Tertiary freshwater.
- 3. Post-tertiary formations.

B. Metamorphic Rocks

Red Gabbro.

C. Igneous Rocks.

1. Serpentine — secondary period.
2. Selagite — tertiary period.
3. Basalt of Radicofani, &c.

* Since writing the above, I find that the same features of three parallel ranges have been described by M. A. Burat, in a paper lately read before the Institut de France. See *Comptes Rendus*, 1843 (p. 1279.).

A. Stratified Rocks.

I. *Secondary Formation.*

These rocks, which constitute by far the greatest portion of the mountainous districts of Tuscany, forming the parallel ranges extending from N.W. to S.E., consist of various beds of sandstone, indurated marls and shales, and compact grey lithographic limestone or scaglia, either alternating with each other or more or less developed in different localities.

The sandstone consists of three different varieties, viz., —

(*a*) Hard grit (*macigno*), considerably developed near Florence, particularly to the W. and S.W., where it forms large mountain masses, and is extensively quarried along the banks of the Arno, and at various other points, for building-stone and for the slabs employed in paving the streets of Florence. A very considerable quarry, affording an excellent section of thin beds of this rock, alternating with a soft bluish shale, occurs on the banks of the Ema, near Ponte d'Ema, about two or three miles S.E. from Florence. Many of the slabs show slight appearances of fucoidal stems. It generally occurs alternating with thin bands of shale of a dark blue or reddish colour. It varies considerably in dip, although most frequently inclined to the N., N.E., and N.W. The grain of this stone is generally coarse and compact, and it is often traversed by thin veins of calcareous spar.

(*b*) A fine-grained greenish sandstone (*pietra serena*), extensively quarried near Fiesoli, where the beds dip to the N.W., and used for architectural purposes in Florence. It also occurs at Monte Catini, just above the village of that name, dipping S. and S.E.

(*c*) A soft friable sandstone, of a yellowish brown colour, slightly micaceous. It is broken by numerous fissures into rhomboidal masses of various sizes and shapes. It forms hills of considerable height and extent in the Val d'Arno di sopra, above Levane and Arezzo. I only met with one locality producing anything resembling organic remains, and these consisted of a few vegetable impressions.

The indurated marls and shales are generally associated with the hard grits and sandstones; but the former are sometimes developed to a great thickness, forming masses of considerable extent, and consisting of numerous strata. This formation came under my notice in the vicinity of Castiglion Fiorentino, between Arezzo and Cortona, and in the neighbourhood of the mines of Monte Catini. In the former locality it is traversed by several thick veins of calcareous spar; and in the latter it consists of a great variety of thin strata, dipping from the region of the copper mines to the S. and S.W., and underlying a thick formation of secondary lithographic limestone. Numerous beds of indurated shales also occur in the neighbourhood of Florence, in the hills above the Certosa, where it is overlaid by thick beds of macigno.*

The limestone called in the country *alberese*, and often associated with the above-described sandstones and indurated argillaceous shales, is very compact, varying in colour from a bluish to a yellowish white, and resembles lithographic limestone and the scaglia of the N. of Italy and Greece, which is generally referred to the Cretaceous period. The principal localities at which I had an opportunity of observing it were : 1, near the Impruneta, six or seven miles S. of Florence, where it is extensively quarried. Not far from hence, at a place called Mugnano nummulites are said to have been found in great abundance in one of the limestone beds ; 2, at San Donato, 9 miles S. E. of Florence, on the road to Arezzo, where it forms hills of considerable height. It is either horizontally stratified or dips slightly to the E. It may be traced for several miles to the S. in the bottom of all the ravines, overlaid by tertiary sands and gravels, as far as Incisa, on the banks of the Arno ; 3, at Monte Catini ; the *alberese* here overlies the sandstone and indurated marls which have been upheaved and tilted by the protrusion of the igneous rocks with which the copper mines of La Cava are connected. It laps round the uplifted masses of Monte Massi and Poggio alla Croce, and not possessing the same elasticity as the schistose beds, has been much more shattered and broken up by the elevatory action to which it was exposed. It also occurs in the same chain of hills further westward, towards Monte Miemo, where, not being in such immediate contact with igneous rocks, it still preserves its compact and stratified character. Proceeding westward, towards Castellina, it is found in several places near Monte Vaso, where attempts are now making to obtain copper on the strength of indications similar to those of Monte Catini.

To the S. of the Cecina, in the midst of a wild and wooded mountain district, consisting chiefly of serpentine or ophiolitic rocks, the same scaglia limestone also occurs, forming elevated plateaux and ridges, on which, notwithstanding the enormous fragments by which the ground is encumbered, the industry of the inhabitants is constantly directed to the raising of crops of corn. My attention not having been so particularly directed to these secondary formations, I regret that I cannot more clearly describe the different groups into which they are subdivided.

II. *Tertiary Formation.*

The tertiary formations of Tuscany may, for the purposes of arrangement, be subdivided into three groups, as already mentioned : —

* Captain Portlock's paper has been communicated since this was written.

1. Tertiary Marine Formation.

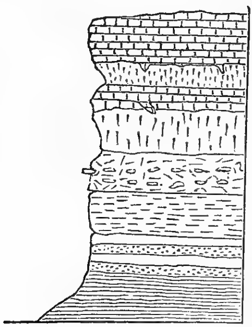
The principal localities in which I observed this formation may be referred geographically to the following districts: —

a. The basin of Volterra and its neighbourhood, with the valley of the Era.
b. Leghorn.
c. Poggibonzi, including the country from Colle to S. Casciano, with a great portion of the valley of the Elsa.
d. Sienna, and the country watered by the Ombrone, extending to Buon Convento, S. Quirico, and Pienza.
e. The upper portion of the Val di Chiana, and the basin containing the lakes of Chiusi and Monte Pulciano.

a. The Basin of Volterra and its neighbourhood, with the Valley of the Era.—This district commences on the north with the hills which form the southern boundary of the Val d'Arno, near Ponte d'Era, and extends S.S.E. as far as the Cecina, where it constitutes a range of hills on the south bank of that river, resting against a confused district of serpentine and scaglia limestone. On the east it is bounded by the hills which separate the valleys of the Era and the Elsa, and which, where I had an opportunity of seeing them, consist of secondary limestone; and on the west by the hills to the S.E. of Leghorn, of which the highest point is known by the name of M. Nero. In the S. portion of this region rises the insulated mass of hills extending from E. to W., from M. Catini to Castellina, and which is thence prolonged northwards to M. Vaso. These hills consist of the secondary formation already described, lapping round masses of gabbro rosso and serpentine; this latter rock has protruded itself in many instances, and with it the metalliferous deposits of this district are mainly connected.

The beds of which this tertiary formation consists rise gradually from the N.W., from under the alluvial formation of the Val d'Arno, towards Volterra, where they attain a height of nearly 1800 feet. By far the greater portion of the whole thickness is a stiff blue clay, called by the inhabitants *matajone*, throughout which are disseminated many small crystals of selenite. It first appears at the foot of a lofty cliff on the right bank of the Era, called Ripa Bianca, under the village of Peccioli. It is overlaid by a thick bed of sands, limestone, and arenaceous tuffs, varying in thickness from 20 to 100 feet, the lower portions of which are very friable, and contain many small calcareous nodules, arranged in parallel layers. On the left bank of the Era, near Capannoli, I observed in the sand several parallel beds of oysters, thickly matted together, and associated with a few broken Pectens.

The summit of the lofty hill of Volterra, affording one of the most commanding positions in the country, and remarkable as being the site of an old Etruscan city, gives another interesting section of the limestone and arenaceous beds, which cap the tertiary blue marls; the total thickness of this capping is about 80 or 100 feet. This elevated plateau is nearly 2000 feet above the level of the sea. To the W. and N.W. it presents a long extent of steep escarpment, 80 or 100 feet high, near the northern extremity of which is a deep and precipitous ravine, called Le Balze, in which extensive land-slips are constantly taking place, and where, during the last 150 years, many houses and churches have been engulphed by the gradual working back of the cliff. A spring of water issues at its foot, between the sandstone and the blue marl, which, acting on the lower arenaceous beds, combined with the effect of weathering and heavy rains on the blue marl itself, has undermined the cliff, and caused its fall into the hollow below. The following is a section of this part of the formation:—



The upper bed of shelly limestone is full of *Cardium*, *Pecten*, *Ostrea*, &c., but in a very comminuted state. In the arenaceous beds they are less abundant, but the nodules or calcareous concretions are full, and in fact are sometimes quite composed of them. In some places the separation of the limestone from the sand is not complete, and the whole bed consists of an arenaceous limestone. At a short distance from Volterra to the E.S.E. is another hill called Poggio alla Rocca, consisting, like the former, of blue marl capped with limestone and arenaceous beds, but not rising to the same height. Marine fossil shells are very abundant in many parts of this formation.

This upper formation or capping is evidently a portion of that which, occurring on the summit of many hills in this district, has received from Savi the name of *Panchina*, and which he considers as the result of local submarine springs depositing calcareous matter in the neighbourhood of their sources. But it is of so general a character, and occurs in so many districts under the same circumstances, that I cannot agree to such a partial explanation. Many of the hills S. of the Cecina, and particularly in the neighbourhood of Pomerance, are capped with thick beds of this same calcareo-arenaceous deposit. Pomerance itself is built on a mass of it, and it closely resembles that which I shall hereafter describe in the Sienna district, and on which the towns of S. Quirico, Pienza, and Sienna are also built; although here it is perhaps rather more calcareous. It also occurs to the S.E. of Leghorn, where it forms the substratum of the plain and the beach. It is, however, certainly a remarkable feature that it is seldom quite horizontal, but appears to follow the slope of the hills, lapping over them like a covering. It everywhere contains numerous marine shells, chiefly *Pecten* and *Ostrea;* the latter sometimes constituting whole beds, while the material is in many places sand and pebbles, with a hard calcareous matrix. Although this formation is always found as a capping of the hills, and never occurs in the valleys, it is not seen on the high hills of Monte Catini and Monte Vaso, which were probably already elevated into islands before it was deposited; but it may, I think, be traced in a few places circling round the eastern portion of these hills, opposite Volterra. Of these the localities most worthy of observation are where the new road leading to M. Catini and La Cava has been cut through thick beds of conglomerated pebbles, sand, and calcareous bands containing large *Ostreæ* and *Pectens*, and evidently resting against the unconformable beds of the secondary formation, and of the gabbro rosso.

But the most extensively developed feature in this marine tertiary formation is the blue marl which immediately underlies the last-mentioned beds, and has in the great basin of Volterra a thickness of nearly a thousand feet. It may, however, be a question whether this blue marl does not belong to an older tertiary period, — Eocene, perhaps, instead of Miocene, as the limestone capping, instead of being almost horizontal, generally follows the slopes and undulations of the hills, as if deposited after the valleys had been scooped out.

At Volterra fossil shells are of rare occurrence in the blue marl; but as we approach the borders of the formation towards the north, they become more abundant, and in some cases, as near the junction of the Sterza and the Era, may be said to constitute nearly one half of the whole mass of the formation. They are, however, so broken and fragile, that it was difficult to extract entire specimens. *Dentalium*, *Cardium*, *Venus*, *Cerithium*, *Pleurotoma*, *Turritella*, and large *Ostreæ*, were most numerous. With them were associated small crystals of selenite, which, abounding in many portions of the blue marl, give it a glittering and sparkling appearance.

Below the borgo of Monte Catini is found a singular spotted argillaceous rock, resting against the erupted mass of igneous rock on which Monte Catini is built. Its appearance is that of a trap rock; but, on further search, it proved to be full of shells, chiefly *Cardium*. It is of a greenish grey colour, and at first shows a few light-coloured spots, which, by degrees, become more numerous, and occur even in the shells themselves. Other specimens, in which decomposition or alteration is more advanced, show larger spots; until at length they assume an entirely pisolitic character, the grains being perfectly detached, whether they occur in the mass of the rock itself, or in the shells. I believe it to be the blue marl altered by the eruption of the igneous rock.

But if the blue marl near the centre of the basin is deficient in organic remains, it abounds in numerous productions of mineralogical importance, which, both from their own intrinsic value, and from their connection with other phænomena still occurring in the same vicinity, deserve to be particularly noticed.

About five miles S. S. E. from Volterra, in the deep valley of S. Giovanni, situated in the blue marl, and watered by a small stream, are extensive salt-works, now the property of the Government, but from which, in former times, the inhabitants of Volterra chiefly derived those riches by which their town flourished and preserved its independence and importance. These salt-works are fed by springs of brine collected from nine different spots where the saturated water is pumped up from deep pits. It has been ascertained by sinking wells and by Artesian borings that this brine is derived from beds of rock salt, which, at different depths below the surface, varying from 50 to 100 feet, are found alternating with the blue marl, in the same manner as the alabaster occurs in other parts of the same formation; and in the boilers, during the process of evaporation, much sulphate of lime is deposited. The average annual production of salt is stated to be from 18,000,000 to 19,000,000 Tuscan pounds;—about 140,000 cwt., or 7000 tons per annum.

The other productions found in the blue marl are gypsum, alabaster, and selenite, — the various forms in which the sulphate of lime so abundant in this district has been deposited. They are particularly met with in the neighbourhood of Volterra, where, however, all the varieties of gypsum do not occur. The pure white quality known as alabaster, and in such demand at Florence, is only found in the neighbourhood of Castellina, about twenty miles W. N. W. from Volterra, at the western extremity of the hills of Monte Catini. It may, however, be observed that the great developement of gypseous matter appears to be confined to a narrow line extending from W. N. W. to E. S. E., in which direction a band of only a few miles in width drawn from Castellina to somewhere near Monte Miccioli would comprise all the gypsum and alabaster quarries in the country, as well as the salt-works already alluded to.

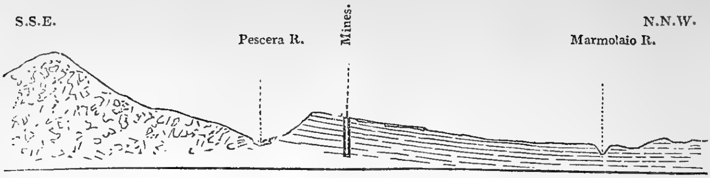
The deposits of Volterra, Picchiaiola, S. Lorenzo, and Castellina may be described as giving the best types of the different forms in which the gypsum of this country occurs. 1. That of Volterra, which is called the variegated alabaster, is most frequently found in detached irregular masses of greater or less size, penetrated by red and green and yellow veins. It is frequently much shattered, and sometimes mixed up with the blue clay: it is harder than the other varieties, and is used principally in the manufacture of vases, candelabra, &c. It occurs chiefly from four to six miles S. E. and E. of Volterra, on the road to Florence.

2. In the immediate vicinity of the little village of Picchiaiola, five miles on the road from Volterra to Florence, is a very considerable mass of gypsum of peculiar character, rising above the surface of the ground. It consists of irregularly compacted masses of crystals of selenite easily detached from one another, and called by the people of the country *specchio d'asino*, or the "ass's looking-glass." On breaking off the outer crystallised crust, an earthy crystalline substance is perceived full of cavities and botryöidal concretions, precisely resembling the substance formed round the vents of the vapours of Monte Cerboli; at once suggesting the idea that some at least of these gypseous deposits may have been produced by similar vapours or *soffioni*.

3. The third form in which the gypsum occurs in this district is that of an irregular broken stratification. The blocks occur at intervals more or less distant, extending in long lines through the marls in which it is found, sometimes occurring as detached masses, and at others in continuous beds. In the neighbourhood of S. Lorenzo, near the suspension bridge over the Cecina, this formation is seen on both sides of the river, but is not of any great thickness. Near Buviano, on the north bank of the Cecina, towards Monte Catini, the gypsum beds occur sloping at a very considerable angle down the hill sides, and apparently following their inclination. Wherever this variety of gypsum occurs it is almost invariably of an opaque white saccharine character. It is found in many detached spots in the Volterra district.

4. By far the most interesting and important of the different varieties of gypsum is the fine white alabaster found in the neighbourhood of Castellina, where it is regularly stratified, and is worked in properly constructed mining galleries. The little town of Castellina, distant about twenty or twenty-four miles from Volterra, is reached by a rocky road over wild and rugged mountains. It is situated on the W. N. W. slope of the hills of Monte Vaso, overlooking in that direction an extensive and slightly undulating plain of tertiary marls, which there can be no doubt extend round the north point of the Monte Vaso chain, and are connected with those of the Val d' Era and the Volterra district.

The mines are situated three miles W. N. W. from Castellina, near the edge of the tertiary marls, where they rest against the secondary rocks. They occur on a slightly rising ground between two streams, the Pescera on the south, which flows between it and the hills, against which the blue marls probably once rested before the river bed was washed out, and the Marmolaio on the north, which flows through the marl itself. (See Section, No. 2.)



The beds have, at the mines, an inclination of about 5 degrees to the N. W. or N. N. W., and consist of regularly alternating strata of blue clay or matajone and grey gypsum, the latter containing in regular layers nodules or spheroïdal blocks of the pure white alabaster. In the shaft of the mine I observed five distinct beds of gypsum alternating with the blue clay, and varying in thickness from five to twenty feet; but as the owner, Signor Mazzoni, had no measurements, and I had no means of obtaining perfect accuracy, the numbers are probably understated. The only known measurement was, that the whole depth of the shaft to the fifth bed of gypsum was 110 braccie, or 200 feet, and in another mine the fourth bed, which was here 20 feet thick, was there said to have a thickness of 30 feet.

The range of low hills in which the alabaster is found, is about four miles in length along the strike of the beds from N. E. to S. W., but the pure alabaster is only found near the centre of this line, and three of the four mines now worked are on the small property of Signor Mazzoni: nor does it extend far in the transverse direction from S. E. to N. W., for about half a mile N. W. the gypsum is of a very inferior quality, and dips under the blue marl; and the mines, though sunk to the depth of nearly 200 feet, are rendered useless by the water having got in.

We entered the mine by an inclined path, and, passing under ground, soon reached an open well or large inverted cone, round which the inclined path is carried, and where the section of marls and gypsum is well exposed. As the descending road passes through the third and fourth gypsum beds, galleries are seen striking into the rock in all directions. The first and second gypsum beds are of a uniform character and grey colour, and do not contain any alabaster blocks. These are found principally in the third and fourth beds, and occur as irregular isolated spherical masses imbedded in the gypsum, from which they are, mineralogically speaking, distinctly separated by a thin black crust, which indicates to the workman the existence of the finer nodules. These nodules are most frequent in the lower part of the stratum, and occur in regular layers, never touching, although varying much in their distances from each other. In bed No. 3. there are two layers of these nodules, and in No. 4. there are three. They vary much in size, weighing from 20 or 30 lbs. to upwards of 2000lbs. When the workman discovers the black crust, he is at once aware that he is near a block of alabaster, and by following the direction of the crust, he removes the gypsum all round until he has nearly detached the whole nodule, which is at last carefully separated from the parent rock. Gunpowder is occasionally used to blast the rock when no black crust indicates the existence of the alabaster. This crust in connection with the pure alabaster is perhaps one of the most curious features of the mine. On close examination it appears to be laminar and concentric, and to consist of layers of blue clay and gypsum. Now the whole formation of gypsum contains a small portion of clay which gives it the greyish colour, and it is probable that, when that peculiar principle, whether crystallisation, attraction or electricity, which caused the aggregation of the particles of gypsum in greater purity and in a more crystalline state was in operation, one of its chief effects was to expel to the circumference all the particles of argillaceous matter previously mixed up with the gypsum; a process which would continue until either the crust itself opposed a resistance to the further action of this principle, or until two opposing spheres nearly came in contact with each other. Very fine crystals of selenite, and sometimes of a large size, are not unfrequently found in the fissures of the gypsum. They are used for the purpose of making the fine Scagliola cement, and are consequently sold at a much higher price than the more ordinary gypsum. The price of the fine alabaster is 5 Tuscan lire the 100 lb. Tuscan at the quarry, or 8 if delivered in Leghorn.

b. Leghorn. — The plain immediately to the S. E. of Leghorn consists of a hard calcareous rock in horizontal beds extending from the mountains to the sea-shore and even into the sea, forming sometimes the low flat beach, and at others the broken cliff above. It is generally very compact and hard, and not unfrequently contains pebbles of alberese and other secondary rocks, and also a few marine shells. It appears to belong to the formation of arenocalcareous rocks, which caps the summit of the Volterra and other hills, and has received from some of the Italian geologists the name of Panchina.

c. Poggibonzi. — The third district in which marine tertiary deposits are found is that of Poggibonzi, including the country from Colle to San Casciano, with a portion of the valley of the Elsa and of the Pesa. I have made this a distinct district from that of Volterra; because it appears to be entirely cut off from it by a chain of hills of secondary formation: geologically speaking, it is probably a portion of the same district. It consists, in its western portion, of thick beds of yellow sand; while towards the N. E., and particularly towards the north, and near San Casciano, it becomes gradually more gravelly, and, at length, consists almost entirely of thick banks of pebbles, increasing in size towards the north as they approach the rocks of the secondary age against which they rest, and from the breaking up or wearing away of which they were, in all probability, derived. On most of the hill tops, oyster beds and pectens of large size are found. In some of the deep ravines and glens, beds of blue marl are perceived underlying the sands and gravels, but not developed to any great extent or thickness. Near the 21st mile from Florence, extensive beds of blue marl are seen in the ravines N. W. of the road, with a perfectly horizontal line of separation between them and the overlying sandstones. In general, however, the whole surface of the hills, the summits, and the valleys are covered with the sands and conglomerates; and it is still doubtful whether or not the valleys were already hollowed out in the blue marl previous to the deposition of the sands and gravels on its undulating surface. I am rather inclined to adopt this view, as in the deep valley of the Pesa the great masses of overlying gravel and conglomerate reach to the bottom of the valley, and much lower than where the blue marl occurs in other places. At all events, we may trace from San Casciano to Poggibonzi, and perhaps even to Volterra itself, a gradual change in the form of the various elements deposited during the tertiary epoch; indicating a greater facility of being held in suspension and transported by water: although, perhaps, this will only apply to that portion of the formation which overlies the blue marls. Near San Casciano, beds of conglomerate abound. As we proceed S., the pebbles become smaller, and gradually disappear, being replaced by a fine compact arenaceous tuff, which occurs in the neighbourhood of Poggibonzi and Colle; and further S. and S. W., the upper beds become still finer and of a more comminuted character.

d. Sienna District.—The fourth district of the tertiary marine formation commences a little to the north of Sienna, and extends, in a S. E. direction, through the country watered by the Arbia and the Ombrone by Buon Convento to beyond San Quirico and Pienza. Its southern limits I did not ascertain; but to the N.E. it is bounded by the secondary hills which separate it from the Val di Chiana and the district of Monte Pulciano. It consists, for the most part, of blue clay or marl, remarkable for its sterility and bleak appearance. It contains, here and there, a few crystals of selenite, but a most careful search, in numerous localities, did not produce a single fossil shell. In many places it is capped by beds, varying in thickness, of yellow arenaceous limestone and sand, some of which are full of marine testacea, constituting entire masses of *Ostrea* and *Pecten*.

These elevated table lands, wherever I observed them, have in early ages been invariably made use of by the inhabitants, as affording safe foundations for their cities, which would be sought for in vain on the soft and yielding masses of the subjacent marl. On such table lands are built the towns of Pienza, San Quirico, Montalcino, Sienna, and probably many others. Pienza is situated near the extremity of a narrow, rocky, peninsula, of which the upper bed consists of a compact, agglomerated, calcareous sandstone, having a slight inclination to the S.W. Immediately below it, and overlying the blue marl, is a more sandy bed, of no great thickness, full of broken shells, chiefly two species of Ostrea.

San Quirico stands upon a similar table land, the only difference being that several beds and layers of conglomerated pebbles, chiefly consisting of the white *alberese* or Scaglia limestone, are associated with the sandstone tuff.

e. Val di Chiana. — The fifth district is the upper or southern portion of the Val di Chiana, and the basin, containing the lakes of Chiusi and Monte Pulciano, extending to the frontiers of the papal dominions, near Città della Pieve. A portion of this district, low as it is, is remarkable, as constituting, since the great hydraulic operations undertaken by the Tuscan Government, the watershed between the drainage flowing into the Arno and the Tiber. Two miles to the south-east of the town is the Pian della Biffa, formerly a marshy lake, across the centre of which is a dyke called L'Argine della separazione, on the respective sides of which the waters flow to the Tiber and to the Arno, sluice-gates being placed at each end to regulate the escape of the water in the spring, and to prevent the plains below, particularly on the banks of the Tiber, from being flooded.

My geological observations in this plain were chiefly confined to the neighbourhood of Chiusi and the north-east flanks of the range of hills on the west side of the plain, from Cetona to Monte Pulciano. The hills round Chiusi, on one of the highest points of which the town is built, consist of numerous alternating beds of gravel, conglomerate, sandstone and blue marl; some of these beds, particularly the latter, and occasionally the sandstone, contain numerous marine tertiary shells. In some, complete oyster beds are still preserved, forming large masses of shells of considerable thickness, which are particularly developed near the lake to the east of the town. Here I observed, in an ascending order, the following section: —

1. Sandy tuff, or friable sandstone, of very great thickness, sometimes containing intercalated beds of gravel. In the so-called tomb of Porsenna, two or three miles north-east from the town, is a band of gravelly conglomerate in this sandstone tuff, which has been made use of to form the flooring or separation between two tiers of excavated tombs or chambers. Most of the well-known Etruscan tombs in this neighbourhood are excavated in this rock, which does not contain any fossils.

2. Blue clay, a few feet in thickness; organic contents uncertain.

3. Reposing on the blue clay is a very thick, solid bed of oyster shells, in which are some of a most diminutive size.

4. A thick bed of gravel and conglomerate, strongly cemented together by a calcareous paste. This is, in many places, of very considerable thickness, forming the capping of the hill on which the town of Chiusi is built, as well as of several other eminences in the neighbourhood. On an estate belonging to the bishop, near

the tomb called "tomba della vigna grande," the series of beds was rather different.

In a ravine, one mile north-west of the town, the blue clay is well exposed, and is of considerable thickness. In it numerous shells are found — *Cerithium*, *Serpula*, *Dentalium* (2 sp.), *Venus*, *Cardium*, *Arca*, *Pecten*, *Natica*, *Pleurotoma*, *Cancellaria*, *Nassa*, and others. The same clay beds are well exposed on the road to Cetona; and, again in the neighbourhood of Sarteano, equally rich in marine testacea. Between Sarteano and Chianciano, *Cardium* is found in the sandstone tuff. Chianciano is celebrated, in the annals of Italian Geology, for the great abundance and variety of its tertiary marine shells, which occur in one or two localities near the town.

From Chianciano the same tertiary formation extends to Monte Pulciano, offering sections of gravels and sands, containing beds of oysters. Monte Pulciano itself stands on a lofty insulated hill of sandstone and gravel. In the sand are many large Ostreæ, and a few *Cerithia* occur in the nodular calcareous concretions. The formation is traversed by a few almost horizontal beds of very hard sandstone. To the north of Monte Pulciano is the commencement of a bleak and arid blue marl district, resembling that so remarkably developed in the neighbourhood of Pienza and S. Quirico, and with which the district of Monte Pulciano and Chiusi was, in all probability, formerly connected.

2. Tertiary Freshwater Formation.

I now proceed to describe those localities in which tertiary freshwater formations came under my observation.

On the range of hills which I have been just describing, between Cetona and Sarteano, the road crosses a spur of limestone rocks, which, from its compact character, colour, and honeycombed appearance, I at first attributed to the Scaglia formation of the secondary or cretaceous period. But, on reaching the summit of an elevated table land, I found in it numerous tertiary freshwater shells, as *Planorbis* and *Limnæa*. It rests against the secondary rocks, and appears to be overlaid by the blue marls containing marine shells.

Another locality, where the same rock occurs, is in the valley of the Bultino, two or three miles south-east of Colle, on each side of which are extensive remains of a tertiary lacustrine formation, through which the valley has been cut, and a large plain has been excavated. The lower beds are very arenaceous, and contain calcareous nodules. Near the village of Campigliano is a good section, where some of the upper beds are of a slightly reddish colour; but, in general, they have the dull grey appearance of an earthy alberese, sometimes assuming a concretionary character. The upper beds contain *Limnæa* and *Planorbis*. This formation extends to Colle, forming a flat, level plain covered with barely a foot of soil.

It would require a longer examination than I was enabled to bestow on it, to ascertain the exact age of this formation; from its position it seems to form an intermediate link between the arenaceous deposits of the marine beds already described, and the post-tertiary beds to which I am about to allude, being connected with the former by the arenaceous beds containing concretionary calcareous nodules, and with the latter by its immediate juxtaposition in the vicinity of Colle. On the other hand, both in its mineralogical character, and in the appearance of its fossils, it closely resembles the freshwater limestone of Cetona, which is supposed to underlie the blue marl formation.

3. Post-Tertiary Formations.

The principal rocks which come under this denomination, are the deposits of calcareous tuff, assuming a concretionary and at times a spongy and tubular appearance, extending for several miles on both sides of the valleys of the Staggia and the Elsa. This formation has been alluded to by Mr. Lyell.* It is best developed in the valley of the Staggia. Near the town of that name is a horizontal formation of travertine, filling up the valley between the two ranges of sand hills, and forming a narrow lacustrine plain, through which the river has subsequently washed itself a bed, exposing the horizontal layers of tuff in the bed of the river. The extent of this deposit, probably derived from one spring or source, is very considerable, and may be traced from the town of Staggia to within a mile of Poggibonzi, a distance of nearly seven or eight miles. It is, however, so modern, that the shells found in it appear to be quite recent, and the stems of plants and roots, round which the calcareous tuff has been deposited, still retain, however slightly rotten, their wooden fibre. Impressions of leaves are very abundant in it.

The beds are more than 100 feet thick in some places; they are both calcareous and arenaceous, sometimes mixed. The variety of form resembles what Mr. Lyell has said † respecting the travertine deposited from the spring near the baths of San Vignone, and is probably owing to a similar cause. At times the calcareous particles are collected in concretionary and botryoïdal masses, sometimes almost stalactitic. Occasionally the beds are soft and friable, while others acquire the hardness and compactness of Scaglia limestone. Some of them are slightly ferruginous, and sometimes they present a strange conglomeration of cylindrical tubes. In places they are much contorted; in others, horizontal or slightly undulating. Species of *Paludina* and *Valvata* abound in some of the softer and more friable beds. This singular formation must have been deposited by a stream highly charged with calcareous matter, which, at no very distant geological period, flowed down the valley of the Staggia. A similar formation occurs in the adjacent valley of the

* Principles of Geol. vol. i., p. 398., 6th ed. † Ib. p. 400.

Elsa near Colle. Other formations, referable to this same recent epoch, are the extensive alluvial and the now drained lacustrine deposits of the Val d'Arno, particularly that portion known as the Val d'Arno di sopra, extending from the rocky defiles of Incisa, once evidently the barrier of these inland lakes, through S. Giovanni, Montevarchi, and Levane, to Arezzo. This formation consists chiefly of denuded hills of gravel, sand, and yellow marl, resting against the secondary sandstones, and in which have been found the abundant fossil remains, chiefly of mammalia, which now form the riches of the museums of Montevarchi and of Arezzo. They include two varieties of Elephant, two species of *Mastodon*, remains of *Rhinoceros*, *Hippopotamus*, *Felis*, *Cervus*, *Bos*, *Antilope*, *Equus*, *Ursus*, and also some long plates of a Tortoise. They are so abundant in places, that the peasants have used them to mark the boundaries of their property, or to line the banks of the streams. The tusks of the elephant are enormous; the fragment of one at Montevarchi is 12 feet long, and nearly 2 feet in circumference.

Another recent deposit remains to be described in the neighbourhood of Chianciano. This place is famous for its hot baths, which are visited by strangers from all parts of Italy; near the source of the thermal spring is a curious natural basin of travertine, about 8 or 10 feet deep, and of an oblong shape. The natives believe it to have been excavated in the travertine, and then crusted over; but it is clearly the result of a natural deposit, formed by some abundantly calcareous spring, which has successively raised the walls of the basin or reservoir in which it rose. It has thus formed a perfectly level bank all round, on which circular lines or ripple marks are distinctly visible, showing the process of the formation. An irregular mass of the same matter extends some way down the hill where the water escaped, deposited by the overflowing of the pool: it is rather remarkable that no deposit whatever is left by the present hot spring, in which the thermometer rises to 31° Reaumur.

B. Metamorphic Rocks.

I now proceed to describe the metamorphic rocks which came under my notice in those portions of Tuscany which I visited.

The only rock of this character is that called *gabbro rosso* by Savi. The origin and nature of this rock has been a matter of great uncertainty and dispute amongst geologists, both as to the period to which it belongs, and as to the source from whence it has been derived. It is here almost invariably of a reddish-brown colour, and is found in immediate contact with the serpentine or ophiolitic rocks, which abound in some districts.

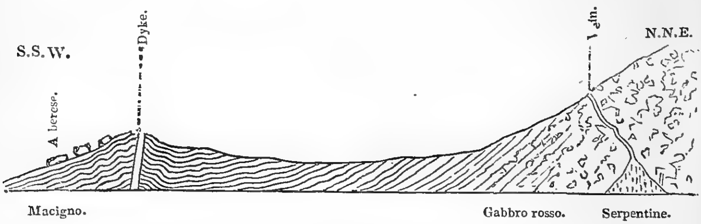
The definition of this rock given by Savi in his memoir on the physical constitution of Tuscany is so correct, that I cannot do better than give an English version of his statement:—

"We understand by *gabbro rosso*, or red gabbro, a class of "rocks produced by a particular alteration of the soil of the macigno, "and particularly of its strata of schistose clay and limestone; an "alteration caused by the ophiolitic rocks, and consisting not only "in the induration and liver-red colouring of the strata, and in "their contortions, but often in a perfect fusion or amalgamation of "the neptunian with the plutonic rocks; by these means, many "rocks of an ambiguous and varied appearance were produced, in "which, at one time, the elements of the neptunian rocks pre-"dominate, and at others, those of the plutonic, so that in former "times they were said to belong to the transition formations. We "have adopted for this class of products the generic name of "*gabbro rosso*, being that which is usually given to it in Tuscany."

The principal points where this rock is exposed are the copper mines of Monte Catini, and the mountain range extending thence to Castellina, besides a few spots on the south side of the Cecina, such as Libbiano, Monte Castelli, and, I believe, Rocca Sillana. The works at La Cava, the spot where the mining operations of Monte Catini are carried on, are all built on it, and very interesting sections are developed round the western extremity of this chain of hills. This rock has all the characters of being of igneous origin; but from careful examination there can be no doubt that it is an altered rock. The principal condition of its appearance is that of large irregular spherical masses, consisting of a darkish red argillo-siliceous substance, at first very hard, but becoming brittle and friable after a short exposure to the air. It is traversed by numerous small veins and filaments of calcareous spar, which facilitates its breaking in various directions. In some of these veins has been discovered a peculiar mineral which has received the name of *Caporcianite*, from the Chapel of La Madonna di Caporciano in the immediate neighbourhood. The centre of the veins of calc spar is sometimes more opaque and of a slightly redder hue; this has been analysed and found to contain a small proportion of manganese. It is said to be peculiar to these mines, and thence it has derived its name, these mines being under the peculiar care of La Madonna di Caporciano. The outer crust of these spherical masses shows after short exposure to the air a small mammillary appearance, which becomes larger as the exposure continues. It is evidently the result of decomposition, acting upon the surface of a body hardened under circumstances which produced a tendency to spherical or concretionary form, a tendency proved not only by this peculiarity of the surface, but by the fact of the whole of the rock consisting of these spherical masses; for not only does this condition appear in sections and surfaces where the rock has been long exposed, but it also occurs in fresh sections opened in the very heart of the mountain, many hundred fathoms below the surface, where the nodules or spheroidal masses, called *nuoccioli* by the workmen, and averaging 2 or 3 feet in diameter, are distinctly visible in the sides of the recently opened galleries. The intervening substance is generally very soft, and consists of green, red, and white earths, the red being generally in contact with the round masses, and the green and white more in the interior.

Although this is the general character of the rock, it frequently assumes other appearances. It is either compact and silicious, or it is argillaceous and soft; it has sometimes the appearance of hornstone or of quartz-rock, and it is at times altered into a mass resembling porphyry. This porphyritic appearance is well seen in the ravine behind the workshops of La Cava, where a portion of it has assumed a quartzose or hornstone character — if indeed this is not the result of veins of serpentine penetrating the metamorphic rock.

Notwithstanding various opinions which have been advanced, I have no doubt that the spheroidal forms assumed by this rock are the result of the conditions under which the cooling and induration of the mass took place, after it had been reduced by plutonic agency to a fused and liquid state. It bears an analogy to the formation of basaltic columns, indicating certain isolated points in which the cooling process, accompanied by certain principles of aggregation, commenced, extending its influence in all directions until interrupted by similar efforts proceeding from other points.



I have said above that this red gabbro is an altered rock; let us consider from what parent rock it has been derived. In the ravine to the south of the workshops and the mine of La Cava, is a good section of the gabbro rosso and true superincumbent beds, showing a gradual passage from the spheroidal masses into thin stratified highly contorted beds, dipping off at an angle of 50° or 60° to the south as represented in the above diagram. These beds are of the same dark liver-red colour, and break into similar small brittle masses, which at first cannot be distinguished from broken hand specimens. As we recede from the central mass of gabbro, the difference becomes more perceptible. Some of the beds are harder than others; and, on obtaining a real fracture, exhibit the appearance of a quartzose grit. Others are friable and gritty, and easily crumble to pieces, with the appearance of a half-baked brick. By degrees ascending the series, a few patches of grey colour occur in them, and this gradually increases. They are twisted and contorted in a most extraordinary manner, being turned completely over in some places like the mica schists and indurated marls of the primary and palæozoic formations, indicating the violence of the actions by which they were upheaved. As we get further from this supposed igneous influence, the beds lose their former character; the shales become more marly and laminated, and the harder beds have a less cherty appearance. It is remarkable, considering the intensity of the agent which must have caused the change, to what a short distance it seems to have extended; for on descending the ravine, about 100 yards further, I came upon the secondary indurated marls, perfectly unaltered, of a grey white colour, resembling those near the Certosa at Florence and at Castiglion Fiorentino on the road to Cortona; and a little way further, the *alberese* or scaglia limestone is also seen unaltered, but dipping considerably to the S. S. W. Here then we have a key to the whole metamorphic formation, which is derived from the altered marls and sandstones (macigno) of the secondary or Apennine formation, acted on by the protrusion of the igneous rocks of the ophiolitic or serpentine class, which are found in the immediate neighbourhood. The passage of the red gabbro into the half altered beds of stratified sandstone and marl, I subsequently found in several other localities round this central mass, particularly on the road from La Cava to Monte Catini, where the contortions of the strata are well exposed, and are really deserving of notice from their extraordinary convolutions. Here, too, in a direct line from the summit of the Poggio alla Croce to Monte Catini, a gradual passage may be traced to the unaltered shales, limestone, and macigno.

C. Igneous Rocks.

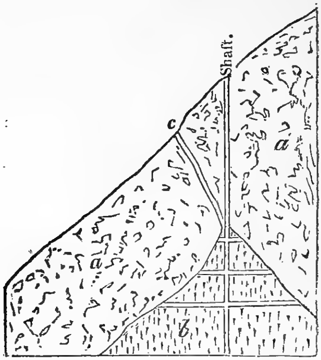
These appear to me to belong to three distinct periods:

1. Serpentine, or ophiolitic rocks (Trap of secondary period).
2. Selagite of Monte Catini (Trachyte of tertiary period).
3. Basalt of Radicofani (Recent).

1. *Serpentine.*

This rock is developed in many parts of the western portion of the Tuscan States. The principal localities where I had an opportunity of observing it, are at the copper mines of La Cava, and along the chain of hills extending from Monte Catini to Castellina, including Monte Miemo. To the south of the Cecina, it bursts forth at Monte Libbiano, where it rises to a considerable height — at Monte Rufoli, where it covers an extent of many miles — at Monte Cerboli — Rocca Sillana and Monte Castelli — all belonging to the same system. Near Florence it also shows itself in two spots, L'Impruneta and Prato, the latter of which I did not visit. It varies considerably in its appearance, character, and hardness, its chief permanent characteristics being its green colour and its soapy feel.

At Monte Catini the rock is soft and soapy, occasionally containing portions of a harder nature. It is of a uniform greyish-green colour, without the white spots which give to that of Prato, L'Impruneta, and Monte Rufoli its peculiar character, resembling the serpentine of antiquity. It here derives its principal interest from the copper mines with which it is associated. The copper ore, which is exceedingly rich, occurs in irregular veins and nodules, following the line of junction between the serpentine and the gabbro rosso. Not that any distinct formation exists between these two rocks; but the copper ore itself generally lies between them; sometimes extending itself into the gabbro, and more frequently into the serpentine, in which it forms large deposits, near the junction of the two rocks.



a. Gabbro rosso. *b.* Serpentine. *c.* Vein of Serpentine.

When this mine was opened, a narrow vein of soft talcose serpentine appeared on the surface, penetrating the gabbro rosso. (See diagram.) This was followed down in a N. E. direction in search of copper; and at the depth of 66 metres, the miners found what appeared to be another vein rising up from the opposite side, and forming a *conjunction*, as they call it; and at this spot a very rich deposit of ore was discovered. The main shaft has been sunk so as to strike on this spot, which is, as it were, the apex of a dome of serpentine, over which metallic deposits are found in all directions, following the line of junction between the serpentine and the overlying gabbro rosso. *Below* this junction point, the shaft, to the depth of some hundred feet, passes through solid serpentine only; which, although soft at first, becomes so hard as to require to be blasted with powder. The ore is a sulphuret (?). The richest portions, which are of a blue-iron colour, produce from 60 to 65 per cent., the poorest about 25 to 30 per cent. The ore is generally in the form of irregular nodular masses, here called ore stones, varying in size from a man's hand to masses several feet in diameter. Sometimes it occurs in large deposits several feet in length and height, and at others it forms a continuous band of a regular thickness, extending some distance along the line of junction of the two rocks. Large masses have also occasionally been met with in the cross galleries, at a distance of 25 feet from the red gabbro, and, on one or two occasions, nodular masses have even been found in the gabbro rosso itself close to the serpentine, which must be considered as the principal agent in the formation of the ore. The amount raised in the year ending September, 1843, was 1,894,765 Tuscan pounds.

In the vicinity of the junction of the serpentine and gabbro, a rather remarkable substance is occasionally found, called Losima. It is generally of a bright red colour, extremely shining and brilliant, soft and soapy to the touch, and apparently argillaceous. It is perhaps the result of friction. In carrying a gallery to the N.E., for the purpose of communicating with a new shaft, the miners have traversed another mass of serpentine; but very slight indications of ore have as yet been perceived in it. The strike of these masses of serpentine, or dykes as they may perhaps be called, is from N.W. to S.E., which coincides with the direction of another serpentine dyke which I traced some way over the hills to the S.W. of La Cava. It may be observed, too, that their direction is parallel to that of the principal mountain chain in this part of Italy.

Veins of steatite (or soap-stone, Pagoda stone, *pietra di sarto*, as it is here called), which sometimes assumes a very asbestos form, occur frequently in the serpentine; and this is a considerable object of export commerce. One of the localities where this steatite is found, is remarkable from the occurrence of numerous veins or layers of carbonate of lime, perhaps deposited by calcareous springs rising up through the serpentine, or it may be the result of chemical segregation, by which the steatitic particles were separated from the lime, and formed into distinct nodules. Perhaps the different appearances would justify both suppositions.

At Monte Rufoli, the serpentine extends over a considerable tract of country, covered with magnificent forests of ilex, which render its examination almost impossible. Here, however, the rock is remarkable for being the seat of the quarries of chalcedony, which supply the beautiful agates used in the Royal and other manufactures of *pietra dura* at Florence.

About two miles east of Monte Rufoli, and on the slope of the hills facing the valley of the Sterza, are the chalcedony quarries. At first their appearance resembles that of quartz dykes, rising up through the serpentine, and forming a low wall, a few feet above the ground. Wherever they have been worked, however, they appear to cease about eight or ten feet below the surface, thus leaving a kind of ditch on the hill side, about three or four feet wide, and varying in depth from eight to ten feet. Besides these principal dykes or masses, of which there are said to be several, although I only saw two, the serpentine is traversed in various directions by small, irregular veins of chalcedony, generally of a reddish colour: other similar masses of siliceous substances overlie the serpentine, as if spread over the surface from the larger dykes, differing both in character and appearance, and representing every possible variety of chalcedonic and agate bodies. They contain numerous cavities, the inner coats of which are covered with botryoïdal and mammillary chalcedony; also masses of concretionary, whitish-grey, earthy chalcedony, with a gradual shading from light to dark yellow near the edges. These are the parts most sought after by the lapidaries of Florence, on account of their beautiful shadings, and the effect they produce in the "pietra dura" works: other portions are more transparent, consisting of agates, cornelians, and opalines of various colours.

These silicious masses, as I observed, are situated in the soft, decomposing serpentine, in which, on each side of the principal dyke, are several thin, narrow filaments of silicious matter (chalcedony), generally of a reddish colour, and parallel to the principal mass.

With regard to the origin of this curious variety of chalcedonic formation, my first impression was, that it must have been a quartz dyke, rising up through the serpentine; but the variety of colour and character which the rock exhibits, incline me rather to attribute it to an aqueous origin. It might be considered as the result of a thermal spring, charged with silicious matter which has been deposited in fissures of the serpentine, unless the occurrence of the remarkable *soffioni* or vapours of Monte Cerboli, in such close vicinity, and that of other similar phænomena in the same district, render it more probable that it is owing to the escape of vapours charged with silicious and other matters; when the silex, as the least soluble, would be first deposited on any sensible diminution of temperature. The subject is one of considerable interest, as connected with other geological phænomena in the country.

Between the village of Monte Gemoli and the high and lofty position of Libbiano, the river Trossa has forced its way through a narrow pass between two masses of serpentine of the same character as that of Monte Rufoli. At Libbiano itself, the serpentine and greenstone rocks have been elevated to a considerable height, carrying with them to the summit a conglomerate of the pre-existing rocks, gabbro rosso and Apennine limestone, mingled with masses of serpentine; these cover the north-east flank of the hill, and give a remarkable appearance to the elevated narrow ridge on which this desolate village has been perched.

Another interesting locality where the serpentine occurs is near the village of L'Impruneta, about six miles south of Florence. The village stands on a hill of green serpentine which crops out even in the market-place, though the principal mass of it is about half a mile further south. It rises up through the secondary rocks, which dip off from it on all sides, more or less altered, and in some places reduced to the metamorphic state of red gabbro, in which all traces of stratification are obliterated.

A new road has been cut through the solid serpentine, leaving a cliff fifty or sixty feet high on each side. Here the rock appears darker and blacker than on the surface, but equally susceptible of decomposition on exposure to the air. Besides the numerous crystals of a pale green colour, which distinguish the serpentine of L'Impruneta, many portions are traversed by thin veins of calcareous spar; others are beautifully marked with red veins, and are much sought after by the statuaries of Florence for ornamental works; others contain veins and masses of a fibrous substance, which sometimes closely resembles the fibrous asbestos; the latter becomes harder by exposure, exactly the reverse of the serpentine itself. Near the south end the serpentine assumes a more scoriaceous character: here the asbestos is more abundant, and in some places penetrates the serpentine with many branching veins; the people called it "pietra alberisata," from its resemblance to the fibres of a tree fossilized.

On the south-east side, near the junction of the serpentine with the stratified rocks, altered into red earthy jasper, and either perpendicular, or inclined at an angle of 80°, with a north and south strike, the igneous rock is much decomposed and softened. It is traversed in every direction by numerous veins of carbonate of lime, which, not decomposing so rapidly as the rock itself, stand some inches above the ground, presenting a curious reticulated appearance.

I did not visit the other spot in the vicinity of Florence in the mountains above Prato, ten miles north-west, where the serpentine is also quarried, and is worked up in Florence for ornaments under the name of Verde di Prato.

2. *Selagite of Monte Catini.*

This name of Selagite is given to a quasi-trachitic rock, the only instance I observed of such formations, rising up through the blue marls at the western extremity of the chain of hills on which is situated La Cava and its copper-mines, and on the upper portion of which stands the ancient village, or Borgo of Monte Catini. Its sides present an almost perpendicular face, in which the columnar structure is very visible, but the columns, though of considerable length, are irregular both in size and form. It is of a bluish-grey colour, gritty to the touch, and full of small crystallized plates of hornblende or amphibole. It is considerably quarried for building-stones, much used in the neighbourhood. Although apparently unconnected with the serpentine rocks, it is remarkable that this trachitic outburst has taken place almost on the direct axis or line of prolongation of the strike of the serpentine masses, which appear to have caused the elevation of Monte Massi and Poggio alla Croce. From the altered appearance of the shelly bed, already described on its north flank, its protrusion probably took place during the early part of the tertiary period.

3. *Basalt of Radicofani.*

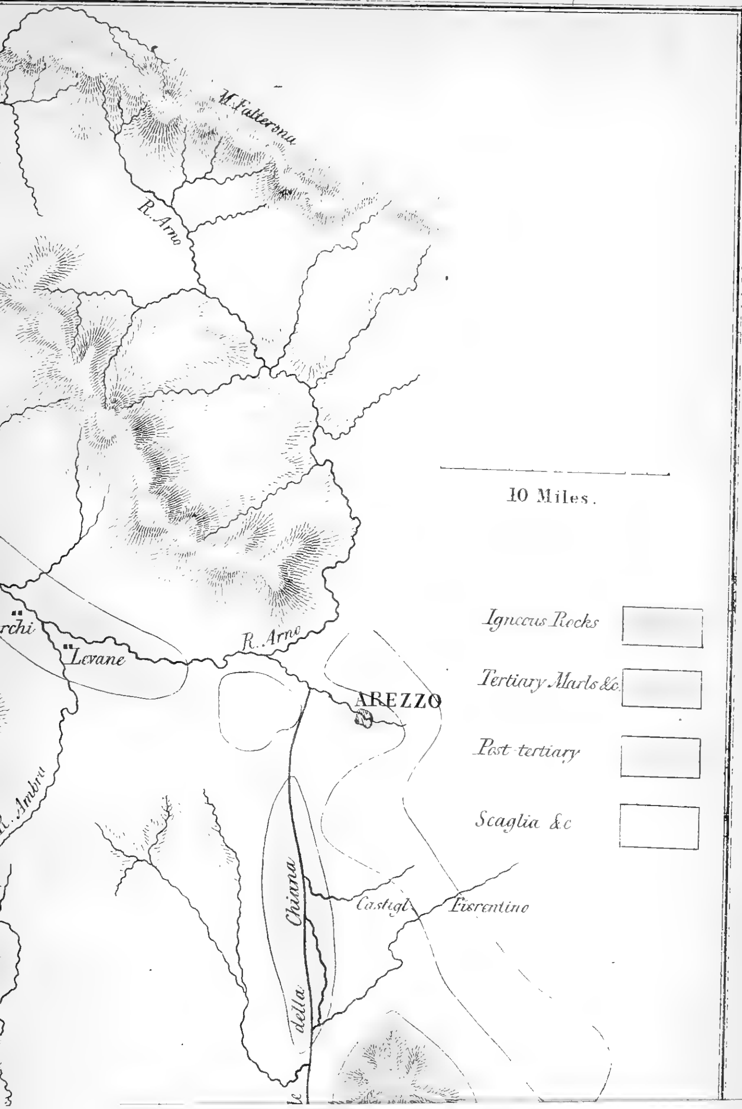
The other igneous rocks to be noticed are the basalts of Radicofani, of which, however, I only introduce the name here, to complete the series, as I had no opportunity of visiting them.

I cannot conclude this imperfect notice of the geology of Tuscany without calling attention to the boracic acid works at Monte

Cerboli, and the remarkable phænomena therewith connected; for I have no doubt but that many of the actual geological features of Tuscany must be referred to agencies and to causes similar to those which are now exhibited in this locality. The works have been already in some degree described by Mr. Babbage in *Murray's Handbook of Central Italy*, p. 178., and by Dr. Bowring in his Report on the Commercial Relations of Tuscany, laid before Parliament in 1837. I shall therefore confine my observations to a few of the principal phænomena.

The numerous and violent jets of vapour from which the boracic acid is extracted, rise, with considerable noise and in large volumes, from a narrow rocky valley in the secondary cretaceous limestone, about 15 miles S.W. of Volterra. Huge blocks of this rock and its associated indurated marls cover the surrounding hills, and add to the desolation of the scene. The vapour naturally leaves a considerable deposit; but this is much increased in consequence of its being compelled by artificial means to pass through water collected into numerous reservoirs. By this process, the water is impregnated with the boracic acid previously held in solution in the vapour; while the greater part of the sulphur, lime, and carbonic acid gas, which it also contains, is deposited in the muddy bottoms of the pools, and assumes, when dry, a crystalline form, being, from time to time, thrown out in the course of the operations: sulphate and carbonate of lime are also deposited in the cauldrons and cooling pans where the boracic acid is obtained by evaporation from the saturated water. Amongst the neighbouring rocks, I saw a remarkable instance, where a large fissure or crack, with several smaller ramifications, had been completely filled up by the matter deposited by the vapour which must once have escaped through it. The sides were coated with a hard compact calc-sinter, while the central portions were filled with a more porous substance, so that the passage of the vapour had been obstructed before the central parts had become so densely consolidated as the sides, thereby explaining at least one of the causes by which these vents are constantly changing their positions, and how the jets of vapour escape sometimes in one place and sometimes in another.

The simple mode by which the boracic acid is obtained is as follows. Small reservoirs, from 15 to 30 feet in diameter, are dug round the most convenient and powerful of the many steam vents; and into these reservoirs a small stream of water is conducted from the mountain side. After being for some time exposed to the action of the rising vapour the water is let off from one reservoir into another, until it has passed through five or six, in each of which it remains about 24 hours, the vapour boiling and bubbling up through it the whole time with much noise and violence. By this time the water is sufficiently impregnated with the boracic acid; and after being allowed to settle in another reservoir to deposit the mud, it is led off into the evaporating houses, where, after undergoing a slow and gradual process of


M. Falterona
R. Arno
10 Miles.
Igneous Rocks
Tertiary Marls &c.
Post-tertiary
Scaglia &c
rchi
Levane
R. Arno
AREZZO
R. Ambra
Chiana
della
Castigl
Fiorentino


Map
OF A PART OF
TUSCANY,
on the Geology of that Country
LUCCA
PISA
FLORENCE
LEGHORN
Castellina
Colle
SIENA
AREZZO
10 Miles
Montepulciano

evaporation, the boracic acid is at length obtained in numerous vats, where it crystallises with great facility.

The great difficulty formerly experienced in this process was the expense of fuel required for the process of evaporation; until the happy idea at length suggested itself to the proprietor of availing himself of the almost inexhaustible supply of heat prepared by Nature herself in the numerous vents from which the streams of boiling vapours were constantly emitted. Acting on this suggestion, he built a sort of chamber over some of the vents, and conducting the vapour by subterranean channels into the evaporating houses, obtained without a farthing of additional outlay all the heat he could require. The consequence of this simple application of natural power was, that the value of the works rose, in one year, from a capital of one thousand pounds, for which the fee simple was offered, to a rental of twenty thousand pounds per annum.

Similar vapours or "soffioni," as they are called, occur in several other localities in the same district, or within a distance of 12 or 14 miles, as at Sarrezano, Castel Nuovo, Monte Rotondo, and others; and it is impossible not to be struck with the manner in which they throw light on many of the geological phænomena in this and other countries; particularly with regard to the filling up of cracks and fissures in rocks, and the local deposits of various substances, such as calc spar, gypsum, sulphate of lime, sulphate of soda, &c., many of which occur in this very neighbourhood. It is highly probable that such emissions of gases and vapours may have produced many of those local phænomena, which have been so frequently attributed to the effect of springs, and are considered as aqueous deposits. That great connection exists between them cannot be doubted, as the soffioni of Monte Cerboli do unquestionably deposit much sulphate and carbonate of lime, and if supposed to rise through water would most certainly deposit much more. On the whole, therefore, whether we consider the remarkable and almost terrific appearance of these vents, from hundreds of which the vapours escape with the noise of a steam-boiler blowing off its steam, or the importance they have in connection with other geological problems to which they may offer a solution, they must be considered as presenting to us some of the most interesting, if not important geological phenomena which the Tuscan States can afford to the pursuer of geological investigations.

November 20, 1844.

Charles Faulkener, Esq., and John Bravender, Esq. of Cirencester, were elected Fellows of this Society.

The following communication was read:—

On the Geology *of* Gibraltar. By James Smith, Esq. of Jordan Hill, F.G.S.

In the absence of the author of this paper from England it has been considered advisable not to publish more at present than a mere announcement of the nature of the conclusions arrived at. After stating briefly the appearance and character of the fundamental rock at Gibraltar (which is of the oolitic period), the author mentions indications of recent marine action, extending up to the very summit of the mountain, and proceeds to describe his reason for concluding that great and repeated elevations have taken place in the district in comparatively modern periods, three being more especially remarkable, since each one of these has elevated the strata through an angle of about 20°. Several interesting phænomena of the tertiary period are alluded to as affording evidence in favour of this view. The author concludes by directing attention to some superficial deposits of sand, covering the flanks of the mountain, and to the bone breccia, some parts of which he considers to be of great age.

December 4, 1844.

Henry Coles, Esq., of Cheltenham, Dr. Travers Cox, Professor Edward Forbes, and I. K. Brunel, Esq., were elected Fellows of this Society.

The following communications were read:—

1. *Remarks on the* Geology *of* British Guiana. By Sir Robert Schomburgk, Ph. D. &c.

The district alluded to by the author in this paper extends along the shore of the Atlantic from the mouth of the Amazons river to the embouchure of the Orinoco, its greatest length (between Cape North and the confluence of the Rio Xie with the Rio Negro) being about 1090 geographical miles, and its breadth (from the mouth of the Orinoco to the confluence of the Rio Negro with the Amazons) 710 miles. Throughout this tract no organic remains have yet been discovered, the whole being occupied by primitive rocks.

The banks and low lands near the chief rivers of Guiana are described as consisting at the surface of a bluish clay, impregnated with salt and mixed with decayed vegetable matter, forming a very productive soil. The delta of the Orinoco, and the embouchure of the Essequibo, present the same appearance.

The blue clay just described is usually succeeded by other clays of variegated colour, and these again by sands, composed of transparent white quartz. Water has been frequently obtained by boring through the clay to these sands, and in such cases the depth from the surface to which it has been necessary to sink varies from 120 to 230 feet.*

The clay extends for a considerable distance inland, and is then terminated by a range of sand hills from 30 to 120 feet high, parallel to which may be traced a number of detached groups of hillocks, seldom more than 200 feet high, and consisting of red iron ochre with occasional layers of silicate of zinc. This is succeeded by a quartzose sandstone resembling the flexible sandstone of Brazil.

The first unstratified rocks occur near Itaka, and consist of different varieties of granite with numerous greenstone dykes, and of porphyry, while in the surrounding mountains, at no great distance, clay iron-stone was observed in small detached nodules. This rock is repeated again towards the south, and occupies the extensive plains or districts of table land, called "Savannahs," which are about 300 feet above the sea, and from the midst of which rise isolated hilly groups from 1800 to 2300 feet above that level. These plains are covered by a conglomerate, containing rounded fragments of quartz, and vast quantities of bog iron ore, while blocks of granite, some of them of large size and much rounded, also abound. The hills are porphyritic, and exhibit also a considerable quantity of mica in foliated masses.

A sandstone resting upon the small-grained gneiss and coarse granite of the Savannahs is next described by the author as forming the mountains of Pacaraima which extend from the upper Orinoko, eastward, to the banks of the river Essequibo. Towards the north, felspar-porphyry, and jasper, are also mentioned, and then succeed lofty escarpments of sandstone rising almost perpendicularly from the plain, and forming the commencement of an extensive range of high table land. This sandstone is described as entirely destitute of organic remains.

Having alluded to these rocks, the author next describes some of the appearances presented by the clay, and other materials in the bed of the river Cukenam, near which on both sides rise lofty mountains, on whose declivities nodules and large blocks of pisiform bog iron ore are found. After this follows an account of another region on the right or western bank of the Cukenam, in which jasper is so abundant as to form the prevailing rock. The mountains are described as rising in a highly picturesque and striking manner to the north of this locality, and are said to be composed of compact sandstone, whence it appears that this rock occupies the highest summits from the banks of the Orinoco towards the south-west, and a similar ridge has also been traced by the author considerably to the west and south. Large blocks of granite are also mentioned by the author as abounding on the flanks of the highest mountains, one of which "Roraima" is espe-

* Ten or twelve feet below the upper surface an irregular stratum of fallen trees (*Avicennia nitida* of botanists) is met with, and a similar bed, 12 feet thick, has also been found at a depth of 50 feet.

cially alluded to as exhibiting much grandeur and great picturesque beauty. Northward of this mountain clay slate is described as being present, and near it, by the banks of the Carimani, black quartz, while in the basin of the river Cuyuni large blocks of coarse conglomerate were seen, although near the junction of that river with the Mazaruni the rocks were basaltic. The rocks at the great falls of Ematupa are said to consist of granite and dark indurated clay slate.

The author next directs attention to various rocks of grotesque form, found in the granitic district of Guiana; some of these, called the 'pyramids,' being of granite and other porphyritic rock, and forming very striking objects in the landscape.

In conclusion, the author states that the geological features of Guiana in some districts render it most probable that gold is present, and that he found specimens in the river sand of the Takutu, which, judging from the tests he was able to employ, he had no doubt were fragments of this precious metal. These specimens, however, with many others, were lost in the course of his journey; but Fray José, the catholic missionary, showed him a piece of massive gold partly embedded in quartz, which had been found on the banks of the Rio Branco where the Takutu enters that river.

The presence of Itakolumite, of mica slate, and of what in Brazil is called the Diamond matrix, proves the existence of a structure in the Savannah regions of Guiana similar to that of the Serra do Espinhaco in the province of Minas Geraes in Brazil.

2. *A Letter to* Dr. Buckland *on the subject of* Glacier Marks *in* South Wales. By W. C. Trevelyan, Esq.

The object of this letter was to direct attention to certain polished and scratched surfaces in the valley of the Conway on the ascent of Moel Siabod and in other places near Snowdon. The author considered that these and other markings he had observed were indications of the former presence of glaciers in these localities.

December 18, 1844.

The following gentlemen were elected Fellows of this Society:—Robert Chambers, Esq., of Edinburgh; James Simpson, Esq., of Chelsea; William Lewellyn, Esq. of Pont-y-Pool; and James Bandinel, Esq. of Westminster.

The following communication was read:—

On the Pipes *or* Sand-galls *in the Chalk and Chalk-rubble of* Norfolk. By Joshua Trimmer, Esq., F.G.S.

In a paper read before the Society in the Session of 1842-3, and intitled "On Pipes or Sand-galls in Chalk*," I have shown that, in the county of Kent, these cavities in the chalk have, in their upper part, a longitudinal extension, and are connected with furrows which traverse the upper surface of the chalk, and which widen and deepen as they approach the pipes. From the nature of the materials with which these cavities are filled, I inferred that, in that county, they were formed before the deposit of the oldest Eocene strata. From the fact, also noticed by me in the same county, that similar furrows and pipes, though of smaller dimensions, occur in the blocks of siliceous sandstone which are dispersed through the superficial deposits, and are derived from the sands of the plastic clay, I concluded that these cavities were caused, not so much by the chemical as by the mechanical action of water; and, from the further observations I made, that still smaller furrows and pipes are actually in the course of formation on the surface of similar siliceous blocks on the coast of Kent, I judged that the mode of this mechanical action was by the flux and reflux of waves breaking on the shore.

Having now extended my observations to the chalk in the vicinity of Norwich, I find that in that district also the pipes constitute the termination of longitudinal furrows; and in this paper I shall adduce evidence, from the phenomena observable in the superincumbent strata of sand and gravel, that these hollows were excavated in the chalk just before the deposit of the Norwich Crag, and that, like the pipes in the chalk of Kent, they owe their origin to the mechanical action of water.

I will first offer some general remarks on the chalk, and on the strata overlying the chalk, in the vicinity of Norwich.

The chalk which bounds the continuous valley watered by the rivers Wensum and Yare, rises to the height of from 60 to 80 feet above the river level. It is covered by the sands and gravel belonging to the Norwich Crag and the Northern Drift. These form a nearly level plateau, intersected by many inosculating valleys, some containing streams, others dry. To judge from the sections laid open around Norwich, the greatest thickness of the supra-cretaceous deposits, at the highest points of this plateau, is about 60 feet : towards the valleys these deposits thin off.

Immediately upon the chalk rests a ferruginous breccia, locally termed "the pan," from one to two feet thick, and composed of large unabraded or slightly water-worn flints; and these are sometimes mixed with marine shells, unbroken and in fragments. It is in this, the most constant member of the crag series in this part of Norfolk, that the bones of terrestrial mammalia are found.†

Above the breccia are beds of sand and silt, containing, in some places, considerable accumulations of unbroken marine shells. These accumulations sometimes occur in drifted masses from one to four feet thick; sometimes they consist of groups of two or three

* Vide "Proceedings," vol. iv. p. 6.

† Mr. Wigham, who has been in the habit of purchasing bones of the workmen for many years, informs me that each pit yields about one bone a year.

species of shells, imbedded in silt, the bivalves having their two valves united, and lying evidently on the spot where the inhabitants of the shells lived. Both of these modes of association may occasionally be seen in the same pit; and they are very different from the arrangement of the shelly remains in the till and in the stratified drift. The greatest height from the surface of the chalk at which I have met with these shells, is less than ten feet.

The rest of the deposit consists of alternating beds and bands of gravel and laminated clay, which, in their upper part, where the stratification is less regular than in the lower, are occasionally associated with unstratified masses of yellow loam. The beds, particularly in their lower part, are often obliquely laminated; and in a cutting of the Yarmouth Railway, between Thorpe and Crostwick, the shelly beds of the crag, which are there seen in contact with a mass of unstratified blue till, exhibit contortions like those which occur in the Cromer Cliffs.

The epoch of the Norwich Crag was of considerable duration. On the coast of Norfolk, at Mundesley, we see the lowest member of that formation, the pan, overlaid by a fluviatile deposit; and at Runcton Gap * a similar fluviatile deposit is overlaid by a bed containing shells of the same species that belong to the pan of Mundesley and Happisburgh.

At Happisburgh the pan is overlaid by a bed of large fossil trees; and these are buried beneath stratified and unstratified drift. Near Norwich there is no trace of the intervening period when the crag became dry land. Moreover, the only instance I have seen of blue till in that neighbourhood, is in the cutting of the Yarmouth Railway above noticed; and in the general absence of this unstratified detritus, there is nothing in the district to define the limits between the crag and the stratified drift, which might pass together for one continuous deposit.

I will now proceed to describe, in the first instance, the appearances I observed in two pits worked in the solid undisturbed chalk, situate within five miles of Norwich. In these pits, twice or thrice a week for several months, I made measurements and drawings of the surface of the chalk and of the cavities in it, as, during the progress of the works, they became cleared of the overlying deposits.

In describing these and the other pits referred to in the present paper, I shall adopt the following local terms, used by the workmen. Cavities in the chalk, of greater breadth than depth, they call "drops"; deep conical or cylindrical pipes in the chalk, they call "pots"; the overlying gravel, sand, &c. they call "uncallow."

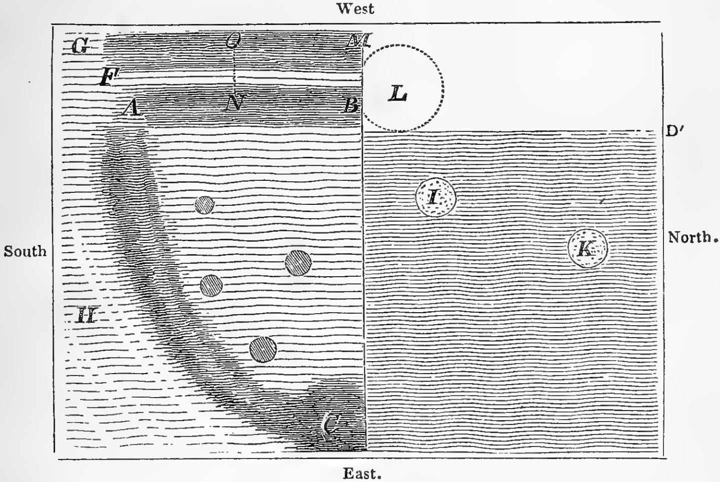
* The bed of shells at Runcton occurred to the east of the Gap; but on a visit I made to the spot in the spring of 1845, a fall of the cliff had covered up the bed. To the west of the Gap, however, I found a bed of marine shells, lying, like that to the east of it, above the freshwater deposit. The frozen state of the cliff prevented my obtaining specimens. The shells I found to the east of the Gap were, *Natica helicoides*, *Mya* (a large species), *Fusus striatus?* The shells I observed to the west of the Gap were all of the same species, viz. a large truncated gaping bivalve, and had both valves united.

The first of these two pits is situate in the village of Thorpe, about a mile to the east of Norwich, at the junction of the great east and west valley of the Yare with a small north and south valley. The works are prosecuted in the direction of both valleys.

Owing to the great thickness of the uncallow (from 15 to 70 feet), it is removed only to a small extent at a time; and when the chalk has been worked away to that extent, a fresh space is cleared for working.

Fig. 1. Thorpe Chalk Pit.

(*Ground Plan.**)



The diagram (fig. 1.) is a ground plan of so much of this pit as I propose to describe. On the left hand, outside of the curved line C A F G, the chalk had been worked away long before my first visit to the pit, and the outer space was filled with refuse from other parts of the works. At the surface of the chalk, over part of this space, to the left of a line drawn from H to F, there had occurred, as the workmen stated, a large "*drop.*" When I first visited the pit, the chalk had been worked away in the excavation B C E D (of which a portion only is represented) to the depth, measured from the surface of the rock, of about 50 feet; and subsequently, in the course of the season, it was removed to a further depth of 5 or 6 feet, when the workings were interrupted by water.

C A B is a triangular surface of chalk, of which the length C B is about 18 feet, and the breadth at the further side A B, about 15 feet. On my first visit to the pit, it had been recently cleared of uncallow; and a clean vertical section, about 60 feet deep, of

* In this diagram certain furrows which ought to have been indicated, and which proceed towards the west and south-west, from near the round marks on the left-hand side of the middle of the diagram, have been accidentally omitted.

deposits of that description, then presented itself above the chalk, along the whole of the line A B D.

Subsequently, the uncallow was removed also from the space B A G M (about 15 feet by 9 feet); and afterwards, to the whole extent of that space, and of the triangular space C A B, the chalk was worked away, and a vertical section of the uncallow was then exposed above the lines G M and M B.

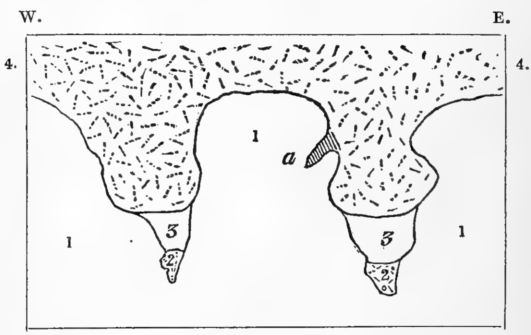
At C was a large conical pot. At I and K, in the floor of the excavation B C E D, were horizontal sections of two cylindrical pots, each about $2\frac{1}{2}$ feet in diameter; and, as the workmen stated, these pots had been of the same diameter throughout their whole lengths of 55 feet; and at that depth from the surface of the chalk there was no appearance of their terminating. Most of the pipes in this pit extended, as the workmen stated, to the very bottom; though occasionally a pipe, on its meeting with a layer of flints, would stop abruptly. At L was another large pot.

On the surface of the chalk, in the triangular space C A B, were several circular basins, about 10 inches in diameter, and 2 or 3 inches deep in the centre: there were also several very shallow irregular furrows.

On the outer margin of this space, extending from the pot C to A, were the remains of a deep curvilinear furrow; from A to B was a straight deep furrow, communicating at B with the pipe L; and parallel to A B was another deep furrow, extending from G to M.

Fig. 2. THORPE CHALK PIT.

(*Cross Section of the two Furrows* G M *and* A B, *from* O *to* N.)

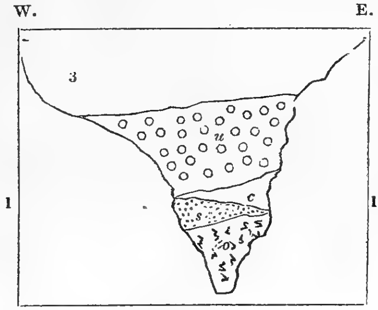


1. The solid chalk.
2. The bottom of the furrows G M and A B, filled with sand, umber, and yellow ochre, and sometimes containing thin layers of chalk.
3. Layer of reconstructed chalk.
4. Sand — (*a.*) represents a projection filled with umber.

A cross-section of these two furrows, on a line N O, nearly midway between the points A and B, is represented in fig. 2.; and fig. 4. is another transverse section of the same two furrows, drawn through the points A and G. On each of the above lines of section, the furrows are excavated in solid chalk, and they are separated from one another by an intervening ridge of solid undisturbed chalk.

Fig. 3. THORPE CHALK PIT.

(*Cross Section of the bottom of the furrow* G M.)



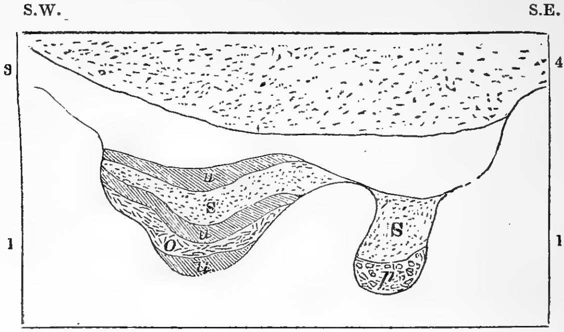
1. Solid chalk.
o. Yellow ochre.
s. Sand.
c. Chalk.
u. Sand mixed with umber.
3. Layer of reconstructed chalk.

On the line of section N O, each of the furrows is from 7 to 8 feet deep, and, at the surface of the solid chalk, is about 4 feet wide; but on the line of section A G, both the furrows are wider and shallower. At and near the line of section N O, the width of the furrows on a level with the surface of the solid chalk, is sometimes less than it is about a foot and a half below that level; but at a greater depth the width again diminishes, and it then tapers downwards to the bottom. Sometimes, however, the transverse section is nearly that of a wedge.

Near the line of section N O, the lower part of the furrow G M, to the height of about a foot from the bottom, was irregular in shape, and, at that height, was from 1½ to 2 feet wide. This part was sometimes filled with a mixture of yellow ochre and umber, of a blackish or brown colour, and very low specific gravity: sometimes the umber lay above and the ochre below, a thin layer of fine sand separating the two; sometimes a layer of fine ferruginous sand lay beneath the ochre and umber, and sometimes, as in Fig. 3., thin irregular layers of chalk were mixed with the other contents of this lower part of the furrow. At the bottom of the furrow A B, near the point A in the ground plan, was an accumulation of water-worn pebbles, which was covered by sand. (See Fig. 4.)

Fig. 4. Thorpe Chalk Pit.

(*Cross Section of the two furrows* G M *and* A B *from* G *to* A.)



1. Solid chalk.
o. Yellow ochre.
u. Umber.
S. Sand.
p. rounded pebbles.
3. reconstructed chalk.
4. Sand.

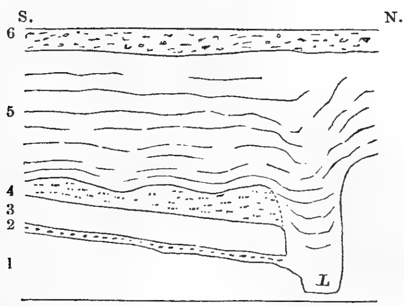
Near the line of section N O in each of the furrows, at the height of about a foot from the bottom, was a layer of chalk about 4 feet thick, but thicker towards the sides of the furrow than towards the middle. The chalk bore evident marks of reconstruction in some of its parts, but in other parts was apparently so solid as to render it difficult for the observer to believe that it had ever been disturbed. The upper surface of the reconstructed chalk in each of the two furrows appeared to have been exposed to the same kind of furrowing action which the solid chalk has undergone at the base of the furrows. From the top of this layer of reconstructed chalk to the level of the surface of solid chalk, upon this line of section, was a perpendicular height of 3 or 4 feet. This space in the furrow A B was filled with fine sand, intermixed frequently with much umber, less frequently with yellow ochre, and sometimes with a mixture of the two; and in one part, where the surface of the layer of reconstructed chalk was depressed below its ordinary level, a layer of rounded gravel occurred beneath the sand. Above the layer of reconstructed chalk, in the furrow A B, small conical protuberances, about 4 inches in length and diameter, projected from the sides of the furrow into the solid chalk, in which they formed cavities, and these cavities were filled with umber. (See fig. 2.)

It is probably from the decomposition of the iron pyrites in the chalk, that the yellow ochre in these furrows has resulted; for it is often seen forming small lumps in the solid chalk, near the surface of the latter. The umber is of frequent occurrence, in connection with the pipes in the chalk, both in Kent and Norfolk. In the former county I have found pipes 6 inches in diameter, and 2 feet in depth, nearly filled with this substance; and I have frequently observed it mixed with the clay which lies between the chalk and the overlying loam, and which also forms the lining to the pipes. In Norfolk it enters largely into the composition of the pan, and occurs as well in the pipes as in the furrows; but I have nowhere met with it so pure, nor in such large masses, as in the lower part of the furrow G M, above described.

The reconstructed chalk, which, in the line of section N O, lay within the furrows at the depth of 3 or 4 feet below the surface of the solid chalk, completely fills up and overtops the furrows and the ridge of solid chalk which divides them, on the line of section A G. Over this layer of reconstructed chalk, extending continuously from furrow to furrow, lies a bed of sand.

The following figure (5.) is a vertical section, passing north

Fig. 5. THORPE CHALK PIT.



1. The solid chalk.
2. The bottom of the furrow A B, filled with sand, umber, and yellow ochre, and occasionally containing thin layers of chalk.
3. Layer of re-constructed chalk.
4. Sand.

S, S′ General surface of the solid chalk, at the sides of the furrow.

5. Sand, alternating, in the lower part, with seams of clay and gravel. From S, S′ to the top of 5, the height is about five yards.
6. Loam, sand, and gravel. From the bottom of 6 to the surface is about eighteen yards.

L. The sand-pipe, so marked in the ground-plan, fig. 1.

and south along the middle of the furrow AB. It shows the connection of that furrow with the pipe L, and the manner in which the lower strata of crag bend down into the broader and deeper pipes, such as L appears to be. Since the disturbance of the strata does not extend more than 15 feet above the general level of the surface of the solid chalk, the upper horizontal strata of loam, sand, and gravel, of the aggregate thickness of about

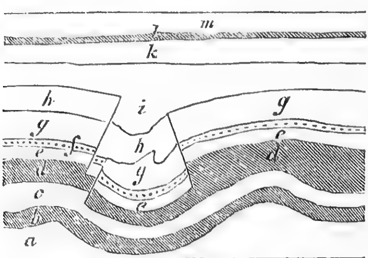
18 yards, which lie above the disturbed strata, are omitted in the figure.

The strata overlying the chalk, as exhibited in vertical section over the line G M in the ground plan, were the following, in descending order: —

		Feet	In.	Feet	In.
	Loam, with patches of gravel	30	0		
m.	Sand, with seams of gravel	21	0		
				51	0
		Feet	In.		
l.	Clay	0	6		
k.	Sand	2	0		
i.	Dark brown gravel, about	3	6		
h.	Ferruginous sand	2	0		
g.	Yellow sand, about	3	6		
f.	Ferruginous sand, about	0	9		
e.	Whitish sand, about	1	3		
d.	Clay	2	0		
c.	Yellow sand, about	1	6		
b.	Clay, whitish towards the bottom	2	0		
				19	0
a.	Solid chalk			Feet 70	0

I met with no crag shells in these strata at the pit at Thorpe. About midway between the points G and M, and near the point O, in the ground plan, some of the lower of the above supercretaceous strata were faulted in the manner represented in Fig 6., the greatest perpendicular displacement being about 2 feet:

Fig. 6.*



but those strata in that section, whose vertical distance from the chalk exceeded 16 feet, remained undisturbed and horizontal. From the sequel it will appear probable that this displacement is owing to the occurrence of a sandpipe in the chalk, to the west of the line G M; but the existence of such a cavity was not proved in this instance; for, during my visits to the chalkpit, the clearing of the chalk had not proceeded beyond the line in question.

* The references to this diagram are given in the above table of the strata overlying the chalk.

The second of the two pits above referred to, worked in the solid chalk, lies about 4 miles N.E. of Norwich, a little to the north of Rackheath church. It is on the east side of a north and south valley, which terminates northwards in the east and west valley of the Bure.

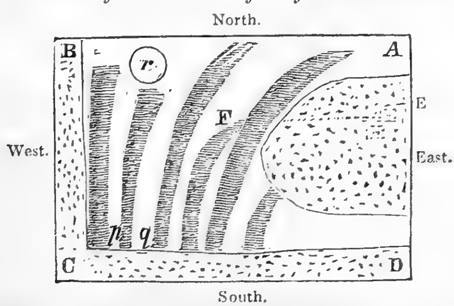
The surface of the chalk is marked by broad undulations, 3 or 4 yards asunder, and about a yard deep, the prevailing direction of these undulations, drawn lengthwise, being north and south; but this direction is liable to exception. The chalk is worked to a depth of from 12 to 18 feet below its own surface, the depth increasing with the distance from the valley. Paramondras, which are generally abundant in the chalk of this part of Norfolk, are particularly so in this pit; and I noticed one of them, having its lower part fixed in the chalk, and its upper enveloped in the sand of the crag, which here covers the chalk.

The crag is from 10 to 18 feet thick; but it thins off towards the valley. The *Pan* rests immediately on the chalk; and above the pan are beds of yellow and white sand, alternating with bands, 2 or 3 inches thick, of gravel and laminated clay. In the spring of 1844, in the progress of the workings, a bed of crag-shells was exposed, about 3 feet long and 2 feet thick, at the height of about 3 feet above the surface of the chalk; and another thin layer of crag shells may be seen in the bank of an adjoining road. The above lower crag strata conform to the irregularities in the surface of the chalk, both where it sinks towards the valley and where it rises above the ordinary level. The valley therefore appears to have been partially excavated in the chalk, before the supra-cretaceous beds were deposited. The upper beds consist of less regularly stratified sand and gravel.

In the beginning of May, 1843, a space, A B C D (see Fig. 7.), bordering on the edge of the valley, 19 yards by 14, was cleared of the sand and gravel, which were here from 10 to 12 feet thick. The surface of the chalk thus exposed was traversed by numerous shallow and nearly parallel furrows, which had a

Fig. 7.

(*Ground Plan of the cleared Surface of Chalk at Rackheath.*)



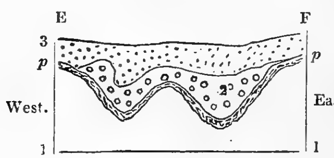
The shaded parts represent the ridge, and the blank parts the furrow.

prevailing direction from N. to S., agreeing with that of the valley; but such a parallelism between the furrows in the surface of the chalk and the nearest valley does not hold as a general rule; for in a space that was subsequently cleared, less than 20 yards from that shown in the diagram, the direction of the furrows was E. and W. Upon the whole, however, the north and south furrows seem to be the deepest.

The deepest of the furrows shown in the diagram, which was *p*, was about 3 feet wide, and 1 foot deep: the next furrow, *q*, was 6 inches wide and 3 deep; and, for the length of 2 or 3 yards, was as clean cut as a gutter-tile. It led to a circular cavity, *r*, 3 feet in diameter, which looked like the mouth of a pipe; but, on removing the sand, it was found to be only 1 foot deep in the centre. The rest of the furrows were broader, shallower, and less regular than the two former, and were lost in a large irregular cavity, not visible at my first visit to the pit, but afterwards exposed to view in a vertical section, passing through the line E F, about 12 feet to the south of the line A B.

The hollow (see Fig. 8.) thus laid open was about 11 yards

Fig. 8.



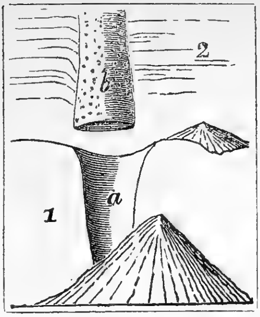
1. Solid chalk.
p. Pan, or ferruginous breccia.
2. Sand, black towards the bottom, yellow towards the top.
3. Whitish sand.

wide, and was divided by a ridge of chalk into two cavities, which were respectively 21 and 12 feet wide, and 3 and 7 feet deep. The bottom of this hollow, like the surface of the chalk generally, was lined with the pan; above this, within the hollow, was sand, blackish towards the bottom, but yellow towards the top. Over this and over the Pan beyond the limits of the cavity, was a whitish sand.

In other parts of the Rackheath pit, several sections of deep pots were visible; and one of the most remarkable of these is represented in Fig 9.

"*Core*" is the term given by the workmen to the column of unstratified, tenacious, gravelly loam, which is sometimes found over a "*pot*" in the chalk, rising through and traversing the regularly stratified and alternating bands of sand, gravel, and clay, belonging to the crag and overlying the chalk. One of these cores, projecting *in relief* above the strata of the crag, is represented in the annexed diagram. On one side, the laminæ of stratification bend

Fig. 9.



1. Solid Chalk.
2. Sand, gravel, and clay.
a. Pot in the chalk.
b. Core above the pot.

down towards the core; on the other, they abut abruptly, in a horizontal position, against it.

Over the larger sandpipes in this pit generally, the stratification of the lower beds of crag is disturbed, and, in some places, quite obliterated.

From the state of the strata of the uncallow above, the workmen profess to be able to determine the nature of the cavity in the chalk below. It may be stated, as a general rule, that over "*drops*," or other irregularities in the surface of the chalk, of greater width than depth, the alternating beds of sand and clay are disposed in gently curving flexures, which are evidently original conditions of deposit: that over deep pipes, not exceeding a foot in diameter, the laminæ of the sand and gravel are undisturbed; that over pipes of greater diameter the laminæ usually suffer disturbance; but that even over the widest pipes, the disturbance does not extend to the height of 20 feet from the surface of the chalk. When the Uncallow exceeds that thickness, the disturbed strata are overlaid by others which are horizontal.

Among the contents of the sand-pipes in the solid chalk near Norwich, I have not met with any fragments of chalk; though in two instances I have seen rounded pebbles of chalk, lying near the clay which usually lines the sides of these cavities. The flints in the pipes are rarely waterworn, and appear to have been rarely detached from the chalk. In Kent, on the contrary (particularly in a pit near Canterbury, described by me in a former communication) a large portion of the flints in the pipes have undergone considerable attrition; but the form of the pebbles is not orbicular nor ellipsoidal, but rather that of two cones, placed base to base.

As a general fact, crag-shells have not been found in the pipes in the solid chalk near Norwich, even in cases where such shells are abundant in the overlying crag strata. Neither have I discovered in these pipes any mammalian bones, nor have I learned that any such discovery has been made by others.

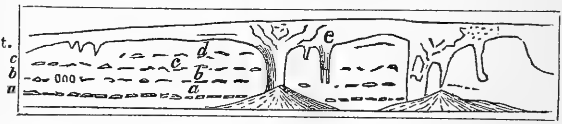
I have now to describe some sand-pipes near Norwich, not in solid chalk, but in reconstructed chalk or chalk-rubble.

The pit in which these occur is at Crostwick, about five miles N. E. of Norwich, on the western side of Rackheath Valley, and at its point of confluence with the valley of the Bure. The dimensions of the pit are about 35 yards by 48 and the sections of its southern, eastern, and western sides, are represented in the three following diagrams : —

Fig. 10. CROSTWICK PIT.

South.

East.

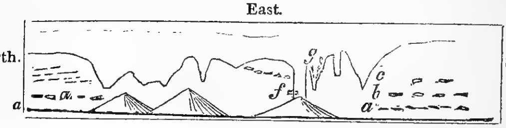


West.

Fig. 11.

East.

North.

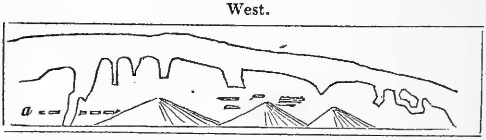


South.

Fig. 12.

West.

South,



North.

Note. — The references to the above three diagrams are as follows : —

a, b, c, d. Various layers or seams of flint in the gravel and sand overlying the chalk (*Uncallow*).

e. A pipe which divides into two cylinders.

f. A flint protruding from the chalk into a sandpipe.

g. Various flints (not in layers) in the uncallow.

Various irregular seams of clay also occur in different parts of the uncallow, as near *e* in fig. 10. (to the right of that letter); to the left of *f* in fig. 11. ; and where lines are represented in fig. 12.

Seams of crag shells also occur at two or three points near *b* in fig. 10. and above *f* in 11.

The lowest line of flints, marked *a, a,* runs with great regularity all round the pit ; and must, I think, be in solid undisturbed chalk. The next line (*b, b*) is less regular and continuous ; but it contains two Paramoudras, in their proper vertical position. The third line (c, c) is more irregular, and some of its tabular masses of flint lie horizontally, while others stand up vertically; and a little below this line, on the southern side, are some irregular lines of gray clay, with a ferruginous tinge. Above the fourth line of flints (d, d) to the west of the middle point of same side, a seam of similar clay is continuous for several feet.

On the eastern side, towards the north end, similar seams of clay occur above the lowest line of flints (a, a), at intervals of from 6 inches to 2 feet in perpendicular height. They are rarely more than 6 inches long, and an inch thick. Several seams also occur about the middle of the same side, below the level of the third line of flints (c, c). Irregular seams of clay and sand appear also about the middle of the western side of the pit; and these occasionally expand into masses of sand, 6 inches long and 2 or 3 inches thick. The seams of clay dip, on the south side toward the north, on the east side toward the east, and on the west side toward the west. In the north-east corner of the pit, the reconstructed chalk rises to the height of 12 feet above the level of the lowest line of flints (a, a).

Near the middle of the eastern side of the pit, at the depth of about 5 feet below the surface of the reconstructed chalk, a layer of crag shells occurs, about 10 feet long, dipping eastward. The general thickness of this layer is from 1 to 3 inches; but in one part, for the length of 2 feet, it swells out to the thickness of 1 foot; and the shells are here mixed with sand and a few pebbles. Among the shells, which are chiefly in large fragments, Mr. Wigham recognized *Astarte plena*, *Tellina obliqua*, and *Cyprina islandica*, the last shell being the most abundant.* I have before stated that the pan which underlies the fluviatile deposit of Mundesley, and the bed which overlies the fluviatile deposit at Runcton Gap, agree as to the species of shells which they contain; and it becomes a question with which of these two beds the crag of Crostwick was contemporaneous.

So solid in appearance is the reconstructed chalk of this pit, that, until I discovered the above described layer of crag shells, I had no suspicion that it was any thing but solid chalk; and even now, when I am convinced that a large portion of the matter in which this pit is excavated is chalk-rubble, I am unable to assign, with any degree of precision, the limits between the reconstructed and the solid chalk. The fragments of chalk in the rubble of Crostwick do not exhibit the slightest appearance of attrition.

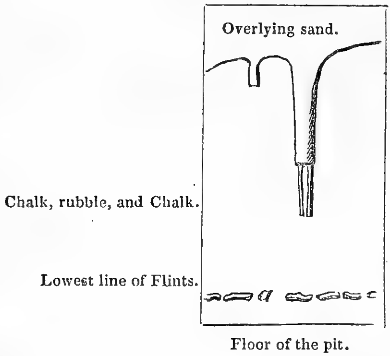
As to the deposits above the reconstructed chalk, they rise to the height of about 4 feet above the general level of the latter. Of the Pan there are no distinct traces. The lower of these overlying deposits are more regularly stratified than the upper.

* The entire skeleton of an elephant was found some years ago, as Mr. Wigham informs me, in a pit of chalk-rubble in the neighbourhood of Crostwick; and, as he believes, in this very pit. In this part of Norfolk, "marl" is the name which the farmers give in common both to chalk and to chalk-rubble.

One of the most remarkable phenomena in this pit is to be observed on its southern side. A cylindrical pipe (*e*), of small diameter, divides into two smaller cylinders, two or three inches in diameter each. They are separated one from the other by an interval of 2 or 3 inches, and each holds an uninterrupted course through the chalk to the depth of several feet. In this and in other instances of the same kind that I have met with in Norfolk, the division of the pipe into two branches appeared to have been caused by a flint obstructing nearly the whole area of the pipe;

Fig. 13.

South side.



and the diameters of the smaller cylinders into which it divided appeared to be influenced by the size of the apertures left in the mass of flint.

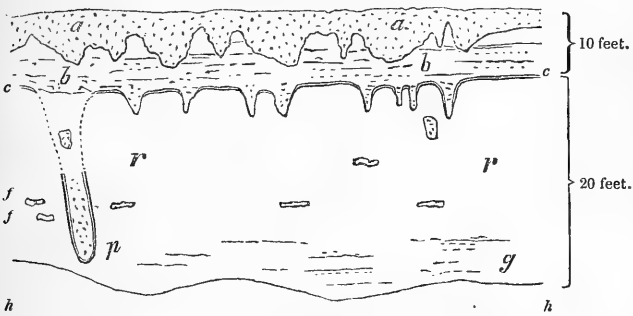
In another pipe on the east side of the Crostwick pit, a flint (*f*), is seen, one part of which remains imbedded in the chalk, while the other part projects into the cavity of the pipe. The upper surface of the projecting part has indications of wear, while its under surface retains the original chalky coating.

In another part of the same pit I observed fissures radiating from one of the pipes; and these fissures were filled with the same fine clay with which the pipes are usually lined. I have since met with similar fissures, similarly lined, in pipes traversing the solid chalk: they occur in pits in this part of Norfolk.

In a paper on the detrital deposits of part of West Norfolk, (Proceedings of the Geol. Soc. vol. iii. p. 185.), I showed that the chalk is there covered by two deposits of very variable thickness. The upper consists of ferruginous sand or loam, and of numerous chalk flints, which have undergone scarcely any abrasion, together with a few fragments of other rocks, such as trap, porphyry, &c., which indicate distant transport: and with these ingredients, beds of rolled chalk-pebbles are occasionally associated. The lower deposit consists mainly of fragmentary chalk, which has undergone very little attrition; and sometimes this constitutes almost the sole material; sometimes there is an admixture of a variable proportion of sand and clay. The lower deposit, though very generally distributed, is more local than the upper. There can be no doubt that both belong to the northern drift.

The surface of the lower deposit is often very much eroded with conical and cylindrical pipes, and with irregular furrows from a few inches to a foot or two in width, and rarely more than 3 or 4 feet in depth. I gave in the same paper an instance of this at Gallows Hill, near Burnham Market, on the side of a valley which opens to the sea, and is excavated in the solid chalk. This

Fig. 14. Burnham Market.



a. Ferruginous sand, with unabraded flints, and pebbles of trap and porphyry.
b. Lighter-coloured gravel, with angular flints, rounded pebbles of chalk, and pebbles of trap and porphyry.
c. Where the lining is darker, is a lining of clay. This lining extends also round the sand-pipe *p*.
r. Comminuted chalk, mixed with clay and sand, and with rounded and partially waterworn fragments of chalk.
f. Large tabular unabraded masses of flint.
g. A bed of gravel.
h. Solid chalk.

mass (*r*, *r*) was 20 feet thick, and consisted of finely-comminuted chalk detritus, mingled with clay and sand, and containing rounded and slightly waterworn fragments of chalk, and large tabular flints, not in the least abraded. It had seams of sand, several inches thick, in its lower part; and one of these expanded into a bed of gravel 2 feet thick. It was traversed by a sand-pipe (*p*), which appeared to extend through its entire thickness.

In a recent communication I mentioned a bed of chalk-rubble near Trimmingham, which occurs enveloped in drift, and is so pure as to be burned for lime. I have since met with another such deposit near the Thorpe entrance to Gunton Park, which is also burned for lime: it consist of fragments of chalk which have undergone some little attrition. This bed is from 12 to 15 feet thick; rests upon sand; and is covered by from 2 to 4 feet of sandy loam. In an area from which the uncallow had been recently cleared, 15 yards long, and from 3 to 5 yards broad, I found the surface of this bed honeycombed with sand-pipes, which were from 1 to 3 feet deep, and scarcely 2 feet apart. They were connected by furrows running in various directions.

From the phenomena above recorded as occurring in Norfolk, combined with those which I formerly observed in Kent, it may be concluded, that the surface both of the solid and reconstructed chalk in those counties has been exposed to the action of which sand-pipes are the result; and this at various epochs, extending from a period prior to the deposit of the sands of the plastic clay, to the close of the period of the stratified drift.

The phenomena, observable in Norfolk, of the horizontal strata of sand and gravel, superincumbent on the chalk, bending down into the cavities of the larger sand-pipes as they approach those cavities, led Mr. Lyell to attribute these irregularities to the gradual removal of the chalk after the sand and gravel had been deposited; and the agent by which he supposed the chalk to have been removed, was acidulated water, percolating the overlying deposits, which deposits subsided into the hollows beneath, on their losing their support.

That a certain amount of subsidence has, in many instances, taken place, I am by no means disposed to deny; and we have evidence of this in the vertical striæ which I have often observed on the walls of pipes, and which I find, from the paper of Mr. Rose on the geology of West Norfolk, that he has also noticed. The faulted state of the bands of sand and clay at Thorpe, represented in Fig. 6. (supposing that fault to be attributable to some neighbouring sand-pipe), may also be adduced in proof of the subsidence of the strata into those cavities.

I believe these cavities to have been formed before the superincumbent strata were deposited. The shallow circular basins observed on the surface of the chalk at Thorpe and Rackheath, and formerly also in Kent, I consider as incipient pipes. The formation of such hollows in siliceous blocks on the sea-shore, by the rotation of sand and water, I formerly pointed out in my paper on the sand-pipes of Kent. I have also observed minature furrows, and conical and cylindrical cavities, now forming on chalk, by the action of sand and water, on the coast of Norfolk, between high and low water mark. These cylindrical cavities are 2 inches in diameter, and 4 inches in depth.

I beg to compare the sand-pipes in the chalk with the rock-basins worn in the river-beds of gneiss and granite in Southern India, of which Lieut. Newbold has given an account. (Proceedings of the Geol. Soc., vol. iii. p. 702.) These cavities are from 4 inches to 4 feet in diameter, and 4 feet deep; and they are connected one with another by shallow channels. For the further details on this subject, I beg to refer to the abstract of his paper.

The effect of cavities, when once formed in the bed of a rapid river or tide, is to occasion whirlpools, which set in rotation the matters within the cavity, the heavier bodies remaining within it, while the lighter are ejected. In this way, it appears to me that pits in the chalk may have been kept open for some time after the deposit of the crag had commenced.

The bending down of the lower strata of the crag into the hollows of the larger and deeper pipes, may be regarded as an extreme case of the stratification conforming itself to pre-existing irregularities of surface, a conformity which is so apparent in the same strata when extending over the broad and shallow hollows in the chalk. A subsidence to a limited extent in matters so deposited is not incompatible with the mode and circumstances of their deposition.

January 8, 1845.

George Dawson, Esq. of Birmingham, was elected a Fellow of this Society.

The following communications were read:—

1. *On the Discovery of the Fossil Remains of* BIDENTAL *and other* REPTILES *in* SOUTH AFRICA. By ANDREW GEDDES BAIN, Esq., Surveyor of Military Roads under the Corps of Royal Engineers.

THE district in which these fossils were found is on the eastern frontier of the Cape Colony in South Africa, about 500 miles east of Cape Town. No granite has been observed here, and the lowest rocks are stratified, and in consequence of the dip, though variable, tending on the whole towards the interior of the country, the lower members of them are those nearest the coast.

A red quartzose crystalline sandstone is described by the author as the fundamental rock, and as alternating with a talcose slate. This sandstone is assumed to be of the carboniferous period, vegetable impressions, apparently of a Lepidodendron, having been found in it, and it is traced by the author towards the west, parallel to the coast to within 50 miles of the Cape.

Over this there occurs a rock, called by the author a claystone porphyry, containing fragments of the sandstone; next an argillaceous slate, alternating with sandstone and containing thin laminæ of limestone, and at a little distance is a stratum full of vegetable remains.

Further to the north is a ferruginous sandstone with argillo-calcareous nodules, in which nodules were found the remains of reptiles characterised by the author as *Bidental*, and described by Professor Owen in the subsequent memoir. From the basin of Fort Beaufort to near the southern foot of the Winterberg range (which is about 90 miles inland) the same beds appear to be continuous, but they are interstratified with beds of greenstone which also occasionally intersect them.

The Winterberg peak (between 5,000 and 6,000 feet high) is a flat tabular mass of basalt. Several hundred miles to the westward of the peak a region extends of horizontal sandstone capped on the eminences by basalt and intersected by numerous basaltic dykes. A similar region extends to the north of the peak. Here again reptilian fossils have been discovered, and they have also been brought from the country far to the north beyond the Orange River. Ammonites have been found at the summit of the Compass-berg 150 miles N.W. of the Winterberg.

The author does not venture to decide on the geological age of the formations he thus describes, but proceeds in conclusion to allude to some overlying deposits found near the southern coast of Albany, one of which is a red sandstone conglomerate, entirely without fossils and resting unconformably on the supposed carboniferous sandstone: others are distinctly tertiary, and abound in shells resembling those of animals still living on the South African coast. A thick diluvial deposit is found near Fort Beaufort, and from the plains far to the northward beyond the Orange river the fossil skull of a kind of buffalo has been obtained.

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2. *Description of certain Fossil Crania, discovered by* A. G. Bain, Esq., *in Sandstone Rocks at the South-eastern Extremity of Africa, referable to different Species of an extinct Genus of Reptilia* (Dicynodon), *and indicative of a new Tribe or Sub-order of* Sauria. By Richard Owen, Esq., F.R.S. F.G.S., &c.

The most remarkable character in these fossils is the presence of two long curved and sharp-pointed tusks, which, like those of the Walrus, descend one from each superior maxillary bone, and pass on the outside of the fore part of the lower jaw, a character rare even in Mammals, and hitherto only met with in that class; but in these specimens combined with a structure of the cranium, proving that the animals belonged to the class Reptilia, but were members neither of the Crocodilian nor Chelonian orders. The Lacertine Sauria offer characters for comparison, but the minor deviations from the ordinary Lacertian structure are so numerous, the mode in which Crocodilian and Chelonian characters are interwoven upon an essentially Lacertian base is so interesting, and the individual and distinctive characters of the Dicynodons so striking and peculiar as to require a detailed osteological description for their complete illustration.

In these animals, the Crocodilian structure is chiefly manifested in the occipital region of the skull, and gives place to the Lacertian characters in the upper and fore part; but in regard to these deviations it must be remembered, that the distinctive features of the Crocodilian type are most broadly manifested in the existing representatives of the order, and are modified and rendered less salient in the more numerous and varied extinct members.

It is necessary to bear in mind this tendency to the amalgamation of Crocodilian and Lacertian characters in the older Loricata, in order to form a right estimate of the value of those correspondences with the cranial peculiarities of the existing Lacertians.

Nevertheless, various characters justify the conclusion, that the general type of cranial organisation manifested by modern lizards was that in which the peculiar modifications of the Dicynodon have been superinduced. It is not, however, amongst the modern lizards that we find the nearest approximation to the Dicynodon. For this we must go as far back into the period of Reptilian life on this planet as the epoch of the new red sandstone, when the *Rhynchosaurus* manifested the Lacertian type of skull, combined with toothless jaws, which were most probably sheathed with horn. What concerns us most in the present inquiry is the anomalous edentulous sharp edge of the upper and lower jaws in the ancient Rhynchosaur, and the Chelonian form of the deep lower jaw, the same anomaly having been repeated in the extinct African lizard of apparently as remote a period, with the superaddition of Mammalian canine tusks. For the rest, much difference of form is manifested in the two extinct genera; but it is interesting to remark the same peculiar contraction of the cranial cavity, indicating an arrested developement of brain in both of them. The dental peculiarity of the African Saurian forms its chief distinction from the Rhynchosaurus, as from all other Sauria: but with the strange superaddition of its two canine tusks, we must bear in mind that the affinities linking the Dicynodon to Crocodilians and Chelonians are much more strongly manifested than they are in the Rhynchosaurus.

The author, in concluding his account of the Dicynodon, adverts to the analogy of structure, which radiates from this genus in the direction of the Ophidian division of existing Reptilia, although it is unsupported by any other concordances of cranial or dental organisation than those about to be cited. In the poisonous serpents, the rattle-snakes for example, the intermaxillary bone is single and edentulous; the maxillary bone supports a long, curved, pointed tooth, which, when advanced, descends outside the lower jaw. Apart from all the other peculiarities of the maxillary and dental systems of the poison-snakes, they alone, of all existing Reptilia, repeat, in the above-cited structures, the characters of the Dicynodon. But, in addition to the two large maxillary teeth, the rattle-snake has smaller teeth in rows upon the palatine, pterygoid and mandibular bones. To complete the resemblance between the tusks of the Dicynodon and the venom fangs of the snake, you must deeply groove their fore-part, or bore a canal through their centre; you must remove those strong columns of bone which converge to, abut against, and strengthen the fixed socket of the tusk, and you must suspend the maxillary bone by a moveable pedicle to the pre-frontal and malar bones. Besides, the perforated tusk of the poisonous serpent is always followed by one or more similar teeth, in various stages of growth, ready to supply its place, according to the general law of the maintenance in serviceable state of the dental armature of the jaws throughout the Reptilian class.

The canine tusk of the Dicynodon consists of a simple body of compact unvascular dentine, with a very thin outer coat of enamel, which may be traced into the alveolus for a short distance. Rather more than one-third of the tusk is lodged in the socket, the basal conical pulp-cavity is continued from the base about one-half down the implanted part of the tusk, and a linear continuation extends along the centre of the rest of the tusk, from which the dentinal tubes of the solid body of the tusk radiate. They present gentle parallel secondary curves or undulations throughout their course, divide dichotomously twice or thrice near their beginnings, and send off numerous small lateral branches, chiefly, but not exclusively, from the side next the apex.

The principal difference in the microscopic texture of the tusks of the Dicynodon, as compared with the teeth of the crocodile, consists in the closer and more compact arrangement of the calcigerous tubes of the dentine; by which character it makes a closer approach to the intimate texture of that tissue in the canine teeth of the carnivorous Mammalia.

In the other Reptilia, recent or extinct, which most nearly approach the Mammalia in the structure of their teeth, the difference characteristic of the inferior and cold-blooded class is manifested in the shape, and in the system of shedding and succession of the teeth. The dental armature of the jaws is kept in serviceable order by uninterrupted change and succession; but the matrix of the individual tooth is soon exhausted, and the life of the tooth itself may be said to be comparatively short. Evidence of this low organised dental condition, common to fishes, has been obtained in every reptile, in which the implanted base of the teeth has been examined by the author.

The existing Lacertians superadd to this endless shedding and succession of teeth, the ichthyic character of anchylosis of the base of the teeth in use to the osseous substance of the jaw; so that in the *Rhynchocephalus* and other acrodont lizards, the teeth appear like small enamelled processes of the alveolar border. The Dicynodons not only manifest the higher type of free implantation of the base of the tooth in a deep and complete socket, common to Crocodilians, Megalosaurs, and Thecodonts, but make an additional and much more important step towards the Mammalian type of dentition by maintaining the serviceable state of the tusk by virtue of constant renovation of the substance of one and the same matrix, according to the principle manifested in the long-lived and ever-growing tusks and scalpriform incisors of the Mammalia. This endowment of the teeth of a reptile is far more remarkable and unexpected than the more obvious character of the size and shape of the long exserted tusks themselves, superadded as they are, and in such strange combination, with the otherwise edentulous jaws of a bird or turtle. Yet if we consider the fact in its relations to the exigencies and convenience of the living animal, the wisdom and beneficence of the principle is apparent, and the departure from the ordinary rule manifests a power transcending the trammels of scientific system. The teeth of the Dicynodon being but two in number, and their use to the animal indicated by their unusual size to be of unusual importance, the inconvenience and detriment that must have ensued from frequent shedding and replacement is very obvious; we may readily conceive it to have been incompatible with their functions, and therefore abrogated in favour of another mode of renovation which is abnormal in reptiles, simply, perhaps, because the form, proportions, and function of such tusks were unique, and are now no longer manifested in a cold-blooded class.

Some observations may be naturally expected in reference to the probable use of the tusks to the Dicynodons, and the mode of life of those ancient and most remarkable saurians. In the Mammalian class, where alone we now find the analogous instruments, tusks are usually given as weapons of offence and defence, — an office exemplified in the hornless musk-deer, the boar, and in the large canine teeth of the Carnivora. The elephants use their tusks chiefly, though not exclusively, as lethal weapons: the Walrus is said to apply his tusks to aid in clambering over icebergs, as well as in combat and defence: the Dugong is supposed to wear the exserted points of the tusks in detaching fuci for food. Such an office at first suggests itself as a very probable one in regard to tusks descending, like those of the Dugong, from the upper jaw, and combined with edentulous and probably horny mandibles like those of a fucivorous turtle.

On inspecting the remains and the impressions of the tusks in the fossils under consideration, and especially in the almost entire skull of one species, the *Dicynodon lacerticeps*, we perceive that these weapons are sharp-pointed, and present no trace of that obliquely bevelled or chisel-shaped extremity which is produced by habitual application in acts of obtaining daily food, as, for example, in the protruded extremities of the tusks of the Dugong and the incisors of the Rodents. The tusks of the Dicynodon, though similar, in their origin from maxillary bones and downward direction, to the tusks of the Walrus, are so much shorter, at least in the single specimen in which their entire length is shown, that they could not be available in locomotion. I conclude therefore from their shape, proportional length, sharp points and dense texture, that the tusks of the Dicynodon were applied by the living animal either for the purpose of killing its prey, or of defending itself from its foes, or in both acts; and that they were offensive and defensive arms.

A further insight into the habits and mode of life of the Dicynodons may reasonably be expected to follow the examination of the skeleton of the trunk and the organs of locomotion. This will form the subject of a subsequent memoir; but the vertebræ of the Dicynodon present the sub-biconcave structure common to most of the older extinct saurians, which structure, in comparison with the ball and socket vertebræ of the modern species, indicates a more aquatic and perhaps marine theatre of life for the amphibia which swarmed in such plenitude of development and diversity of forms during the ancient secondary periods of the geological history of this planet.

January 22, 1845.

David Walter, Esq., of Colchester, was elected a Fellow of this Society.

The following communications were read:—

1. *On the Newer Coal Formation of the Eastern Part of* Nova Scotia. By John Dawson, Esq.

In some notes communicated last year to the Geological Society, I stated the results of observations on the gypsiferous formation of Nova Scotia, tending to confirm the views of Mr. Lyell respecting the age of that series of rocks. In introducing those notes, it was stated that the carboniferous strata of this province may be included in three groups; first, the gypsiferous or mountain limestone formation; secondly, the older coal formation; and thirdly, the newer coal formation: of these the two former have almost exclusively attracted the attention of geologists, the latter having been in a great measure neglected. In connection with the Pictou coal field, however, and probably also in other parts of this and the neighbouring colonies, the newer coal formation is an extensively distributed deposit, often attaining considerable thickness, and, though not containing valuable beds of coal, ironstone, or gypsum, yet so associated with the rocks including these minerals, that a knowledge of its structure and relations is essential to their satisfactory investigation. In a palæontological point of view also it possesses considerable interest; as its fossils show the continuance of the coal flora during the deposition of a series of red sandstones newer than the great coal measures; and also the co-existence of that flora with terrestrial vertebrated animals.

The coal measures of the Albion mines, on the banks of the

East River of Pictou, a series of beds, estimated by Mr. Logan at 5000 feet in thickness, and constituting our older coal formation, are succeeded, in ascending order, by a great bed of coarse conglomerate, which, as it marks a violent interruption of the processes which had accumulated the great beds of coal, shale, and ironstone beneath, and as it is succeeded by rocks of a character very different from that of these older coal measures, forms a well-marked boundary, which we may consider as the commencement of the newer coal formation.

This conglomerate appears in the East River section, at New Glasgow, where it dips to the north. From this place its outcrop, rising above the neighbouring softer rocks, may be traced, in a western direction, as far as the West river, nine miles distant, and eastward for a few miles, when it either disappears beneath the surface, or passes into red sandstones, which appear in the same direction, as far as Merigomish Harbour, six miles distant.

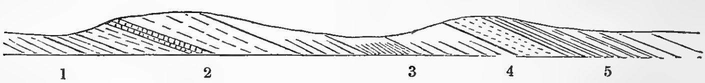
On the East River the conglomerate is accompanied and overlaid by soft reddish sandstones. Northward of New Glasgow, however, the banks of the river are covered with detritus, and the only rocks which appear are grey sandstones and grey and reddish shales, which are seen in a few places. In one part of the section numerous fragments of black shale, with coprolites and scales of ganoid fishes, appear to indicate the presence, in this series, of a bed of that description. Wherever the dips of the rocks, on this section, can be ascertained they are northerly, but usually at a very small angle.

Eastward of the Ewer section, and in geological position probably a few hundred feet above the conglomerate, there is a bed of grey limestone, twelve feet or more in thickness, containing a few minute univalves, and having in one part of its thickness a peculiar laminated and concretionary structure. Above this limestone, and separated from it only by a few inches of underclay, is a small bed of coal. The outcrop of these beds can be traced across the country, parallel with that of the conglomerate, as far as Merigomish Harbour, where they are seen dipping to the north at an angle of about 25°, and are accompanied by reddish and grey sandstones and shales. The latter rocks form a series of at least 2000 feet in thickness, portions of which appear at various places on the shores of Merigomish and Little Harbours. Red sandstones prevail in the lower part of this series, but in its upper portion there are thick beds of grey sandstones, accompanied by grey shales; and, in one place, by a bed of coal 11 inches thick, with an underclay. They also include a thin bed of dark grey limestone, in concretionary balls, separated by clay. Near Merigomish, these beds dip to the north at an angle of about 20°, but further westward the dip becomes very small, and they spread over a greater surface, so as to occupy the shore nearly as far as the entrance of Pictou Harbour. In the grey sandstones on this shore, coniferous wood, fossilized by carbonate of lime, is very abundant; and *Calamites*, *Endo-*

genites, *Lepidodendron*, and carbonized vegetable fragments are frequent.

Northward and westward of Pictou Harbour, is a series of rocks, nearly resembling those just described, and generally dipping to the south-east, at angles of 15° to 25°. In Rogers Hill, six miles westward of Pictou, are thick beds of coarse conglomerate, considerably disturbed, associated with greenstone and hard claystone, and showing, in one part, a thick vein of crystalline sulphate of barytes. This conglomerate I believe to be geologically identical with that of New Glasgow. It is succeeded by a great series of deposits, chiefly consisting of reddish sandstones and shales; but including several thick beds of grey sandstone, affording quarries of valuable grindstone and freestone, and accompanied by grey shales, conglomerates, thin beds of coarse limestone, and a thin bed of coal. As there are no very good natural sections in this part of the country, it would be difficult to ascertain the aggregate thickness of these deposits; it must, however, be great, since they occupy, with general south-east dips, the whole country from the hills last named to the entrance of Pictou Harbour. The principal fossils found near Pictou, are *Calamites*, *Lepidodendron*, *Endogenites*, coniferous wood, ferns, *Sternbergia*, and carbonized fragments of wood impregnated with iron pyrites and with sulphuret and carbonate of copper. In this series, also, and near the town of Pictou, is the bed of sandstone containing erect calamites, noticed by Mr. Lyell in his papers on the fossil trees of the Joggins. A section of the rocks accompanying this bed is annexed.

Section of rocks of the Newer Coal Formation at Dickson's Mills, near the town of Pictou (330 yards).

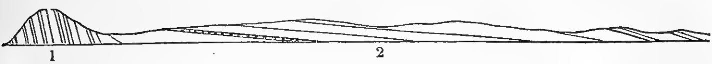


5. Coarse reddish sandstones with finer reddish and grey beds and shales, especially in the lower part. *Ferns* and *Stigmariæ*.
4. Brown conglomerate not coarse.
3. Reddish sandstones and shales.
2. Grey sandstone coarse above and finer below (thickness 50 ft.), in upper part prostrate *Calamites* and *Lepidodendron*; lower part erect *Calamites*, concretions of impure limestone with calamites and endogenites succeeding the sandstones.
1. Reddish sandstones and shales with fucoid marks and impressions of ferns.

The coast section, westward of the entrance of Pictou Harbour, is for some distance very imperfect. Much red sandstone, however, appears; and a bed of limestone from two to three feet thick, and a small bed of coal, have been discovered. Some grey sandstones also appear: in one of which, of a coarse pebbly texture, there are numerous fragments of carbonized wood, containing sulphuret and carbonate of copper. This deposit and others of a similar nature, found in this series at various places, have given origin to hopes, probably delusive, that valuable deposits of that metal might be found in our newer coal formation.

Beyond Fowey River, ten miles north-westward of Pictou, the coast affords a good section, exposing reddish sandstones and shales, containing some grey beds in their upper part, and including a thin bed of dark grey limestone. Some of the red shales contain leaves of ferns and fucoidal marks. The dip of these rocks is to the S.S.E., at a very small angle: on approaching Cape John, however, the angle of inclination becomes greater, and grey beds again become numerous, some of them being thick-bedded and coarse-grained sandstones, and containing calamites and carbonized wood. At the extremity of the Cape the strata becomes vertical, and here (but below low-water mark) is a bed of white granular gypsum, about three feet in thickness. The rocks in which this small bed is situated, must belong to the newer coal formation, and probably to its lower part; and it is the only instance with which I am acquainted, of the occurrence of gypsum in that part of the carboniferous system. As it appears in none of the other sections which I have examined, the range of this bed is probably small, and it is too unimportant in thickness, to invalidate the claim of the older carboniferous deposits to the title of *gypsiferous* series.

Coast Section of the Newer Coal Formation from Cape John, 8 miles to the Southward.



2. Reddish sandstone and shale with grey beds and limestone, containing *ferns*, *Sphenophyllum* and *Lycopodium*.
1. Grey and reddish sandstones and shales with conglomerate and gypsum. *Lignite* and *Calamites*.

Beyond Cape John, a band of comparatively level country, skirting the shores of the Gulph of St. Lawrence, and extending as far as Wallace Harbour, is occupied by the newer coal formation, which here contains a greater proportionate abundance of red sandstones than near Pictou; and instead of being bounded on the inland side by carboniferous rocks, is met by, and seems to overlie unconformably, a series of hard grits, slates, and limestones, with scales of *Holoptychius*, *Encrinites*, and fragments of bivalve shells, and which are probably of Newer Silurian or Devonian age. The last mentioned rocks, with various kinds of trap, form an elevated ridge belonging to the Cobequid chain of hills. A copy of the section exposed by the French river of Tatmagouche, which was described in my paper of last winter, and well illustrates the structure of this region, is annexed.

SECTION of FRENCH RIVER of TATMAGOUCHE ($6\frac{1}{2}$ miles).

5. Grey and red sandstone and shale. *Calamites*, &c.
4. Red sandstones and shales with a few grey beds.
3. Light grey and red sandstone and shale.
2. Slate, limestone and grit with scales of *Holoptychius*.
1. Trappean rocks.

When examining the red sandstones, near Tatmagouche, last summer, I found in one of the beds a few footmarks of an unknown animal, specimens of which were sent to this society. They were mere scratches made by the points of the toes or claws, and therefore could give few indications of the form of the feet which produced them. Their arrangement, however, appeared to indicate that the animal was a biped, and their form is quite analogous to that of the marks left by our common sandpiper, when *running* over a firm sandy shore. On a subsequent examination of the same place, I found a series of footmarks of another animal, and obtained a slab with casts of eight impressions, which I send with this paper. In this specimen the tracks are somewhat injured by the rain-marks which cover the slab, and the clay in which they were made was probably too soft to give good impressions; it has, however, preserved a furrow which must have been caused by the body or tail of the animal trailing over it. Many of the beds in the neighbourhood of that containing these footmarks are rippled, rain-marked, or covered with worm tracks; and as such indications of a littoral origin are not infrequent in other parts of the newer coal formation, it may be anticipated that many interesting relics of terrestrial animals will in future be discovered. At present, however, as no quarrying operations are carried on in the red beds, it is difficult to obtain access to the surfaces on which tracks might be expected to occur. The only vegetable remains found in the red sandstones of Tatmagouche are some of those irregular branching stains which have been considered as fucoidal marks; but in a bed of grey sandstones above the strata containing tracks, I found *Calamites*, *Endogenites*, *Stigmaria ficoides*, and fragments of carbonized wood. In a fragment from a dark calcareous bed near this place, I found a portion of a fossil plant covered with shells of a species of *Spirorbis*, and a few small scales of ganoid fishes. A bed of limestone, similar to that of Cape John, has been observed in the sandstones of Tatmagouche, but no coal, gypsum, or conglomerate have been seen. It is probable that most of the sandstones and shales, seen in the French river section, are equivalent to the newest of the strata seen near Pictou.

To give more precise views of the composition and appearance of the newer coal formation, and of the differences between it and the lower carboniferous series, it may be useful shortly to describe the various rocks of which it is composed.

The *red sandstones* are of various shades, from brick red (which is not common) to reddish brown. They scarcely differ, in their range of colours, from those of the gypsiferous formation, except that in the latter purplish tints are more frequent. They are often flaggy and micaceous, and obliquely laminated, and there is every gradation, from very coarse sandstone to shale.

The *red shales* are generally laminated, but not finely; occasionally, but rarely, they want lamination and then can scarcely be distinguished from the fine sandstones and mudstones which, in the gypsiferous formation, have been named marls. They often have greyish fucoidal marks, and sometimes remains of land plants. The red sandstones and shales are usually soft, and I have nowhere seen them attain the hardness so often found in the similar rocks of the gypsiferous formation.

The *grey sandstones* vary in colour from neutral grey to brownish and yellowish tints; the latter owing to the decomposition of iron pyrites. The sandstones are sometimes coarse, and full of white quartz pebbles, but are more frequently of finer texture. They are accompanied by greyish shales and clays, and the groups of grey sandstone and shale, occurring in the newer coal formation, are much more important than those of the gypsiferous series These groups of grey beds are always accompanied by thin layers of coarse grey limestone, usually wedge-shaped, and consisting of a basis of sand cemented by lime, containing concretions and small fragments of argillaceous limestone. These coarse limestones, and the sandstones with which they are associated, are always much harder than the red-coloured beds.

From the constant existence, in the grey sandstones, of carbonized plants with sulphuret of iron, it may be inferred that this sulphuret has been produced by the decomposition of the sulphates in sea water, in consequence of the action of decaying vegetable matter, and the combination of their sulphur with iron derived from the surrounding deposits (a process now taking place in many estuaries). By supposing the bleaching of red sands and clays to have been effected in this way, we should, perhaps, account for the connection of fossil remains with grey beds, and for the comparative absence of red tints from the highly carboniferous rocks of the older coal formation.

There are at least two beds of limestone in the newer coal formation, quite distinct from the impure sandy layers before noticed. The principal stratum, that seen near New Glasgow, is of a grey colour, in some places very dark; its structure varies in different parts of its thickness, being flaggy above, concretionary below and in the middle, showing a peculiar combination of concretionary and laminated structure, unique among our limestones, and preserved by this bed as far as it can be traced. The limestones seen at Little Harbour, Pictou Island, Cariboo and Cape John are of a dark grey colour, caused by carbonaceous matter;

they have a tendency to concretionary structure, and sometimes degenerate into beds of marly clay with large balls of limestone. The limestones appearing at the four last mentioned places are, perhaps, portions of one bed.

The two small beds of coal are similar in appearance to those of the older coal formation. One of them, with its under clay, is included in coarse grey sandstones; the other rests on limestone, and is succeeded by some grey clay and dark shale.

The conglomerates cannot be distinguished from those of the lower carboniferous series. Both are of reddish-brown colours, and composed of fragments of various hard rocks, usually united by a calcareous cement.

It appears from the foregoing descriptions that, in lithological character, the newer coal formation of Pictou strongly resembles the lower carboniferous series; the chief differences being that, in the former, the beds of grey sandstone are of greater comparative thickness, and that, in the latter, there are great beds of gypsum and of limestone with marine shells. Our coal measures may thus, in one point of view, be regarded as a subordinate group, included in a great thickness of sandstones and shales, mostly of red colours.

The sections which I have described are included in a district extending about fifty miles along the shores of the Gulf of St. Lawrence, from Merigomish to Wallace; forming, I believe, the largest continuous tract of rocks of the newer coal formation in Nova Scotia. Along the coast, between these extreme points, the strata are arranged in an undulatory manner, so that the beds seen at Little Harbour probably re-appear at Cariboo, Cape John, and Tatmagouche. Notwithstanding these undulations, however, the general strike of the formation nearly corresponds with the general direction of the coast. This arrangement is due to the circumstance that the great anticlinal line of the Cobequid Hills, instead of being continued to the shores of the Gulf of St. Lawrence, turns to the southward, and appears to be continued by a group of hills extending across the Pictou coal formation trough, and greatly complicating its arrangement. This group, however, being composed of stratified rocks of the older and newer coal formation, must have owed its elevation to disturbances much more recent than those which determined the main direction of the Cobequid Hills, and that of the great anticlinal line, southward of the Pictou coal field.

The greater part of the rocks composing the newer coal formation of Pictou, were formerly confounded, under the name of New Red Sandstone, with a part of the gypsiferous series, and with a deposit of non-fossiliferous red sandstones skirting the shores of the Bay of Funday, and unconformably superimposed on the older carboniferous strata. I have no doubt, however, that in other parts of Nova Scotia the newer coal formation will be found to be a well-marked carboniferous group. To facilitate comparison with the equivalent rocks of this and other countries, I annex the following synopsis of our Carboniferous series.

Synopsis of the Carboniferous Rocks of Pictou.

1. Newer Coal Formation. — The prevailing rocks are alternations of reddish and grey sandstones and shales, with some coarse conglomerates, especially in the lower part. Subordinate to these, are dark grey concretionary limestone, thin beds of coarse sandy limestone, two thin beds of coal and one of gypsum. Thickness, 5000 feet or more.

    Fossils.—*Coniferous wood, Calamites, ferns, &c., Ganoid fish, tracks of land animals.*

2. Older Coal Formation. — The prevailing rocks are dark shales and clays, grey and brown sandstones; and subordinate to these are coal, ironstone, dark limestone. Thickness, 5000 feet.

    Fossils.—*Ferns, Stigmaria, Calamites, Lepidodendra, &c., Cypris.*

3. Mountain Limestone, or Gypsiferous Formation. — The prevailing rocks are reddish sandstones, shales, and clays, with some grey beds; conglomerates, especially in lower part; and subordinate to these, thick beds of limestone, thick beds of gypsum with anhydrite. Thickness, 6000 feet or more.

    Fossils.—*Calamites, fragments of carbonized plants. Producta, Terebratula, Encrinites, Madrepores, &c.*

Small quantities of copper ores are found in the sandstones of the gypsiferous and newer coal formations, especially in the latter. Salt springs rise from the older coal and gypsiferous formations in a few places. Veins of hematitic iron ore occur in the gypsiferous rocks of the East River. The strata of the two older members of the carboniferous system are more disturbed and hardened than the newer series, and contain interstratified and intrusive traps, which appear in no part of the newer coal formation, except the conglomerate at its base.

Appendix. —*On the Junction of the Carboniferous and Silurian System at Maccara's Brook.*

Silurian and Lower Carboniferous Rocks as seen in the Coast Section at Maccara's Brook.

3. Sandstone and shale of a red and grey colour.
2. Conglomerate.
1. Hard shales and impure limestone (Silurian) of a dark grey colour. Fossil shells.

In my notes on the lower carboniferous rocks, I described this place; but from want of time, and owing to the state of the tide, when I examined it last summer, I was unable to ascertain the exact nature of the junction of the two formations. Having re-examined the section under more favourable circumstances, I have been enabled to observe distinctly the unconformable superposition of the carboniferous system on the Silurian rocks. As I formerly noticed, the gypsiferous system at this place, in consequence of the absence of gypsum, and the presence of great beds of hornblendic trap, presents a very unusual appearance, and could scarcely be recognised, were it not for the presence of limestone with its characteristic fossils. Of the beds of trap there are four, one of them about 200 feet thick; and that they are true beds which have been poured out over the bottom of an ancient sea is proved, not only by their regular interstratification among aqueous deposits, and by the earthy texture and amygdaloidal structure of their upper parts, but by the quantity of trap fragments included in the conglomerates which alternate with them. The lower part of one of these beds of conglomerates is, by the admixture of these fragments, converted into a kind of tufa. One of the beds of trap forms the bottom of the carboniferous series, and rests on the edges of hard shales and thin bedded limestones, filled with Silurian fossils. The edges of the Silurian rocks are slightly altered at the point of contact.

These rocks being on the margin of the great line of ancient disturbed strata, which extend from Cape St. George along the southern edge of the Pictou coal trough, have been subjected to more than one igneous convulsion. A few miles further along the shore, the same beds of conglomerate and sandstone, with interstratified amygdaloid, are seen in a vertical position, with their sandstones changed into quartz rock and jasper. This is, apparently, in consequence of the eruption of the crystalline greenstone and other igneous rocks which appear in their neighbourhood, and we are thus informed that the igneous action along the above-named anticlinal line, which continued to the close of the carboniferous period, was exerted also at the commencement of that period, and no doubt influenced the deposition of its strata in a manner as yet very imperfectly understood.

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2. Geological Features *of the Country round the* Mines *of the* Taurus *in the Pashalic of* Diarbekr *described from Observations made in the Year* 1843. By Warington W. Smyth, Esq., B.A., F.G.S.

In that part of Asiatic Turkey, where the provinces of Anatolia, Armenia, Kurdistan, and Mesopotamia unite, the chain of the Taurus is bounded on the one side by the Euphrates and on the other by the Tigris, and this district, being now out of the way of the main roads of commerce, has until within a few years been almost entirely neglected.

The interest, however, attached to these regions in the present precarious state of the Ottoman empire, and the difficulty of obtaining information concerning them, will excuse the imperfect condition of the sketch now offered of the geographical and geological configuration of the country; but I have to regret that my absence during some years from England prevented my being acquainted with the valuable information to be obtained from the published routes of Messrs. Brant and Ainsworth.*

The line of road which I took enabled me to complete the section of the country in a direct line from the Euphrates to the town of Sivas, and a stay of some weeks put it in my power to obtain some interesting details concerning the important mines of copper at Arghaneh Maden, and of silver at Kebban Maden, as well as others more or less neglected, which lie in various parts of Armenia and the N.E. of Asia Minor.

The great mountain chain called the Taurus by the ancients, runs from the province of Cilicia (now *Adana*) in a north-easterly direction, and often forms large irregular elevated groups; on the eastern side of the Euphrates it spreads in various directions around the great lake of Van, and merges into the high land of northern Kurdistan and the volcanic plateaux of Armenia. At the point where the Euphrates cuts through the Taurus the chain appears to consist of one main ridge, and this afterwards branches off into elevated tracts of very irregular form, one portion extending eastward from the river, and another commencing considerably to the west of it and stretching away towards the north.†

The division of the Taurus with which we have to deal, is separated into two parts by the valley of Kharput, the waters of which flow to the north-east and join the eastern Euphrates. The first of these two portions, in which the river Tigris takes its rise, contains the most elevated points, varying from 6000 to 8000 feet above the sea, and then, proceeding towards the north-east, it joins another range called the Darkush Dagh (Niphates) some of whose peaks are estimated at from 8000 to 10,000 feet high.

The second portion from Kharput to the Euphrates does not attain an elevation of more than 5000 feet, and on the north sinks gradually towards the valley of the Murad Tchai.

The eastern or main ridge, whose breadth between Arghaneh and Kharput may be estimated at nearly 50 English miles, presents us with a series of limestones and marly slates belonging to the cretaceous period, and resembling the formations of various countries bordering on the Mediterranean.

The higher portions generally consist of calcareous strata, abounding in nummulites; whilst the marls, which for the most part occupy a lower position, are highly metamorphic, being changed in colour and frequently hardened to the consistency of silicious slate. Below both, although sometimes occurring in dykes high up the mountain sides, appear rocks of diallage and actinolite in great variety.

To the west of Kharput, the mountains exhibit a different cha-

* See "Journal of Royal Geographical Society" for 1841.

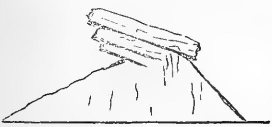
† The lesser ridge of the Karajah Dagh (Masius) which strikes off from hence to the south-east, should not be considered, as it is represented on the maps, as a branch of the Taurus, being almost wholly unconnected with the greater range, and composed of rocks not seen again nearer than forty miles to the westward.

racter. Their chief mass is composed of limestones and slates of an older period; the limestones of a darker colour than that around Arghaneh; the slate chiefly talcose, and connected with the mica-slates and other primary rocks, described by Russegger as forming the nucleus of the Taurus in the district of Adana. The eruptive rocks, occurring in juxtaposition with these, are syenite, diallage rock, basalt, similar to that of the plateau of Diarbekr, and lastly, at Kebban Maden, a felspar-porphyry.

Such are the rocks presented in this transverse section of the chain, and the determining of their boundaries is much assisted by the nature of the ground; for the Taurus is, in this part, so totally bare, that it seldom happens that its geological features are obscured by trees, grass, or even vegetable earth. That forests, however, have once existed, and that at no very distant period, is evident from the oak brushwood which is occasionally met with; though the inhabitants, in order to supply the furnaces, cut away with unsparing vigour the shoots as fast as they spring up.

The city of Diarbekr is built on an extensive plain, covered with rough fragments of basalt, resting upon more compact masses of the same rock; and through these the river Tigris has cut for itself a valley about a hundred feet in depth. On the south of the city, the hills of the Karajah Dagh exhibit varieties of the same rock, which is sometimes amygdaloidal, sometimes scoriaceous. These hills often rise up in strongly marked cones, which bear exactly the type of the ancient secondary cones of Etna; and are covered by various accumulations, and in some cases overgrown with trees. On the south-west, this igneous formation extends beyond the town of Siverek, a distance of sixty miles from the Tigris; and in approaching the mountains to the north-west, we find the same series continued for twenty miles. At Arghaneh the southern outposts of the Taurus present their most remarkable features. The celebrated Armenian monastery of this name is built on the summit of a calcareous mountain, which attains a height of 2000 feet above the plain, or 4000 feet above the sea, and is conspicuous from a great distance, owing to its two sharp peaks. Hence we find the place designated in some old maps as Arx bicornis. The chief component rock of this and the neighbouring elevations, on the north and east, is a compact light coloured limestone, generally abounding in nummulites, and sometimes exhibiting fragments of pecten and ostrea. Against its flanks, on the east and west, rest beds of porphyritic conglomerate, of which the rolled fragments consist chiefly of greenstones with imbedded large crystals of hornblende. The stratification of the limestone is not very distinct at this spot; but, on the road to the north-west, the beds become remarkable, being exhibited in long denuded parallel lines, generally tilted from the southward. The limestone is accompanied by slates of a highly metamorphic character: they are black, grey, ferruginous, or green in colour; and from beneath them there appears a greenstone porphyry, which, in some parts having its hornblende replaced by diallage, or its felspar paste by a magnesian one, passes gradually into diallage rock and serpentine, and rises in dykes, or is laid bare in the bottom of deep valleys, at several points between this and a Koord village about five miles to the north-east.

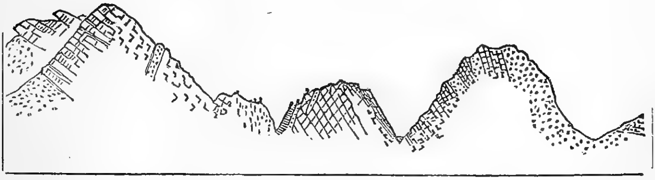
The elevated peninsula formed by the Tigris, which is crossed by the road to Arghaneh Maden, is composed almost entirely of ophiolite, or of a variety of serpentine and diallage rock. These are seen immediately on the western side of the river, which is here crossed by a stone bridge. The colour of the rocks is commonly bottle green; but hardly a square yard of it is homogeneous, so frequent are the changes in the material. The cracks and fissures are filled with precious serpentine, with asbestos, and other minerals, chiefly of silicates of magnesia. The greater portion of the rock, however, is characterised by interspersed foliated crystals of diallage, sometimes as large as the palm of the hand, which reflects so brightly the sun's rays as to be generally taken by the natives for a species of silver. About a mile further to the north, at the opening of a valley which runs up from the Tigris in the direction of Maden, are found some very singular conical mounds and hills, which render probable the eruptive origin of the serpentines. Their summits are formed by a crest of tilted strata of limestone or shale, supported by a mass of serpentine or diallage rock, which has been much decomposed by exposure, and is even sometimes so much worn that the cap of harder stone projects from its base, as if nicely balanced upon it by art.



On the road to the mines, are passed strata of finely laminated shales, which are, here and there, interrupted by dykes or masses of diallage rock, and frequently become allied to jasper.

The serpentine is laid bare at Arghaneh Maden, in the valley of

Mining District of Arghaneh-Maden.



The dotted parts in this diagram represent diallage rock, the crossed lines an irregular mass of sulphuret of iron and copper in which the mines are situated, and the remainder of the marks, limestones, and metamorphic slates of various periods.

the Tigris, and in the ravine formed by a rivulet which pours in its tribute close below the town. The rock is generally full of diallage, and contains the other magnesian minerals before described. From its being intersected in all directions by fissures and joints of separation, it is not applicable to the purposes of building. Between the rivulet and the Tigris, or to the north of the main portion of the town, the serpentine does not rise high above the level of the valley, but, at a few feet above it, is capped by slates and marls, partly crumbling and partly jaspery; the former being of a dark grey colour, and the latter having a brownish red tint.

The steep south side of the ravine is of a different character. In contact with the serpentine appears a ferruginous breccia, consisting of angular fragments of ochreous marls and sandstone, and, more rarely, pieces of porphyry, cemented together by hydrous oxide of iron, and forming a bed of considerable thickness. This is used as a building material, being easily worked, and tolerably durable, but its dull rusty appearance, combined with the total absence of herbage and the strangely coloured sterile slopes of the surrounding mountains, give the place a character of unequalled dreariness.

Higher on the mountain there rise up, from beneath beds of marl, rugged masses of diallage rock, and these extend in the form of a powerful dyke over the shoulder of the height towards the south. In the portions where it is friable this dyke is deeply furrowed by the rains and the tracks of the animals, which are constantly passing and repassing with charcoal for the furnaces. Its position in this form and at this elevation is important, as tending to prove that the limestone was not deposited upon it, as might have been argued, from seeing the diallage rock constantly laid bare in the deep valleys, where the superincumbent limestones and marls have been removed. On the summit of the mountain, to the west of the town, marls and limestone are again found; and the limestone incloses numerous nodules of serpentine projecting from the weathered face of the rock, and thus exhibiting a greater degree of hardness.

It is to its copper mines that Arghaneh Maden owes all its importance. The breccia before mentioned appears to constitute the outer wall of the cupriferous mass. This mass, though it continues in depth to the level of the waters of the Tigris, has not hitherto been opened anywhere except on the surface of the mountain above the town.

It appears to be but one huge lump of ore, consisting of the double sulphurets of copper and iron, planted amid the serpentine, or perhaps between it and the marls. In the mines which I entered, not the slightest character of a vein or bed was to be seen, but floor, and roof, and walls consisted entirely of solid pyrites, diversified only by stalactitic coatings of blue and green vitriol. This extended to a depth of 10 or 12 fathoms; but the additional 20 or 30 feet which had been excavated, were filled with water, which had for upwards of a year kept the works almost at a standstill. It is only by waiting patiently until the month of July or August, that access is gained to the lower parts of the mine. The accumulated rains of the winter and spring at that time gradually find their way out through crevices into the valley below, and leave the mines dry for a few weeks.

The shafts, which belong to different individuals, are scattered irregularly over a part of the mountain, which is almost level, and is about fifty fathoms in diameter; and since in all of these shafts the same appearances are presented, we may be justified in considering the ore as forming rather an insulated mass, than as belonging either to a bed or lode.

The pyrites varies so much in quality, that a large proportion is left untouched by the miners, not repaying them for working; the generality of ore contains from 10 to 12 per cent of copper, whilst the better sorts rise to 20 or 24 per cent; and occasionally a little vitreous copper, or pure sulphuret occurs, when the per centage is much higher. The boundary of this mass of ore is hitherto unexplored, but judging, as before, from the area occupied by the mine entrances, it cannot be less than fifty fathoms in diameter; and since the ore is again met with, and even of better quality, in an adit now driving from the valley of the Tigris, it appears that it continues also thus far in depth, perhaps 50 or 60 fathoms.

The workings are conducted on a miserable plan, adopted indeed in all the Turkish mines, but which will soon bring the present undertaking to an end, and entail difficulty on future enterprise. A shaft is sunk from the surface at an angle of 45° with the horizon; and it is secured, somewhat insufficiently, by timbering, and provided with rough wooden steps for ingress and egress. As soon as a good portion of the ore is thus reached, the miners work off in different directions, digging out in the most irregular manner only that which pays them best, and leaving the rest to stand or break down as accident shall determine.

The road to Kharput or Palu ascends steeply, to the west of Maden, across a ridge through which the Tigris rushes, in a narrow glen many hundred feet below. The first part of the acclivity, after leaving the diallage rocks, is composed of very thin marly slates, easily separating into rhomboidal fragments. Then follow various amygdaloidal rocks, exhibiting spicular crystals of felspar in a paste, composed partly of felspar, and partly of carbonate of lime, — a continuation, in short, of the metamorphic rocks which generally accompany the near approach of the serpentines to the secondary limestones and shales. The crest of the mountain is composed of powerful banks of limestone, tilted towards the north-east, to which succeeds, about a hundred feet lower down, serving as a base to the rugged cliffs presented by the stratified rocks, the hornblende-porphyry which we before had in conjunction with the serpentines. After this steep descent, the road ascends by a very gentle rise the course of a stream to the west, in a valley bounded sometimes by mountains whose lower parts are porphyritic, and sometimes by limestone hills inclining to the north-west. It then crosses a water-shed, and, after passing a third isolated khan, enters a perfectly level plain of about six miles in length and two in breadth, through which the main feeder of the Tigris flows from some peaks on the south-west. Judging from the quantity of snow which still lay there in the month of June, the elevation of these peaks must be considerable. After ascending from this plain, a narrow and low ridge of limestone strata, inclining to the north-east, separates the waters of the Tigris from those of the Euphrates. On its western side is a lake, the direction of which is nearly east and west, its length being ten or twelve miles, and its breadth three or four; and this lake is said to give off its surplus water to the Euphrates. In the valley, at its eastern end, through which flows a small tributary stream, occur numerous instances of diallage rock, in which the foliated crystals are remarkably large and beautiful. The ascent westwards is again over porphyry and greenstone. The summits of the high ridge we then cross are formed principally of limestone, and the descent to the broad valley which lies on its other side, offers steep slopes, on which are exposed, at intervals only, rocks of actinolitic porphyry and diallage, which appear to be intimately connected with each other.

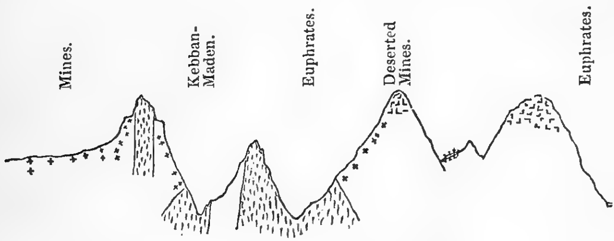
This fertile valley, through which a stream takes its course to the Murad Tchai, near the town of Palu, is entirely covered by alluvial soil; and being carefully irrigated by the inhabitants of its numerous villages, presents a great contrast to the sterility of the mountains. Its height above the sea, from the observations of Ainsworth and Brant, is about 2500 feet. The hills which project into it towards the town of Kharput consist mainly of marls and sands, much decomposed and deeply furrowed by rains.

At Kharput, a fine natural section is presented to the steep face of rocks opposed to the east. This lower portion is composed of a greenstone porphyry, disintegrated and rounded by the action of the weather, whilst the upper part consists of thick massive strata of compact limestone, having an inclination to the north-west, of about 30°, and split by numerous fissures at right angles to the plane of inclination. The contact of the two rocks may easily be observed; but the limestone appears to have undergone no change, whilst the porphyry has become so friable that it is generally eaten away by the air and rain to a depth of several feet below the bed of limestone.

To the west of Kharput, the country assumes a very broken aspect, and exhibits confused groups of lower elevations, extending towards the valley of the Murad Tchai, beyond which is now seen a magnificent range of mountains, the Dujik Dagh, running about east by north, and west by south, and in the month of June still capped with snow. The hills nearest to Kharput consist of limestone and shale, but about three miles to the north-west appears a grey syenite, with large and well-formed crystals of black hornblende, yielding very readily to the action of the atmosphere. The mounds thus composed open out into a plain which is divided into natural terraces, and which in its geological features presents a repetition of the plateau of Diarbekr on a small scale, the whole surface being strewed with blocks of basalt of every size, which are so numerous as to render the road very difficult for the horses, and make it necessary for the inhabitants to form huge piles of stones in preparing a small piece of ground for cultivation; though the quality of the black soil, then sparingly occurring, is good enough to repay them for their labour. The low ridge which bounds this plain on the west consists of a grey limestone, associated with thin marls, the strata inclining to the south-east; and on its opposite side, where the road winds among some narrow gullies previous to entering among higher mountains, syenite, diallage rock, and hornblende porphyry are found in close connection with each other.

About eighteen miles west-north-west from Kharput, a group of limestone mountains fills up all the space intervening between this point and the Euphrates to the north and west; and through these a deeply-cut valley runs to the north-west, extending for six or eight miles to the Euphrates, where, for some distance around the point of confluence, are worked the silver mines of Kebban Maden.

Mining District of Kebban Maden.



The dotted parts indicate the presence of felspar porphyry, the small crosses metalliferous threads and nodules; two of the hills are capped with limestone, chiefly of the cretaceous period, and the rest of the diagram represents older limestones and talcose slates.

The mountains around the silver mines exhibit, in general, bare surfaces of grey compact limestone, or of argillaceous and chloritic slates, both of which appear to be without fossils. On both sides of the valley in which the town is situated, rise sharp peaks of a hard felspathic porphyry, containing large crystals of pink common felspar, and sometimes exhibiting a slaty texture, with the crystallised parts so ill defined, that where it occurs in contact with the clay slates, it is difficult to assign to each its proper boundary. This eruptive rock also makes its appearance more frequently in the bottom of the neighbouring valleys; as, for instance, below the furnaces, and at the lower parts of the slopes which border the Euphrates. A sharp ridge of the same rock runs along the back of the east side of the town, and there forms bold precipices facing the river which flows almost beneath. A little further to the north, the porphyry is interrupted by a band of ochreous matter, which, probably before the formation of the valley of Kebban, communicated with a similar patch on the opposite side, forming a lode or dyke. The surfaces of the hills, as well here as on the opposite side of the Euphrates, are covered with innumerable rubbish heaps, formed in attempts to open mines which have rarely been pushed more than two or three feet into the ground. The mines at present worked (which are three in number) lie beyond the ridge on the west of the town, and are even more miserably directed than those of Arghaneh. The adit mouths are driven through shale and limestone, which, here and there, shows on the surface small strings and lumps of galena; but so irregular and dirty are the works, that little can be seen underground to inform us how the ore occurs. The lower mine exhibited some rich portions of nearly pure argentiferous sulphuret of lead, but it nowhere had the appearance of occurring in veins, and I could not hear of crystallisations or druses. In the upper mine, a large quantity of soft iron ochre, a sort of gossan mingled with threads of gypsum, is excavated as ore, being found to contain, like the galena, from an ounce to an ounce and a half of silver in 100 lbs.

The miners told me that near the junction of two species of rock, whether limestone or shale, or of one of these with porphyry, they find the ore more plentifully disseminated than elsewhere.

Dressing or preparing the ores is not understood, so that all which is not rich enough to go at once to the furnace is wasted.

Between the Euphrates, at Kebban Maden, and the Kizil Irmak, or Halys, at Siwas, extends a broken and neglected high land, in which the traveller meets with no habitations, except in villages fifteen or twenty miles apart, and these are inhabited by koords of a somewhat lawless character.

On leaving the felspar porphyry which is found in peaks, or below the sedimentary rocks at Kebban, a high land of limestone and shales is reached. This high land extends up the course of the Western Euphrates, above Eghin, and towards Kamak, where the limestone forms the sides of a magnificent gorge through which the river flows. Superimposed on the older grey limestone, occur beds of a white calcareous rock of softer character, which mineralogically has a strong resemblance to the *calcaire grossier*, or *Grobkalk* of the Vienna basin, and contains the shells of oysters. About twelve miles from Kebban, the almost level country is strewed with basalt blocks, like those of the plateau of Diarbekr, which continue beyond the village of Ergavan. An hour's distance from hence, a long valley running up towards the north-east, exhibits porphyries frequently trachytic in character, and containing hornblende crystals in a felspar paste; and also banks of a conglomerate, containing fragments of the same porphyry. Then, after passing the water shed, about ten miles before reaching Hakim Khan, rise on the right hand precipitous heights of compact limestone in beds inclining to the west; and in some places porphyry comes up from beneath them. The country on the south-west, towards the Euphrates, is composed of low undulations of sand and marls.

Around Hakim Khan are crumbling marls, in vertical or highly inclined positions, running N. E. and S. W.; above which rise a few remarkable peaks of bare white limestone.

Towards Hassan Tchelebi, on the road side for six miles, diorites and serpentine rocks appear, the heights above which, often wooded, and said to be tenanted by wild goats and deer, are of limestone. These calcareous strata, having a moderate inclination to the westward, continue visible as far as the village last mentioned.

From Hassan Tchelebi, for about twenty miles, the rocks are hidden by vegetable mould and grass; though fragments of porphyry, limestones, and marls are found.

From Alajah Khan, for a distance of four or five miles, diallage rocks, often much discoloured by iron, are found; and after this appears limestone, tilted towards the west, then for some distance before reaching Kangal, and from thence as far as Delikli Tash, the slopes are covered with thin grass.

The chain of the Anti-Taurus (Itschitchegi Dagh), attaining an elevation of 5800 feet, runs in a very marked line from W.S.W. to E.N.E. The limestones of which the higher part is formed, rest on serpentine; which appears to have coloured and hardened the beds of shale, near the surface of contact. Immediately on the west, towards which side the beds incline, granular gypsum appears in beds of considerable thickness on both sides of the road; and on this lies salt, the presence of which is betrayed by a lake, whose waters evaporate in summer. Eighteen miles from Delikli Tash is found a quartzose sandstone in strata from 2 to 6 feet thick, inclining gently towards the west, and between this and the deeply cut valley of the Kizil Irmak (Halys), that rock continues without interruption.

The preceding observations collected in the course of a single traverse are not a sufficient foundation on which to base general conclusions as to the constancy of the order in which the rocks occur; but since the mere enumeration of the rocks in geographical order is, in general, but a dry repetition, and, for want of comparison with some known scale, is not easily kept in mind, it may be of advantage to conclude with a sketch of the probable order of the formations above mentioned, which may serve as a guide to future travellers in these districts.

The oldest stratified rocks of the series are unquestionably the limestones and chloritic slates of Kebban Maden, which appear to be in connection with the mica slate, forming the nucleus of the Taurus at Adanah: they overlie a felspar porphyry, which seems to have pierced them in dykes, and near the contact affords ores of argentiferous lead.

The second deposit may be the quartzose sandstone which occurs between the range of Anti-Taurus and Siwas; and this deposit, no doubt, belongs to the system observed by Hamilton near Eregli *, to the south of Kaisariyeh, towards the head of the

* These saliferous deposits are probably more recent than the Scaglia Limestones. W. J. H.

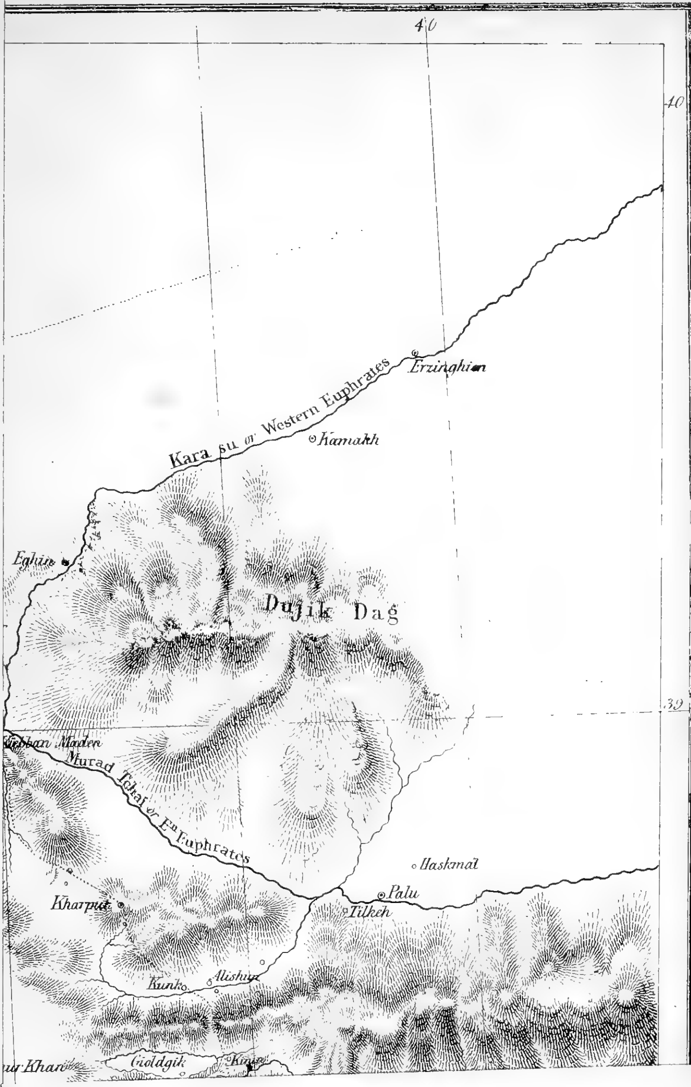
river Melas, and mentioned by him as stretching across from Galatia to Cappadocia. In both places, it is a hard red grit, associated with strata of gypsum, and with red and grey marls; and, in the first case, also with salt.

The grey limestone of Arghaneh, Kharput, and the Anti-Taurus, must be referred to the vast calcareous deposit, which, cotemporary with our green sand, occupies an enormous extent of country in Italy, Dalmatia, Albania, Greece, and Syria, on the one hand; and in South France, Spain, the Balearic islands, Sardinia and Sicily on the other, a zone in fact which, from what we find of it again in Egypt and Algiers, appears to encircle the whole Mediterranean. In the Taurus, as in many of those countries, it has been upheaved and pierced by serpentine and diallage rock; and these are the circumstances which in the country I have endeavoured to describe, as well as in the Maremme of Tuscany, at Monte Castelli, Rocca Tederighi, Monte Catini, &c., are associated with the presence of the sulphuret of iron and of the sulphuret and other ores of copper. The lower beds of this limestone, often described under the name of scaglia, are not yet very definitely referred to their place in the geological scale; since they differ much among each other, and are often poor in characteristic fossils; but the upper portion, with its nummulites and the marls associated with it, retains more nearly the same type throughout.

The date of the eruption of the serpentines, which are associated with the cretaceous beds, has been referred by most observers to the tertiary epoch; nor would it appear that those of the Taurus are an exception, since their occurrence in dykes near Arghaneh proves their outburst to have been subsequent to the deposition of the limestones.

I should be inclined to refer to the tertiary period also those limestones which occur on the summit of the mountain west of Arghaneh Maden, and contain imbedded fragments of serpentine; and also those which cap the mountains near the junction of the Murad and Frat; but the line of distinction, from the difficulty of procuring fossils, is not easily drawn. It is however very possible that a more accurate examination may show them to be secondary, and thus prove the outburst of the serpentines to be of remoter date than is generally supposed; or, what is more likely, to have happened not all at once, but at several successive periods.

To the deposition of these calcareous strata have succeeded the further elevation of the chain, and the formation of the existing valleys; phenomena probably contemporaneous with and due to the same cause as those which produced the protrusion of the igneous rock occupying several large tracts in the district under consideration. A further study would doubtless prove these rocks to be connected with the vast series of volcanic rocks, of the same general character, which extend at intervals from the Katake kaumene of Asia Minor to the Taurus, and thence to Mesopotamia on the one hand, and through the north of Syria to Galilee on the other. The protrusion of these rocks is one of the principal agents to which the present configuration of this important tract of country is due.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Kara su or Western Euphrates
Erzinghian
Kamakh
Eghin
Dujik Dag
Murad Tchai or Eʳⁿ Euphrates
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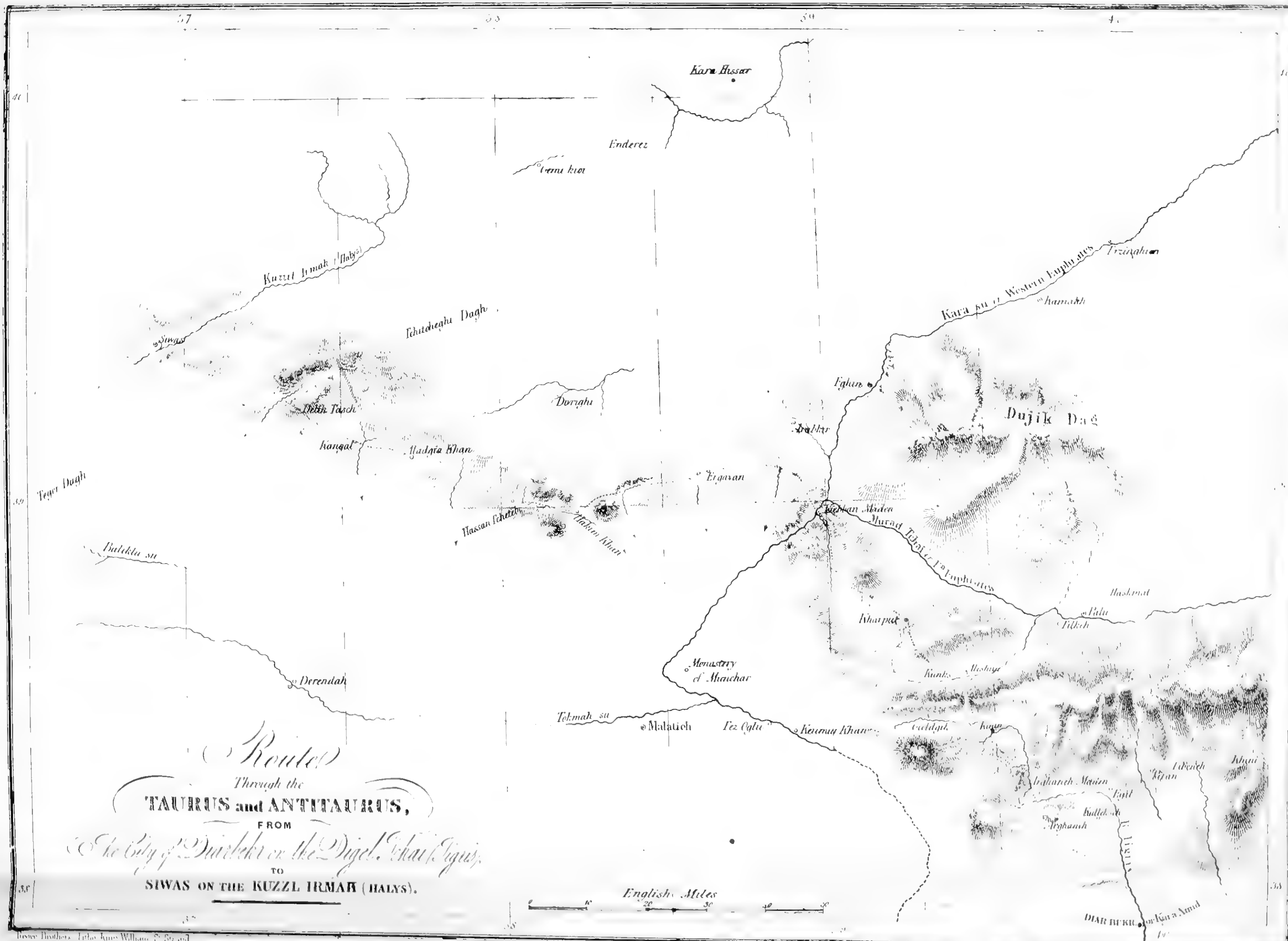

Route Through the TAURUS and ANTITAURUS, FROM The City of Diarbekr on the Digel Tchai (Tigris) TO SIWAS ON THE KUZZL IRMAK (HALYS).

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FEBRUARY 5. 1845.

Thomas Longman, Esq., J. Durance George, Esq., and Captain Barham Livius, were elected Fellows of this Society.

The following communications were read:—

1. *On certain Conditions and Appearances of the* STRATA *on the* COAST *of* ESSEX *near* WALTON. By JOHN BROWN, Esq., of STANWAY.

IN this paper the author first alludes to the information that has been obtained, of late years, respecting changes of elevation that have taken place on many parts of the earth's surface, at comparatively recent geological periods, and refers to the memoir by Mr. Smith, of Jordan Hill, on this subject, as illustrating the nature of the evidence to be sought for. He then endeavours to show that such evidence exists with regard to certain beds containing shells, on the Essex coast, which beds he had been able to examine in consequence of their having been laid bare by an unusually high tide, and by the gradually wasting action of the sea on that coast. He mentions three places in particular, namely, Walton, Clacton, and the valley of the Colne, near Colchester, at each of which he has obtained marine shells from heights to which the sea does not now reach.

At the first of these, Walton Gap, the author describes a bed to which he gives the name of the *till* (assuming it to be identical with the beds so denominated on the banks of the Clyde), composed of clay, with boulders of various kinds and sizes, the surface of which is about 5 or 6 feet above high water mark. The beds containing shells, and supposed to form a raised beach, are seen to rest immediately on this till, or boulder clay, and the shells consist chiefly of those of the common oyster (*Ostrea edulis*) associated with the common muscle (*Mytilus edulis*), and cockle (*Cardium edule*), and other abundant coast shells, such as *Venus decussata*, *Buccinum undatum*, and *Turbo littoreus*. These shells are described as being for the most part quite perfect, and they are generally covered with sand, or with a freshwater bed, about 5 feet thick. The author also alludes to a bed of *Turbo littoreus*, on the spot now occupied by the terrace at Walton.

The next spot described is at Clacton, on the same line of coast, and about eight miles to the south of Walton. A considerable number of marine shells are stated to have been here collected at various heights above high water mark, the highest bed being 8 feet. In this case the marine shells are of the same species as those found on the coast and in the adjacent sea, and they are associated with freshwater species also common in the neighbourhood.

On the western side of the valley of the Colne, and at a distance of about 600 yards from the river, similar beds of shells are described as occurring at a height of about 5 feet above high water mark. The shells are numerous and broken, and they are associated with concretions of carbonate of lime. The author considers that this deposit may have been formed at a time when the valley of the Colne was an estuary of the neighbouring sea. The shells are all those of the common recent species found on the coast, but the bed is now ten miles distant from the sea.

The author considers that the perfect state of the shells in these cases precludes the possibility of their having been drifted, and that they therefore afford sufficient proof of the general level of this part of the British coast having undergone a small elevation at a recent geological epoch.

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2. *On* Dykes *of* Marble *and* Quartz *in connection with Plutonic Rock on the* Upper Wollondilly *in* Argyle County, New South Wales. By the Rev. W. B. Clarke, M.A., F.G.S.

The tract of country described by the author in this memoir is situated not far from Sydney and Port Jackson, the river Wollondilly, whose gorge lays bare the geological structure of the district, taking its rise in latitude 34° 26′ S., longitude 149° 23′ E., and after receiving the waters of several streams running into the Nepean river, and emptying itself into the Ocean considerably to the south of Sydney.

The stratified rocks traversed by the remarkable defiles through which these rivers flow, belong to the sterile upper portions of the carboniferous formation so widely spread in Australia; and these carboniferous rocks are traceable (with occasional interruptions from basaltic dykes) from the district in question to the borders of the Illawarra region, where they present a lofty mural escarpment.

The Wollondilly, however, from its source to its junction with the Uringalla (except near Towrang), is described by the author as running through igneous and metamorphic rocks, which are laid bare over a considerable area between the Cockburndoon, the Derra, and the Uringalla rivers, where recent volcanic outbursts have disturbed the older rocks. The sedimentary rocks wrap round the margin of this area, the beds dipping at a considerable angle.

On the north banks of the river, at a place called Jaoramin, beds of conglomerate are described containing fragments apparently of transition rock; and the author considers, from the condition and appearance of the river banks, and the fact that a wide space, at a considerable height above the water, is covered with the débris of these conglomerates, that a considerable change of level has taken place in the district producing elevation.

Having given a general account of the districts, the author then proceeds to describe the different plutonic rocks found in it, and states that they consist of syenite, syenitic granite, protogine and porphyritic rocks of various kinds, and of greenstones, basalt, and trachyte, all, with the exception of the three latter, passing by regular gradations from one to another. The syenites are said to resemble those of Skiddaw, and the syenitic granite that of Guernsey, while a protogine is described greatly resembling a beautiful rock of the same kind in St. John's Vale, near Keswick.

At Arthursleigh, the author describes a spot where the face of an exposed cliff exhibits a net-work of quartz veins with dykes of syenitic rock and hornstone; and not far off a dyke of ironstone, and others of basaltic rocks, amongst which are some injected trachytes that have been much used for building purposes.

Having described the position and mineral character of these igneous rocks as they appear *en masse*, the author then proceeds to allude to some singular instances of intrusive dykes of limestone and marble, at a spot known as "Campbells," or "Shepherds," situated on the estate of Arthursleigh just alluded to. These dykes occur in contact with hard large-grained grey syenite, and were seen on the right bank of the river Wollondilly.

In the first instance mentioned, the width of the dyke is stated to be nearly 47 yards, its dip 50° S.W., and its strike S. 22° E. "Alternations of quartz rock and crystalline white and grey marble compose this dyke; innumerable lines and scratches mark the edges and face of the marble; and the quartz has also been subject to a semi-crystalline action, the surface being crumpled or doubled up into parallel anticlinal ridges." There appears to be no line of demarcation traceable between the quartz and marble; and the two together, after descending into the bed of the river, suddenly curve round and re-enter the granite as a second dyke. Traces of green carbonate of copper are found associated with the other minerals of this dyke.

The author considers that the scratches and furrows which he has observed, and other phenomena in the line of dip, could not have been in existence before the formation of the present river channel.

A second dyke is then described in a place where the rocks are thrown into great disorder, and the author details some changes which have produced singular conditions of mineral structure. He also supposes that they exhibit marks of a gradation existing between limestone and quartz. A third dyke of the same character is then mentioned, in which the constituents of the granite are mixed up with the calcareous rock; and the author states that near these dykes the granite assumes a distinct character, a greater proportion of felspar and less mica being present.

At Jaoramin, higher up the river than the spot just alluded to, the structure of the rocks is described as somewhat different, the felspar being less completely mingled with the other minerals, but the rock occasionally passing into porphyry. Where it is not denuded, the rock, however, is here overlaid by a mass of conglomerate, from 200 to 300 feet thick, through which the river makes its way. At St. Peters are low hills more decidedly granitic. Near Stuckeys farm are numerous fragments of crystalline rock, the surface of which is much worn, as is the case with other calcareous rocks all over New South Wales. No traces of fossils have been found in these limestones.

The author remarks that the greenstone becomes compact near the marble, and assumes a bottle-green colour, traces of limestone being common in it; whilst on the other hand, the marble near the greenstone is also changed, so that a passage may be traced from one to the other.

The author concludes by referring to other instances in New South Wales, in which similar phenomena have been produced. He mentions one case in lat. 32° 6′ S., and long. about 151° E., where, in the neighbourhood of the river Page, veins of marble intersect a lava-like trap; and another about 16 miles north of Arthursleigh, where a magnificent tunnel in white crystalline marble occurs in the bed of a creek surrounded by basaltic rocks. On a branch of the Abercrombie river, west of the Dividing Range, and about 40 miles south of Bathurst, a similar tunnel of gigantic dimensions, nearly 800 feet long and 80 feet high, also passes through a mass of white crystalline marble at the bottom of a ravine in the middle of a country of volcanic rocks and blocks of snow-white quartz.

The author hopes to be able, at a future time, to describe these examples more fully; he alludes to them now to show that there is reason to believe that these connections of limestone, plutonic rocks, and quartz dykes, are not without their application to a condition of geological phenomena, to the elucidation of which the banks of the Wollondilly have exhibited a clue.

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3. *On the* Atherfield *Section of the* Lower Greensand, *in the* Isle of Wight. By W. H. Fitton, Esq., M.D., F.R.S.

[This paper is postponed, not having been received from the author in time for notice in the present number of the Proceedings.]

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY OF LONDON.

VOL. IV. PART III. 1845. No. 103.

AT THE

ANNUAL GENERAL MEETING,

21st of February, 1845,

THE following Report from the Council was read :—

In calling the attention of the Members to the state of the Society, the Council have the satisfaction of stating that, during the year 1844, 22 new Fellows have been elected and admitted, besides 2 others elected in former years, whose subscriptions had not previously been paid in, thus making an increase of 24 new Fellows. On the other hand, they regret to state that the loss by death has been unusually great, not less than 23 deaths having been announced during the last year; 7 resignations have also been received. During the same period there have been 3 Honorary and 2 Foreign Members deceased, and 3 new Foreign Members elected; thus making a decrease in the numbers of the Society of 8; the total number of Members having been 883 at the close of 1843, and being reduced to 875 at the close of 1844.

In their Report last year, the Council called the attention of the Society to the great expenses which had been incurred in the publication of the Proceedings and Transactions. With the view of inquiring into the state of the Society's affairs a Finance Committee was appointed last year, who, after considering the average annual income and expenditure of the Society, independent of publications, came to the conclusion that there only remained a sum varying from £250 to £300 per annum at the disposal of the Council, to be expended in the publication of Transactions or Proceedings, without anticipating future income or encroaching on the capital of the Society.

With regard to the finances of the past year, the Council have the satisfaction of stating, that in consequence of the careful system of economy rigidly maintained, the excess of income over expenditure during the year 1844, independently of publications, amounts to the sum of £286 5*s*. 8*d*. It is the intention of the Council, so far as shall be found consistent with the interest of the Society, to carry out the recommendation of the Finance Committee, that the amount to be expended in publication in any given year shall not exceed the sum which, in the annual estimate, shall appear to be the excess of income over ordinary expenditure.

During the year 1844 only one Fellow has compounded: this composition has been funded, together with three others received in 1842 and one received in 1843, the funding of which the Council had found it expedient to delay.

The legacy of Mr. T. Botfield, announced in the Report of last year, has also been funded. By these additions the value of the funded property of the Society has been raised from £2598 (the amount stated last year) to £2896 11*s*. 3*d*. At the close of 1844 the number of living compounders was 116, and the amount which had been received from them in lieu of annual contributions was £3654, thereby reducing the difference between the amount received from living compounders, and the actual value of the funded property of the Society, to the sum of £757 8*s*. 9*d*.

The office of Curator and Librarian has, to the great regret of the Council, become vacant by the appointment of Prof. Forbes to the office of Palæontologist to the Museum of Economic Geology: the Council were consequently compelled to look out for a competent successor. Out of the considerable number of deserving candidates they resolved on appointing Prof. Ansted, Fellow of Jesus College, Cambridge, to the vacant office with the title of Vice-Secretary; and this appointment has been subsequently confirmed by the General Meeting, to whom, in conformity with the bye-laws, it was communicated.

The mode of publishing the Proceedings of the Society in an illustrated form, contemplated in the last annual Address, not having met with that sale which would have justified the Council in its continuation, owing to the inadequacy of the receipts as compared with the estimated expenditure, which would have been about £500 per annum, compelled the Council to enter into arrangements which will diminish the call on the funds of the Society, and will, they trust, ensure that regularity of publication, no less important to the public than essential to the interests and character of the Society.

They have consequently to announce, that in the month of December last they signed an agreement with Messrs. Longman and Co., the immediate result of which was the publication, on the first of this month (February), of the first number of the "Quarterly Journal of the Geological Society." Notwithstanding the short time allowed for its preparation, the Council feel confident that the appearance and contents of this number will convince the members of the Society that no effort has been left untried to ensure its permanent success. The agreement has been made for one year, renewable at the expiration of that period; and some of the principal conditions are as follows:—The work shall be edited by the Vice-Secretary of the Geological Society, under the control of its Council; the proceedings of the

Society shall constitute the first and principal portion of each number; the journal shall appear quarterly, on the 1st of February, 1st of May, 1st of August, and 1st of November; the cost of the work is to be defrayed by the publishers, who take upon themselves the risk and profits; the option is reserved to the Fellows of receiving either the Proceedings gratuitously or the entire journal at the trade price.

The Council have also reserved to the Society the right of publishing in the quarto form, any papers, abstracts or illustrations, which may be considered to require such a form of publication.

The considerable stock in hand of the last five volumes of the Transactions, together with the wish expressed by several Members of the Society to purchase separate memoirs, has induced the Council, by way of trial, to assign ten copies of these volumes for the purpose of being broken up and the papers sold separately. But they will not proceed further in this measure until the financial result of the experiment has been ascertained. A catalogue of the separate papers has been printed and published.

It has hitherto been the practice of the Society to present copies of its Transactions to the Board of Admiralty, the Boards of Ordnance in England and Ireland, the East India Company, &c.; and on the same principle the Council have recently directed that a complete set of the Second Series of the Transactions should be presented to the Museum of Economic Geology: and the Council have much pleasure in announcing, that Her Majesty's Government have directed that copies of all reports and proceedings from the Museum of Economic Geology, of all government publications connected with geology, and of all the geological maps published by the Ordnance office, should be furnished to this Society.

The Council have further to announce, that they have resolved that the Wollaston Medal be awarded to John Phillips, Esq., F.R.S., Professor of Geology at the University of Dublin, for the services he has rendered to Geology by his various published works; and that the sum of £21 1*s.* 6*d.*, the balance of the proceeds of the Wollaston fund, be given to Mr. Andrew Geddes Bain, for his extensive explorations in South Africa, and particularly for his original discovery in that country of the remains of bidental and other reptiles.

They have also resolved, that at the ensuing and future presentation of the Wollaston Medal, the metal to be employed should be Palladium, the discovery of which was due to the sagacity of the distinguished founder of the fund; and that the Medal should henceforth be called the "Wollaston Palladium Medal."

Report of the Museum Committee for 1845.

The additions made to the British collection during the past year have been few: they consist of the following specimens, viz.—

Tertiary.—About twenty species of freshwater shells from the newer Pliocene of Claxton, by John Brown, Esq., F.G.S.

A few marine species from Bridlington and from the London Clay, by Mr. Charlesworth and Mr. Tennant.

Chalk.—Six species only from this deposit have been added, including a Hippurite from Kent, by Mr. Bunbury.

Greensand.—A valuable addition has been made to this part of the collection from Kent and the Isle of Wight, chiefly by Mr. Austen, Captain Ibbetson and Prof. Forbes. Its importance is greatly increased in consequence of the report which Prof. Forbes has made upon it.

Lias.—With the exception of some specimens from Deddington, presented by Mr. Faulkner, nothing has been added to the oolitic department of the collection.

Coal.—A single coal plant has been received from Mr. Dawes.

Silurian.—Mr. Majendie and Mr. Hallam have added some desirable specimens to this part of the collection.

The additions made to the foreign collection are more extensive, chiefly belonging to the Tertiary series. They consist of a series of Miocene remains from Lisbon, a considerable number of species from Gibraltar, a large series from Bordeaux, and a few specimens from Madeira and Porto Santo. These have all been presented by Mr. Smith of Jordan Hill. The Earl of Enniskillen and Sir P. Egerton have given a series from Egypt; Sir W. Parish, Lieut. Spratt and the Earl of Enniskillen one from Malta; and Mr. Forbes and Lieut. Spratt one from the freshwater deposits of Asia Minor.

A series of Casts of Bones of the Dinornis has been presented by the College of Surgeons.

Secondary.—Mr. Smith has added a few specimens from Lisbon and Gibraltar, and Captain Graves others from Lebanon. These several additions have been arranged in drawers by Mr. Woodward, and form a very valuable accession to this part of the collection.

Your Committee have examined a large part of the collection, both British and foreign, and they regret to observe that so considerable a number of specimens are without specific names. They therefore repeat the recommendation made by the Museum Committee of 1843, "that all the species be described and named, and that they be published in the Society's Proceedings." In furtherance of this recommendation, a report on the fossils belonging to the lower division of the Cretaceous series has been presented to the Society by Prof. Forbes. This report your Committee recommend should be published with as little delay as possible, and also that the investigation be continued until the whole collection has been examined.

Your Committee have ascertained that certain portions of the collection lent to individuals for scientific purposes, with the sanction of the Council, have not been returned: viz. crag fossils to Mr. Lonsdale, some bones to Mr. Owen, and specimens from the London Clay to Mr. Charlesworth. They have also been informed by the subcurator, that it has been the practice to borrow specimens under the same restrictions as those which are adopted for lending the books. To this practice your Committee express their decided objection, and recommend, that in future no specimen be allowed to be taken from the Museum except with the sanction of the Council.

S. P. PRATT.
H. T. DE LA BECHE.
CHARLES LYELL.
ROBERT A. C. AUSTEN.

Library Report.

During the last year the Library has been increased by donations of about 200 volumes and pamphlets. The Board of Ordnance continues to present to the Society the Maps of the Trigonometrical Survey of Great Britain, and of the Townland Survey of Ireland.

The Charts published by the Admiralty and by the Dépôt Général de la Marine of Paris respectively, have likewise been received.

Several of the works in the Library are incomplete; but some of the deficiencies, it may reasonably be hoped, will be supplied on application to the authors or proprietors who have kindly presented to the Society portions of these works, and have omitted to send the remainder.

In order however to place the Library in a more efficient and satisfactory state than it is now in, we recommend that steps be taken to supply *by purchase* those deficiencies which cannot otherwise be made good, and that a sum be annually appropriated to this purpose, and a further sum for binding; many of the works are comparatively unavailable to the Fellows from not being bound.

LEONARD HORNER.
R. HUTTON.

Comparative Statement of the Number of the Society at the close of the years 1843 *and* 1844.

	Dec. 31, 1843.		Dec. 31, 1844.	
Compounders		117		116
Residents		239		230
Non-residents		448		452
		804		798
Honorary Members	26		23	
Foreign Members	49		50	
Personages of Royal Blood	4	—79	4	—77
		883		875

General Statement Explanatory of the Alteration in the Number of Fellows, Honorary Members, &c. at the close of the years 1843 *and* 1844.

Number of Fellows, Compounders, Contributors, and Non-residents, 31st December, 1843				804
Add, Fellows elected during former years, and paid in 1844	Resident	1		
	Non-resident ..	1		
		— 2		
Fellows elected during 1844, and who paid	Residents	8		
	Non-residents	14		
		—22		
			—	24
				828
Deduct, Compounders deceased..................			3	
Residents ,, ...			7	
Non-residents ,, ...			13	
Resigned			7	
			—	30
Total number of Fellows, 31st Dec. 1844, as above				798

Number of Honorary Members, Foreign Members, and Personages of Royal Blood, 31st December, 1843 ..		79
Add, Foreign Members elected		3
		82
Deduct, Honorary Members, deceased	3	
Foreign Members ,, ...	2	
	—	5
Total as above		77

Number of Fellows liable to Annual Contribution at the close of 1844, *with the Alterations during the year.*

Number at the close of 1843		239
Add, Elected in previous years and paid in 1844		1
Elected during 1844 and paid		8
Non-residents who became Residents		4
		252
Deduct, Deceased...........................	7	
Resigned...........................	7	
Compounded	2	
Became Non-resident..................	6	
	—	22
Total as above....		230

Deceased Fellows :—

Compounders (3) : Francis Baily, Esq. ; Dr. James Mitchell ; Robert Walters, Esq.

Residents (7) : James Lord Abinger ; The Dean of Carlisle ; Hugh Fraser, Esq. ; J. L. Guillemard, Esq. ; John Houseman, Esq. ; Richard Knight, Esq. ; Martin Tupper, Esq.

Non-residents (13) : Charles Allsop, Esq. ; Dr. W. J. Bayne ; Dr. J. R. Corrie ; John Gordon, Esq. ; Capt. Basil Hall, R.N. ; William Hatfield, Esq. ; William Ick, Esq. ; Bishop of Lichfield ; Dr. J. G. Malcolmson ; Rev. T. E. Rogers ; Dr. H. H. Spry ; Prof. Thomas Webster ; H. T. Witham, Esq.

Honorary Members (3) : Robert Coleman, Esq. ; Dr. T. C. Hope ; Dr. N. Nugent.

Foreign Members (2) : M. Puillon de Boblaye ; M. J. F. d'Aubuisson de Voissins.

The following Persons were elected Fellows during the year 1844.

January 3rd.—Major Thomas Austin, Bristol ; and George Granville Harcourt, Esq., M.P., Newnham Court, Oxfordshire.

January 17th.—Eaton Hodgkinson, Esq., F.R.S., Manchester ; and Lieut.-Col. Sabine, R.A., F.R.S., Woolwich.

March 6th.—J. Middleton, Esq., Member of the Asiatic Society of Bengal, Principal of the College at Agra.

March 20th.—William Pole, Assoc. Inst. C.E., Professor of Civil Engineering, Elphinstone College, Bombay ; and Francis Joseph Sloane, Esq., Florence.

April 3rd.—John Wilson, Esq., 38 Grove End Wood, St. John's Wood ; Andrew C. Ramsay, Esq., Ordnance Geological Survey of Great Britain ; and Charles Pope, Esq., Member of the Royal Colleges of Physicians and of Surgeons of London, F.L.S., &c., Temple Cloud, Somerset.

April 17th.—Henry Bean Mackeson, Esq., Hythe ; and Sir Thomas Edward Colebrooke, Bart., M.P., Colebrooke Park.

May 15th.—William John Blake, Esq., Danesbury, and Portland Place.

May 29th.—William Meredith Browne, Esq., King Street, Covent Garden ; and George Loch, Esq., 12 Albemarle Street.

June 12th.—Robert Thomas Atkinson, Esq., Newcastle-upon-Tyne.

June 26th.—John Shaw, M.D., Hop House, Boston, Lincolnshire.

November 20th.—Charles Faulkner, Esq. ; and John Bravender, Esq., Surveyor, Cirencester.

December 4th.—Henry Coles, Esq., Cheltenham ; Dr. Travers Cox, 2 Stanhope Place, Hyde Park ; Prof. Edward Forbes ; and I. K. Brunel, Esq.

December 18th.—Robert Chambers, Esq., Edinburgh ; James Simpson, Esq., Chelsea Waterworks ; William Lewellyn, Esq., Mining Engineer, Pontypool ; and James Bandinel, Esq., Little Cloisters, Westminster.

The following Persons were elected Foreign Members.

March 20th.—M. Edouard de Verneuil, Vice-President of the Geological Society of France.

May 29th.—Prof. William Burton Rogers, Virginia; and Prof. Henry Darwin Rogers, Pennsylvania.

The following Donations to the Museum have been received since the last Anniversary.

British and Irish Specimens.

Specimen of *Asaphus Powisii* from Pwllheli, Caernarvonshire; presented by Samuel Holland, Jun., Esq.

Fossils from the Lower Greensand at Peasemarsh, near Guildford, Surrey; presented by Robert C. Austen, Esq., Sec. G.S.

Hippurite and specimens of *Beryx radians* from the Chalk of Kent; presented by E. H. Bunbury, Esq., F.G.S.

A collection of Palatal and other remains of Fish from the Carboniferous Limestone of Armagh; presented by Captain Jones, R.N., M.P., F.G.S.

Fossils from the Lower Greensand at Atherfield, Isle of Wight; presented by Captain Ibbetson, F.G.S., and Prof. Forbes, F.G.S.

Fossils from the Wenlock Limestone and London Clay; presented by Mr. James Tennant, F.G.S.

Specimen of *Pholadomya gigantea* from the Lower Greensand; pre- by — Hills, Esq.

Fossils from the Lias of Deddington, Oxfordshire; presented by C. Faulkner, Esq., F.G.S.

Specimen of *Unio Valdensis* (Mantell) from the Wealden of Brook Point, Isle of Wight; presented by Mr. Shipp.

Terebratulæ from the Chalk and Gault of Cambridgeshire; presented by the Rev. Thomas Image, F.G.S.

Specimens of several species of *Astarte* from the Pliocene at Bridlington; presented by E. Charlesworth, Esq., F.G.S.

Silurian Fossils from the Western flank of the Malverns; presented by A. Majendie, Esq., F.G.S.

Crustaceans and *Nautili* from the London Clay, Isle of Sheppey; presented by Miss White of Swanscombe.

Specimens from the London Clay, Chalk and Wealden; presented by Mrs. Smith of Tunbridge Wells.

Nautilus from the London Clay; presented by Dr. Way.

Specimens of *Lepidodendron* from the South Staffordshire Coal-field; presented by M. Dawes, Esq., F.G.S.

Chalk with Fossils from Trimmingham, Norfolk; presented by Miss Gurney, of North Repps.

Spongeous Flint from the Chalk; presented by Mr. H. Ball.

Fossils from the Kentish Rag, Maidstone; presented by Mr. W. H. Bensted.

Bones of *Palæotherium* and *Chelonia* from Hordle and Barton; presented by Thomas Falconer, Esq., F.G.S.

Fossils from the Lower Greensand, Faringdon, Berks., and an *Am-*

monite from the Red Chalk, Hunstanton; presented by Henry Stone, Esq.

Foreign Specimens.

Fossils from Egypt and Malta; presented by the Earl of Enniskillen, F.G.S. and Sir P. Egerton, Bart., M.P.

Fossils from the Freshwater Tertiaries of Asia Minor; presented by Lieut. Spratt, R.N., F.G.S., and Prof. E. Forbes, F.G.S.

Fossils from Malta; presented by Lieut. Spratt, R.N., F.G.S.

Collections of Miocene Tertiary Fossils from the neighbourhood of Lisbon and Gibraltar; Shells from the raised deposit (post-pliocene), Gibraltar; Tertiary Fossils from Bordeaux, Madeira and Porto Santo; and Secondary Fossils from Lisbon and Gibraltar; presented by James Smith, Esq. of Jordan Hill, F.G.S.

Specimens of *Terebratula gracilis*, from the Baltic Chalk; presented by J. W. Flower, Esq.

Fossils from Lebanon; presented by Captain Graves, R.N.

MISCELLANEOUS.

A series of Casts of the Bones of the Dinornis of New Zealand; presented by the Royal College of Surgeons.

Cast of the Vertebræ of a Saurian from the River Volga near Simbirsk; presented by R. I. Murchison, Esq., F.G.S.

Electrotypes of two Crustaceans from the Coal-measures; presented by Dr. Ick, F.G.S.

CHARTS AND MAPS.

Ordnance Townland Survey of the Counties of Dublin, 30 sheets; and of Limerick, 62 sheets; presented by Col. Colby, by direction of the Lord Lieutenant of Ireland.

The Charts, &c. published by direction of the Lords Commissioners of the Admiralty during the year 1843; presented by Capt. Beaufort, R.N., by direction of the Lords Commissioners of the Admiralty.

Sheets 88 and 89 of the Ordnance Map, in continuation of the Trigonometrical Survey of Great Britain; presented by the Master-General and Board of Ordnance.

Pilote Française, 6me partie; presented by the Director-General of the Depôt de la Marine of France.

Carte Géologique de la chaine du Tatra et des Soulèvemens parallèles; presented by Prof. L. Zeisznera.

Geological Chart by Thomas Austin; presented by the Author.

Section XX. of the Geological Map of Saxony; presented by the Council of Mines of Freyberg.

Carte spéciale des chemins de Fer Belges, 1843, and Plan de chemin de Fer compris entre Liège et Aix-la-Chapelle, 1843; presented by M. Ph. Vandermaelen, F.G.S.

Vues et Coupes du Cap de la Hève, by M. C. A. Lesueur; presented by the Author.

Three Maps of Asia Minor and three of Australia; presented by H. Warburton, Esq., M.P., Pres. G.S.

The following List contains the Names of all the Persons and Public Bodies from whom Donations to the Library and Museum were received during the past year.

Academy of Sciences of Paris.
Admiralty, The Right Hon. the Lords Commissioners of the.
American Philosophical Society held at Philadelphia.
Ansted, Prof. D. T., F.G.S.
Athenæum, Editor of the.
Austen, R. A. C., Esq., Sec. G.S.
Austin, Thomas, Jun., Esq.

Ball, Henry, Esq.
Beaudouin, M. Jules.
Bensted, Mr. W. H.
Bombay Branch of the Royal Asiatic Society.
Boston Society of Natural History.
British Association for the Advancement of Science.
Browne, Peter A., LL.D.
Buckland, Rev. Prof., D.D., F.G.S.
Bunbury, E. H., Esq., F.G.S.
Burmeister, Hermann, Dr.

Calcutta Journal, Editors of the.
Calderini, C. G.
Charlesworth, E., Esq., F.G.S.
Chemical Society of London.
Chevalier, M. M. E.

Dana, J. D., Esq.
Darwin, C., M.A., V.P.G.S.
Daubeny, Prof., M.D., F.G.S.
Dawes, M., Esq., F.G.S.
De Garay, Don José.
Dépôt Général de la Marine de France.
Desor, M. E.
D'Hombres-Firmas, M. le Baron.

Egerton, Sir P., Bart., M.P.
Enniskillen, Earl of, F.G.S.

Falconer, Thomas, Esq., F.G.S.
Faulkner, C., Esq.
Featherstonhaugh, G. W., Esq., F.G.S.
Flower, J. W., Esq.
Flügel, Dr. T. G.
Forbes, Prof. E., F.G.S.
Franklin, Sir J., K.C.H., F.G.S.
Freyberg, Council of Mines of.

Geneva, Nat. Hist. Society of.
Geological Society of Dublin.
Geological Society of France.
Göppert, Herr R.
Graham, Sir James, Bart., M.P.
Graves, Captain, R.N.
Gregory, W., M.D.
Griffith, R., Esq., F.G.S.
Gurney, Miss.

Haarlem Société Hollandaise des Sciences.
Hausmann, Prof. J. F. L., For. Mem. G.S.
Hawkins, Thomas, Esq., F.G.S.
Herschel, Sir J. F. W., Bart., F.G.S.
Hills, — Esq.
Hœninghaus, Herr F. W.
Holland, Samuel, Esq.
Hopkins, Evan, Esq., F.G.S.
Hutton, R., Esq., F.G.S.

Ibbetson, L. L. B., Esq., F.G.S.
Ick, Dr., F.G.S.
Image, Rev. Thomas, F.G.S.
Johnston, Prof. J. F. W., F.G.S.
Jones, Capt. R.N., M.P., F.G.S.

Kœnig, Charles, Esq.
Koninck, M. L. de.

Lea, Henry C.
Leeds Philosophical Society.
Lesueur, M. C. A.
Lille, Société Royal de.
Linnæan Society of London.

Majendie, A., Esq., F.G.S.
Morton, S. G., M.D.
Murchison, R. I., Esq., F.G.S.
Museum of Natural History of Paris.

Nattali, Mr. M. A.
Newman, Edward, Esq.
Nicholson, Dr. Charles, F.G.S.
Nicol, James, Esq.
Nyst, M. P. H.

Ordnance, Master-General and Board of.

Parish, Sir W., K.C.H., F.G.S.
Philadelphia Academy of Natural Science.
Porta, Signor Leonardo.
Pratt, S. P., Esq., F.G.S.

Raulin, M. Victor.
Rees, G. O., M.D., F.G.S.
Reeve, Mr. Lovell.
Royal Academy of Berlin.
Royal Academy of Brussels.
Royal Academy of Naples.
Royal Agricultural Society of England.
Royal Asiatic Society.
Royal Geographical Society.
Royal Geological Society of Cornwall.
Royal Irish Academy.
Royal Polytechnic Society of Cornwall.
Royal Society of Copenhagen.
Royal Society of Edinburgh.
Royal Society of London.

St. Petersburgh Mineralogical Society.
Scheerer, Dr. Thomas.
Shipp, Mr.
Silliman, Prof., M.D., For. Mem. G.S.
Simms, F. W., Esq., F.G.S.
Smith, Mrs.
Smith, James, Esq., F.G.S.
Society of Arts.
Sopwith, Thomas, Esq., F.G.S.
Spratt, Lieut. T. A. B., R.N., F.G.S.
Stone, Henry, Esq.

Taylor, Richard, Esq., F.G.S.
Tcheffkine, General.
Tennant, Mr. J.
Tilley, Prof. T. G.

Vandermaelen, M. Ph., F.G.S.

Warburton, H., Esq., M.P., Pres. G.S.
Watson, Rev. J. S.
Way, Dr.
White, Miss.
Wiley and Putnam, Messrs.

Zeisznera, M. L.
Zoological Society.

List of Papers *read since the last Annual Meeting, February* 16*th*, 1844.

Feb. 21st.—Some Remarks on the White Limestone of Corfu and Vido, by Captain Portlock, R.E., F.G.S.

——— Some Account of the Strata observed in the course of the Blechingley Tunnel, by F. W. Simms, Esq., F.G.S.

——— Remarks upon Sternbergiæ, by John S. Dawes, Esq., F.G.S.

——— On the *Thalassina antiqua*, a Fossil Crustacean from New Holland, by Thomas Bell, Esq., Professor of Zoology, King's College, London, F.G.S.

March 6th.—On the genus *Creseis*, by E. Forbes, Esq., Professor of Botany, King's College, London, F.G.S.

——————— On the Geology of North Wales, by Daniel Sharpe, Esq., F.G.S.

March 20th.—Report on a collection of Tertiary Fossils from Malta and Goso, by E. Forbes, Esq., Professor of Botany, King's College, London, F.G.S.

——————— Extract from a Letter to Rev. Prof. Buckland, D.D., F.G.S., by W. C. Trevelyan, Esq., F.G.S., on some fractured Boulders found at Auchmithie, near Arbroath.

——————— On the origin of the Gypseous and Saliferous Marls of the New Red Sandstone, by the Rev. W. D. Williams, F.G.S.

April 3rd.—On the occurrence of Fossils in the Boulder Clay, by Robert Harkness, Esq.

——————— On the traces of the action of Glaciers at Porth-Treeddyn, in Caermarthenshire, by Robert W. Byres, Esq.

——————— On the existence of Fluoric Acid in recent Bones, by G. Owen Rees, M.D., F.G.S.

April 17th.—On the Geology of the Southern part of the Gulf of Smyrna and the Promontory of Karabournoo, by Lieut. T. A. B. Spratt, R.N., F.G.S.

——————— On the Fossils collected by Lieut. Spratt in the Freshwater Tertiary Formation of the Gulf of Smyrna, by E. Forbes, Esq., Professor of Botany, King's College, London, F.G.S.

——————— On the remains of Fishes found by Mr. Kaye and Mr. Cunliffe in the Pondicherry Beds, by Sir P. Egerton, Bart., M.P., F.G.S.

——————— On the occurrence of a bed of Septaria, containing Freshwater Shells in the series of Plastic Clay at New Cross, Kent, by H. Warburton, Esq., M.P., P.G.S.

May 1st.—Report on the Fossils from Santa Fe de Bogota, presented to the Society by Evan Hopkins, Esq., F.G.S., by E. Forbes, Esq., Professor of Botany, King's College, London, F.G.S.

——————— Comparative Remarks on the Sections near Hythe and Atherfield, by W. H. Fitton, M.D., F.G.S

May 1st and February 5th, 1845.—Letter from F. W. Simms, Esq., F.G.S., to Henry Warburton, Esq., President, on the junction of the Lower Greensand and Wealden at the Teston Cutting.

——————— On the Section between Black Gang Chine and Atherfield Point, by L. L. B. Ibbetson, Esq., F.G.S., and E. Forbes, Esq., Professor of Botany, King's College, London, F.G.S.

——————— Description of the Mouth of the Hybodus, found by L. L. B. Ibbetson, Esq., in the Isle of Wight, by Sir P. G. Egerton, Bart., M.P., F.G.S.

——————— Extract from a Letter addressed to L. L. B. Ibbetson, Esq., by M. Dubois de Montpereux, on the Neocomian formation.

May 15th.—Letter from William Ick, Esq., F.G.S., on some Crustacean Remains in Carboniferous Rocks.

——————— On the Anthracite Formations of Massachusetts, by Charles Lyell, Esq., F.G.S.

May 15th.—On the Geology of Cape Breton, by Richard Brown, Esq.

May 29th.—Continuation of the Memoir on the Geology of North Wales, by the Rev. A. Sedgwick, M.A., Woodwardian Professor in the University of Cambridge, F.G.S.

June 12th.—On Fluorine in Bones, its sources and its application to the ascertainment of Geological time, by J. Middleton, Esq., F.G.S.

——— Letter from Mr. Jeffreys to Dr. Buckland on a raised beach at Loch Carron.

——— On the Cliffs of Northern Drift on the coast of Norfolk, between Weybourne and Happisburgh, by J. Trimmer, Esq., F.G.S.

June 26th.—On the Stonesfield Slate of the Cottswold Hills, by James Buckman, Esq., F.G.S.

——— On a Fossil Ray from Lebanon, and on Fossil Fish from the Oxford Clay, by Sir P. G. Egerton, Bart., M.P., F.G.S.

——— On certain bodies found in Ammonites, by H. E. Strickland, Esq., F.G.S.

November 6th.—On the Geology of Tuscany, by William John Hamilton, Esq., M.P., Sec. G.S.

November 20th.—On the Geology of Gibraltar, by James Smith, Esq., of Jordan Hill, F.G.S.

December 4.—Extract from a Letter from John Brown, Esq., F.G.S., to the President, on a Bed of Marine Shells in the Valley of the Colne near Colchester.

——— Remarks on the Geology of British Guiana, by the Chevalier Robert H. Schomburgk, Ph.D.

——— Letter from W. C. Trevelyan, Esq., F.G.S., to the Rev. Prof. Buckland, D.D., F.G.S., on Glacial marks in Wales.

December 18th.—On the Pipes or Sand-galls in the Chalk and Chalk-rubble of Norfolk, by Joshua Trimmer, Esq., F.G.S.

——— Some Remarks on a Boar's Head discovered in the Island of Portland, by the Rev. W. Buckland, D.D., Professor of Mineralogy and Geology in the University of Oxford, F.G.S.

January 8th.—On the Geology of the Eastern Frontier of the Colony of the Cape of Good Hope, by Andrew Geddes Bain, Esq.

——— Description of the Fossil Skulls of three species of an extinct genus of Reptilia (Dicynodon), discovered by A. G. Bain, Esq., in the Sandstone Rocks, Algoa Bay, by Richard Owen, Esq., Hunterian Professor of Anatomy in the Royal College of Surgeons, F.G.S.

January 22nd.—On the Newer Coal Formation of the Eastern part of Nova Scotia, by J. W. Dawson, Esq.

——— On the Geological features of the Country round the Mines of the Taurus in the Pashalic of Diarbekr, by W. W. Smyth, Esq., A.B.

February 5th.—On certain Raised Beaches, and the Shells found in them, occurring in the Coast of Essex, near Walton, by J. Brown, Esq., F.G.S.

February 5th.—On the Geology of the vicinity of the Wollondilly River in Argyle County in the Colony of Sydney, New South Wales, by the Rev. W. B. Clarke, M.A., F.G.S.

After the Reports had been read, it was resolved,—

That they be received and entered on the Minutes of the Meeting; and that such parts of them as the Council shall think fit, be printed and distributed among the Fellows.

It was afterwards resolved :—

1. That the thanks of this Society be given to Henry Warburton, Esq., M.P., retiring from the office of President.

2. That the thanks of this Society be given to Lord Francis Egerton, Charles Darwin, Esq., G. B. Greenough, Esq., and John Taylor, Esq., retiring from the office of Vice-President.

3. That the thanks of this Society be given to R. A. C. Austen, Esq., retiring from the office of Secretary.

4. That the thanks of this Society be given to Lord Francis Egerton, Sir J. A. B. Johnstone, Bart., Prof. Bell, E. H. Bunbury, Esq., and John Taylor, Esq., retiring from the Council.

After the Balloting Glasses had been duly closed, and the lists examined by the Scrutineers, the following gentlemen were declared to have been duly elected the Officers and Council for the ensuing year :—

OFFICERS.

PRESIDENT.

Leonard Horner, Esq. F.R.S. L. & E.

VICE-PRESIDENTS.

Rev. W. Buckland, D.D. F.R.S., L.S., Professor of Geology and Mineralogy in the University of Oxford.
Robert Hutton, Esq. M.R.I.A.
R. I. Murchison, Esq. F.R.S. L.S.
Prof. Owen, F.R.S. L.S.

SECRETARY.

William John Hamilton, Esq. M.P.

FOREIGN SECRETARY.

Sir H. T. De la Beche, F.R.S. and L.S.

TREASURER.

John Lewis Prevost, Esq.

COUNCIL.

Robert A. C. Austen, Esq.
Charles Darwin, Esq. F.R.S.
Sir P. Grey Egerton, Bart. M.P. F.R.S.
Lieut.-Col. Everest, F.R.S.
Hugh Falconer, M.D. F.L.S.
W. H. Fitton, M.D. F.R.S. L.S.
Prof. E. Forbes, F.R.S.
J. H. Green, Esq. F.R.S.
G. B. Greenough, Esq. F.R.S. L.S.
Charles Lyell, jun. Esq. F.R.S. L.S.
Marquess of Northampton, Pres. R.S.
S. P. Pratt, Esq. F.R.S. L.S.
Lieut.-Col. Sabine, R.A. F.R.S.
Rev. Adam Sedgwick, F.R.S., Woodwardian Professor in the University of Cambridge.
Henry Warburton, Esq. M.P. F.R.S.

VICE-SECRETARY.

Prof. D. T. Ansted, F.R.S.

Valuation *of the Society's Property; 31st December* 1844.

Property.

				£.	s.	d.
Balances in hand, including 31*l.* 11*s.* 6*d.* Wollaston Fund and 3*l.* 5*s.* Geological Map				309	3	4
Arrears due to the Society :	£.	s.	d.			
Admission Fees	56	14	0			
Annual Contributions	163	16	0			
				220	10	0
Estimated value of unsold Transactions				1270	5	9
Estimated value of unsold Proceedings				40	0	0
Value of Funded Property, 2896*l.* 11*s.* 3*d.* Consols at 100				2896	11	3
				£4736	10	4

Debts.

	£.	s.	d.
Cash belonging to "Wollaston Fund"	31	11	6
Cash belonging to Map Account	3	5	0
Arrears not likely to be received	150	0	0
	184	16	6
Balance in favour of the Society	4551	13	10
	£4736	10	4

[*N.B. The value of the Collections, Library and Furniture is not here included: nor is the "Donation Fund," instituted by the late Dr. Wollaston, amounting at present to 1084l. 1s. 1d. in the Reduced 3 per cent. Annuities; the dividends thereof being appropriated to the purposes of the Founder.*]

Signed, J. L. PREVOST, Treasurer.

Jan. 24, 1845.

Sums actually Received and Expended

RECEIPTS.

Balances in hand, January 1, 1844.						
	£.	s.	d.	£.	s.	d.
Banker, including 31*l.* 11*s.* 6*d.* Wollaston Fund and 36*l.* 1*s.* Map Account	184	8	8			
Accountant, to meet current expenses	40	0	0			
				224	8	8
Arrears:	£.	s.	d.			
Admission Fees	16	16	0			
Annual Contributions	12	12	0			
				29	8	0
Ordinary Income:	£.	s.	d.			
Annual Contributions	696	13	6			
Admission Fees: £. s. d.						
Residents (8) 50 8 0						
Non-Residents (14).. 147 0 0						
	197	8	0			
				894	1	6
Compositions, two at 31*l.* 10*s.*				63	0	0
Legacy, Thos. Botfield, Esq.				31	10	0
	£.	s.	d.			
Transactions (sold)	96	2	6			
Proceedings (sold)	12	4	0			
				108	6	6
	£.	s.	d.			
Subscriptions to Session 1843–44 (Proceedings)	23	10	0			
Balance of Cheque for 25*l.* to repay same	0	14	3			
				24	4	3
Geological Map				34	10	0
Wollaston Donation Fund, 12 months' Interest on 1084*l.* 1*s.* 1*d.* Reduced 3 per cents.				31	11	6
Dividends:	£.	s.	d.			
Six months on 2706*l.* 19*s.* 1*d.* Consols	39	8	5			
,, ,, on 2739*l.* 5*s.* 2*d.* ,,	39	17	10			
				79	6	3
				£1520	6	8

We have compared the Books and Vouchers presented to us with these Statements, and find them correct.

Signed, W. J. BRODERIP, R. HUTTON, } AUDITORS.

Jan. 24, 1845.

during the year ending December 31, 1844.

PAYMENTS.

	£.	s.	d.	£.	s.	d.
Bills outstanding:						
Scientific Expenditure	2	18	0			
House Expenses	0	14	9			
Transactions	0	7	0			
Proceedings	38	15	3			
				42	15	0
General Expenditure:	£.	s.	d.			
Repairs of House	10	13	5			
House Expenses	105	14	10			
Taxes, Assessed	35	11	4			
Household Furniture	17	2	11			
Household Linen	4	18	6			
				174	1	0
Insurance				9	0	0
Salaries and Wages:	£.	s.	d.			
Curator	150	0	0			
Sub-Curator	112	10	0			
Clerk	100	0	0			
Porter	80	0	0			
Servant	33	4	0			
Collector	23	15	6			
				499	9	6
Scientific Expenditure				48	7	0
Tea for Meetings				36	1	7
Stationery and Miscellaneous Printing				36	2	7
Contribution repaid				3	3	0
Investment in Consols				220	10	0
Cost of Publications:	£.	s.	d.			
Transactions	4	3	8			
Proceedings	13	12	6			
				17	16	2
Subscriptions to Session 1843–44 repaid (including money orders and bal. of cheque)				25	0	0
Geological Map				67	6	0
Award of Wollaston Donation Fund:	£.	s.	d.			
Rev. W. D. Conybeare, Gold Medal	10	10	0			
W. Lonsdale, Esq.	21	1	6			
				31	11	6
Balances in hand, December 31, 1844:	£.	s.	d.			
Banker, including 31*l.* 11*s.* 6*d.* Wollaston Fund and 3*l.* 5*s.* Map Account	269	3	4			
Accountant, to meet current expenses	40	0	0			
				309	3	4
				£1520	6	8

Estimates *for the ensuing year* 1845.

INCOME EXPECTED.

	£.	s.	d.	£.	s.	d.
Arrears due to the Society, Dec. 31st, 1844. (See Valuation-sheet)				220	10	0
Ordinary Income for 1845 estimated:						
Annual Contributions (220 Fellows)				693	0	0
Admission Fees:						
Residents (8)	50	8	0			
Non-residents (14)	147	0	0			
				197	8	0
Compositions (2)				63	0	0
Sale of Transactions and Proceedings				50	0	0
Dividends on "Wollaston Donation Fund"				31	11	6
Ditto on 12 months' Consols, 2896*l.* 11*s.* 3*d.*				84	7	2
				£1339	16	8

Signed, J. L. PREVOST, Treasurer.

Jan. 24, 1845.

EXPENDITURE ESTIMATED.

	£.	s.	d.	£.	s.	d.
General Expenditure:						
Repairs of House	20	0	0			
Taxes	35	11	4			
Insurance	9	0	0			
House Expenses	110	0	0			
Household Furniture and Linen	25	0	0			
				199	11	4
Salaries and Wages:						
Curator	150	0	0			
Sub-Curator	125	0	0			
Clerk	100	0	0			
Porter and Housekeeper	80	0	0			
Servant	33	4	0			
Collector's Poundage	25	0	0			
				513	4	0
Scientific Expenditure				60	0	0
Stationery and Miscellaneous Printing				50	0	0
Tea for Meetings				40	0	0
Cost of Transactions and Proceedings, and Maintenance and Preservation of Library and Maps				275	0	0
Arrears not likely to be received				150	0	0
Employment of the "Wollaston Fund"				31	11	6
				1319	6	10
Balance in favour of the Society				20	9	10
				£1339	16	8

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY OF LONDON.

Vol. IV. Part III. 1845. No. 104.

February 26. 1845.

John Fowler, Esq. C. E., of Stockton-on-Tees, was elected a Fellow of this Society.

The following communications were read:—

1. *On the Miocene Tertiary Strata of* Maryland, Virginia, *and* North *and* South Carolina. By Charles Lyell, Esq., M.A., F.R.S., &c.

Between the hilly country of the United States and the Atlantic there intervenes a low and nearly level region, occupied principally by beds of marl, clay, and sand of the cretaceous and tertiary formations. Maclure, in 1817, in his "Geology of the United States," laid down, with no small approach to accuracy, on a coloured map, the general limits of this great plain, and of the granitic district lying immediately to the westward. He also pointed out, that at the junction of these great geological regions almost all the great rivers descend suddenly by falls or rapids of moderate height, as the Delaware at Trenton, the Schuylkill near Philadelphia, the Potomac near Washington, the James River at Richmond, Virginia, the Savannah at Augusta in Georgia, and many others. At these points, therefore, the navigation is stopped, and a great many large cities have sprung up; so that the line which marks the western boundary of the tertiary, and the eastern of the granitic region, is at the same time one of peculiar geological, geographical, and political interest.

The general elevation of the great plain does not exceed a hundred feet, although it is sometimes considerably higher. Its width in the middle and southern States is very commonly from 100 to 150 miles. The tide, except in the more southern States, flows entirely across it, and the rivers intersecting it form large estuaries, which may have been due to the facility with which the incoherent materials of the cliffs were undermined and swept away, a process of waste still going on.

Throughout the greater part of the Atlantic plain, the cretaceous rocks, if present, are concealed by the overlying tertiary deposits, which consist chiefly of Miocene strata, extending from Delaware Bay to the Cape Fear River, and occupying portions of Delaware, Maryland, Virginia, and N. Carolina, an area about 400 miles long from north to south, and varying in breadth from 10 to 70 miles. There are, besides, some patches of the miocene formation in South Carolina and Georgia, where the Eocene, or older tertiary deposits, predominate almost exclusively, and where the limits of the miocene deposits have not yet been well ascertained.

I have endeavoured to show, in a former paper, read to the Society in February, 1843 *, that the fossils of Martha's Vineyard, an island off the coast of Massachusetts, especially the teeth of sharks, point to a near chronological connexion between the strata of that island and the miocene strata of Europe; but the evidence is far more complete and satisfactory in favour of a similarity of age between the deposits about to be described, which occur 350 miles to the south, or in Maryland and Virginia. In the last-mentioned States these formations extend over a wide area, and have been well described by Mr. Conrad, who identified them in age with the English crag, and called them "medial pliocene," and by Professors W. B. and H. D. Rogers, in their article in the Philos. Trans. of Philadelphia for 1836. These authors considered them entitled to the appellation of Miocene, as containing a proportion of recent shells corresponding to that known to characterise the miocene deposits of Europe.

The principal grounds which induce me to agree in this opinion, and to regard the beds of sand, clay, and marl now under consideration as corresponding in geological age with the crag of Suffolk, the faluns of the Loire, and other contemporaneous formations in Europe, are the following: —

First. On the banks of the James River and elsewhere I saw them resting on eocene deposits, or on sand and clay containing an assemblage of shells resembling those of the London and Paris basins.

2dly. The genera of shells, and the amount of species by which they are represented, agree for the most part with those which characterise the European miocene beds. Many of the most abundant species are allied, and some few are identical.

* Proceed. of Geol. Soc., vol. iv. p. 31.

3dly. The proportion of fossil shells identified with recent species amounts to about 17 per cent, or about one-sixth of the whole, in 147 species collected by me, the recent species agreeing almost entirely with those now living in the neighbouring parts of the Atlantic.

4thly. There is the same mixture of shells of northern and southern forms as in the French faluns.

5thly. Of ten species of corals, all but one agree generically with those of the miocene beds of Europe, and two at least specifically. One of these is a *Lunulite*, the same as a fossil from the Suffolk crag and also from the faluns of Touraine; a second, *Anthophyllum lineatum*, is also common in the French faluns.

6thly. Among the remains of fish are several of the shark family, agreeing with species from the miocene beds of Europe, the faluns of Touraine, the molasse of Switzerland, and the tertiary formation of Malta, among which I may mention *Carcharias megalodon*, *C. productus*, *Lamna xiphodon*, *L. hastalis*, *L. cuspidata*. The ossicles also of the ears of fishes closely resemble those occurring in the Suffolk crag.

7thly. The absence of reptiles is another point of analogy, as also the presence of huge cetaceous remains.

The miocene deposits of the United States consist chiefly of incoherent sand and clay, and in this respect bear a strong resemblance to those of the same age in Europe. The associated siliceous sand imparts a sterile character to the space they occupy, but the soil has often been fertilised by the use of shell marl, derived by the agriculturist from parts of the same formation, a practice which Mr. Ruffin, of Petersburg, Virginia, editor of the Farmer's Register, has done much to promote. This use of the miocene marl and fossil shells affords another singular point of coincidence between the American strata, the English crag, and the faluns of the Loire, all of which furnish the same fertilising calcareous materials for improving light soils.

I began my examination of these middle tertiary deposits in the suburbs of Richmond, Virginia, where I saw in Shockoe Creek red clay and sand, from which I obtained *Artemis acetabulum*, and casts of miocene species of *Astarte* and *Mactra*, reposing on eocene marls with characteristic shells. Between the two formations, a remarkable bed of whitish and yellowish siliceous clay intervenes, from twelve to twenty-five feet thick, of an extremely fine texture. It affords a very sterile soil, and its course through the country is marked on the surface by a band of meagre vegetation, without trees or shrubs. It has been described by Professor Wm. Rogers, in his State Report on the Geology of Virginia for 1840. When examined under the microscope, it is found to consist of an impalpable siliceous powder, derived from the cases of minute animalcules. Dr. Bailey has shown that the siliceous skeletons belong to several species of *Navicula*, *Gaillonella*, *Actinocyclas*, and other genera. The position of the infusorial earth, the bed being perfectly conformable to the miocene strata above, and the eocene below, is not decisive of its age; but I understand that the species are considered by Messrs. Tuomey, W. B. Rogers, and Bailey, as implying that it belongs to the miocene formation; and Dr. Mantell, who has examined them, informs me that many of them belong to living species.

On the right bank of the James River, at City Point, Virginia, about twenty miles below Richmond, in a cliff about thirty feet high, I observed the yellow and white miocene sands resting on dark green earth and marl of the eocene formation, just as the yellow sands of the crag rest on the blue London clay in some parts of the coast of Suffolk and Essex. Several miles below City Point, the overlying sandy deposit contains a bed of shelly marl, sometimes fifteen feet thick, as at Evergreen. Here I was much struck with the profusion of an *Astarte* (*A. undulata* Conrad), which resembles very closely, and may possibly be merely a variety of, one of the commonest and most characteristic fossils of the Suffolk crag, *A. bipartita*. The other shells also, of the genera *Natica*, *Fissurella*, *Artemis*, *Lucina*, *Chama*, *Pectunculus*, and *Pecten*, reminded me of shells of our crag and the French faluns, although the species are almost all distinct. The large *Venus tridacnoides*, however, is very peculiar, and the *Perna maxillata* is unlike any Suffolk or Touraine fossil, though closely allied to a miocene shell of the Mayence basin on the Rhine. A single coral is found plentifully at Evergreen, resembling an Astrea, and called by Mr. Lonsdale *Columnaria* (?) *sex-radiata*. It differs from the genus *Astrea*, as defined by Ehrenberg, in the stars not being subdivided. Large flattened masses of this coral, upwards of two feet wide, were lying on the beach, washed out of the marl. The teeth of sharks in the banks of the James River agree, some of them specifically, with those of the European miocene beds, and several cetaceous bones, analogous to fossils of the Suffolk crag and Touraine faluns, are frequently met with.

On the right bank or southern coast of the river, about a mile and a half south-west of Coggin's Point, a bluish green marl occurs, about sixteen feet thick and not stratified, in which, assisted by Mr. Ruffin, jun., I gathered in a short time more than thirty species of shells, beautifully preserved, of the genera before mentioned, as also *Oliva*, *Turritella*, *Teredo*, *Dentalium*, *Crassatella*, *Corbula*, *Panopæa*, *Cyprina*, *Tellina*, *Cardita*, *Ostrea*, and *Balanus*. The *Lucina divaricata*, precisely like that of Touraine, or the living West Indian variety, was not rare. This deposit was covered by a bed of reddish clay about six feet thick, without fossils. In many places a remarkable variety of bright green marl, somewhat of the colour of chlorite, alternates in this region with the yellow sand and white shelly marls, which more commonly characterise the miocene deposit.

Passing to the other side, or northern shore, of the estuary of the James River, I observed at the Grove Landing, near the old deserted village of Jamestown, and seven miles south of Williamsburg, Virginia, a range of cliff about forty feet high, in which greenish and yellowish sandy marls of the miocene formation are well exposed. At the top of the cliff is a bed of red earth, without fossils, about ten feet thick. Below this is a layer of shells almost entirely composed of *Chama congregata*, both valves in each individual being usually found united. Below is a mass of shells about twelve feet thick, consisting almost entirely of the genus *Pecten*, but associated with others, of which the *Astarte undulata* before mentioned is the most abundant. The Pectens are closely packed together, with only a slight quantity of accompanying earth. A geologist who should merely collect the shells which have fallen in great numbers on the beach would imagine that bivalves preponderate, to the exclusion of univalves, which, however, is not the case. The univalves are more readily destroyed by frost, rain, and the sun, and have therefore disappeared after exposure, but on digging into a fresh stratum, I met with shells of the genera *Conus*, *Oliva*, *Marginella*, *Fusus*, *Pyrula*, *Murex*, *Natica*, and others. I found no admixture of freshwater or land shells here or in any other locality.

At Burwell's Mill, near Williamsburg, I found a bed of marl about twelve feet thick, very rich in shells, so that I collected there more than seventy species, besides seven species of corals, mingled confusedly with the shells, in which last there appeared to be no order of arrangement, except that in one part, near the top, the *Chama congregata*, accompanied with a *Fissurella*, and a few others, predominated greatly. Among other signs of the slow accumulation of this mass of sandy marl and shells, I may mention that full-grown barnacles and corals are attached to several of the Pectens and other large shells. About one in five of the species of mollusca procured from this marl pit are not distinguishable from those now living in the neighbouring sea.

That remarkable variety of miocene marl which is of a bluish green colour, and which I have mentioned as occurring near Coggin's Point, is well exhibited in a valley near the town of Petersburg, Virginia, where it is used for fertilising the land. It rests on eocene strata, also containing green earth, but of a darker colour. The blue miocene marl is about sixteen feet thick, rich in shells, and is covered by yellow sand, and mottled red and grey clay, about fifty feet thick, with many other sandy strata still higher in the series, which may be observed near the summits of the hills bordering the valley.

All the miocene strata of the James River are horizontal, but the upper surface has been denuded very unevenly, and often with a deeply indented outline, after which the whole country has been reduced to one level by the deposition of an incumbent mass, consisting chiefly of red clay. The great width of estuaries such as that of the James and other rivers which have narrow channels in the higher and mountainous region, may probably be attributed to the facility with which, on the eastern coast of America, the action of the tides has removed the soft and incoherent tertiary deposit, when the land was gradually emerging from the sea. There is reason to believe, from what we know of the coast of S. Carolina and Georgia, that this emergence was accompanied by oscillations of level, which would greatly facilitate and prolong the period of the denuding operations.

North Carolina.

In the cliffs at Wilmington, North Carolina, resting on a calcareous eocene rock, are seen miocene shelly strata of the ordinary character, in which I collected about thirty species of shells. The recent species bore a larger proportion than usual to the extinct; but this may be owing to the circumstance that two-thirds of the whole consisted of marine bivalves, which is rather a larger proportion than that observed in the fossil miocene fauna, amounting to about 150 species, which I collected in Virginia. I have invariably found that the proportion of marine bivalves identical with the recent, whether in the English crag, the faluns of Touraine, or other tertiary formations, is greater than that of the marine univalves, a result in perfect harmony with the law of geographical distribution of living mollusca pointed out by M. Philippi, who has shown that the range of species in the marine bivalves is far more extensive than in the univalves. In Touraine I found the per-centage of recent species vary in the faluns as much as 10 per cent., and even more, in different places not very remote from each other; but when the number in each locality was considerable (150 species for example), this variation diminished. As, however, it would be very rash to assume that all the miocene deposits of the United States, especially in countries as far apart as Maryland and South Carolina, were of strictly contemporaneous origin, the fossil faunas of each region should be carefully distinguished, and considered separately.

Fossils of the Miocene Strata.

Mollusca. — Mr. Conrad, in his work on the fossils of the tertiary formations of the United States, Philadelphia, 1838, has described and figured many of the miocene shells, but unfortunately his work has never been completed. The same author has given a catalogue of 187 shells of the middle tertiary, or miocene formation, in the Appendix to Dr. Morton's "Organic Remains" of the Cretaceous Group. He has also described and figured some species in Silliman's Journal, vol. xli. p. 344. In his own cabinet, he has shown me more than 200 species of shells belonging to this formation, of which he considered about a sixth part to agree with species now living, and he supposed that a somewhat larger proportion would be identified, were our knowledge of the living mollusca more perfect.

I shall confine myself to remarks on those shells, amounting to 147 species exclusive of Balani, which I collected myself, and which I have carefully compared, with the assistance of Mr. G. B. Sowerby, with the tertiary shells of Europe, and with recent species.

The following table will show the miocene genera above alluded to, and the number of species in each: —

Miocene Mollusca of Virginia and South Carolina.

Marine Univalves (63 *species*).

Marginella	- 3.	Fulgur (Fusus)	- 3.	Turritella	- 5.
Voluta	- 2.	Cerithium	- 1.	Trochus -	- 2.
Oliva -	- 3.	Pleurotoma	- 6.	Margarita	- 1.
Conus -	- 2.	Cancellaria	- 3.	Solarium -	- 1.
Terebra	- 1.	Natica -	- 2.	Calyptræa	- 2.
Buccinum	- 7.	Sigaretus	- 1.	Crepidula	- 2.
Purpura	- 1.	Bulla -	- 2.	Fissurella	- 1.
Typhis	- 1.	Scalaria -	- 1.	Dentalium	- 1.
Fusus	- 7.	Eulima -	- 1.	Ditrupa -	- 1.

Marine Bivalves (84 *species*).

Solen -	- 1.	Mysia -	- 1.	Pectunculus	- 1.
Panopæa	- 2.	Lucina -	- 10.	Nucula -	- 2.
Myodora	- 1.	Sphærella	- 1.	Crenella -	- 1.
Mactra	- 7.	Astarte -	- 10.	Perna -	- 1.
Gnathodon	- 1.	Cytherea	- 1.	Lima -	- 1.
Crassatella	- 2.	Venus -	- 5.	Modiola -	- 1.
Amphidesma	- 5.	Artemis	- 1.	Pecten -	- 5.
Sphænia	- 1.	Isocardia	- 1.	Plicatula -	- 1.
Corbula	- 3.	Cardium	- 1.	Ostrea -	- 3.
Saxicava	- 2.	Chama -	- 1.	Anomia -	- 1.
Petricola	- 1.	Cardita -	- 2.	Orbicula -	- 1.
Tellina	- 2.	Arca -	- 4.		

Of the 147 species above enumerated, I have been able to identify the following 23 with recent species: —

American Miocene Shells identified with Recent Species.

Purpura lapillus Lin. Petersburg, Virginia.
Fusus cinereus Lin. Petersburg, Virginia.
Pyrula (*Fulgur*) *carica* Say. Petersburg, Williamsburg, &c.
P. canaliculata Say. Maryland.
Natica duplicata Say. Petersburg, &c.
N. heros Say. Maryland.
Calyptræa costata. Wilmington, North Carolina. (Syn. *Dispotœa ramosa* Conrad.)
Identical with a recent species which I have from Valparaiso.
Crepidula fornicata Lam. Williamsburg.
Dentalium dentalis. Wilmington.
Ditrupa gadus. Williamsburg, Maryland; and Petersburg, Virginia.

Solen ensis Lin. Williamsburg and Wilmington.
Panopœa Americana. Maryland and Petersburg.
Same as *P. Aldrovandi.*
Mactra lateralis Say. Petersburg.
Same as *M. similis.*
Lucina divaricata Lam. Williamsburg, Maryland; and Petersburg.
Identical with a West Indian variety.
L. anodonta Say. Evergreen, Virginia; and Wilmington, North Carolina.
L. squamosa. Petersburg.
L. contracta Say. Wilmington, North Carolina; and Williamsburg, Maryland.
It appears to be the same as *L. radula.*
Astarte lunulata Con. Williamsburg.
Identical with a recent shell from South Carolina.
Venus mercenaria Lam. Wilmington, North Carolina.
Nucula limatula Say. Petersburg.
N. proxima Say. Williamsburg.
Identical with recent specimens on the coast of Massachusetts.
Modiola glandula Totten. Petersburg.
Identical with a recent specimen from Massachusetts.
Pecten magellanicus Lam. Petersburg.

The above list would give a proportion of about 17 per cent. of recent species, or about one-sixth; but I have no doubt that if we possessed in London larger collections of the shells now inhabiting the American seas, I should be able to prove that a greater number of them agreed with fossils of the miocene strata in the United States. Thus I have not included *Anomia ephippium*, because the specific characters in this genus are so unsatisfactory; and I have not seen the recent shell which Mr. Conrad identifies with *Lucina crenulata;* nor have I been able to identify *Artemis acetabulum*, given as a recent species by Mr. Conrad, which does not agree with *A. concentrica* Lam., nor with the species which inhabits the Pacific coast of South America.

The general resemblance of the American fossils of this era with those of the Suffolk crag and faluns of the Loire was so great, that I was surprised, on a closer comparison, to find that I could only identify 9 species as common to both sides of the Atlantic, and that out of 147 American fossils, I could only find 13 species in the European miocene, which were so closely allied as to be entitled to be regarded as geographical representatives. A great part, therefore, of the analogy consists in the similarity of the genera.

List of Species common to the American and European Miocene Strata.

1. *Fusus rostratus* Dujardin.
Found by me at Burwell's Mill, Williamsburg, Maryland; and agreeing with a common fossil of the faluns of Touraine.
2. *Purpura lapillus* Lin. Petersburg, Virginia.
American variety: probably the same species as *P. crispata* of the red crag, Suffolk, some varieties of which agree with the European *P. lapillus.*
3. *Turritella plebeia* Say. Maryland.
This agrees perfectly with an abundant fossil of the Touraine faluns, to which Dujardin has given the name, incorrectly perhaps, of *T. Linnæa.*

4. *Dentalium costatum.* Min. Con., Williamsburg.
This species agrees most perfectly with that of the Suffolk red and coralline crag. It is called *D. dentalis* by Conrad.
5. *Ditrupa gadus.*
I cannot distinguish this from a shell of the English crag.
6. *Lucina divaricata.* Petersburg, Virginia.
Identical with the Touraine variety.
7. *Lucina contracta* Say.
Seems undistinguishable from the recent *L. radula,* which is also found in the Suffolk crag.
8. *Perna maxillata* Lam.
Mr. Conrad has considered this the same as the fossil which occurs in the Mayence basin, which seems to agree well, though I have not perfect specimens to compare.
9. *Astarte undulata* Say.
I have some specimens of *A. bipartita* from the Suffolk crag, which agree perfectly with the American fossil, except that in the latter the sides of the hinge teeth are much more distinctly grooved. A few only of the English specimens exhibit a faint trace of this grooving. The species named by the Americans *A. vicina, A. arata, A. cuneiformis, A. obruta, A. perplana,* appear all to be varieties of the above species.

Geographical Representatives; or, American Miocene Species closely allied to European Miocene Fossils.

1. *Oliva,* n. sp. Wilmington.
Resembles *O. hispidula,* and may be considered as representing *O. Dufresnii* Bast., of the Touraine faluns.
2. *Voluta mutabilis.* Maryland and Petersburg, Virginia.
Decidedly represents *V. Lamberti* of the English crag and French faluns.
3. *Buccinum trivitatum* Say. Maryland and N. Carolina.
Closely resembles a common Touraine species, which Dujardin has called *B. elegans,* a name which cannot be retained. In the American fossil the outer lip is not thickened, as in that from Touraine.
4. *Cancellaria lunata.* Maryland.
It comes very near to a crag species in Mr. Wood's collection, and is allied to a Bordeaux species given me by M. Deshayes under the name of *C. contorta.*
5. *Trochus Audibarti* Bast. Williamsburg, Maryland.
The American shell is rather more acuminated than that of Bordeaux, but is so near that some may consider it a variety.
6. *Solarium,* new species. Williamsburg.
Nearly allied to *Solariella maculata,* Searles Wood, An. Nat. Hist. 9. t. 5. f. 7. from the coralline crag, Suffolk.
7. *Calyptræa sinensis?* Petersburg, Virginia.
This fossil nearly resembles, if it be not the same as, *C. sinensis,* found in the Suffolk crag.
8. *Panopæa reflexa* Say. Petersburg.
Nearly allied to *P. Faujasii,* crag, Suffolk.
9. *Corbula elevata* Con. Maryland.
Approaches near to the recent *C. nucleus,* a Suffolk crag species.
10. *Tellina lusoria.* Williamsburg.
Nearly allied to *T. donacina,* Suffolk crag.
11. *Astarte lirata* Conrad.
Nearly allied to *A. gracilis,* Coralline crag, Suffolk.
12. *Isocardia rustica.* Maryland.
Allied to *Isocardia cor,* Suffolk crag.
13. *Pecten Jeffersonius.* Petersburg.
Allied to *P. solarium* of the faluns of Touraine.

Miocene Species of Forms peculiar to America.

While the analogy of the American and European miocene shells is so striking, there are also some species of forms quite peculiar to America; *e. g.*:—

1. Oliva idonea.
2. Fusus quadricostatus *Say*.
3. F. sulcatus.
4. F. parilis *Con.*
5. *Pyrula* (Fulgur) *carica* Say.
6. *P. canaliculata* Say.
7. *Calyptræa costata* (C. ramosa *Conrad*).
8. Gnathodon Grayi.
9. Venus Tridacnoides.
10. *V. mercenaria* Lam.
11. *Modiola glandula* Totten.
12. *Pecten magellanicus* Lam.

The six species in italics in the above list are recent, and are confined to the western side of the Atlantic, and these characteristic forms imply that the beginning of the present geographical distribution of mollusca dates back to a period as remote as that of the miocene strata. It will be also seen that several of the 23 miocene shells identified with recent species in the list p. 419-20. are now inhabitants of the American side of the Atlantic.

On the other hand, when we examine the fossil shells of the European miocene strata, we find most of those which are identifiable with living species to belong to the British seas, to the Mediterranean, or to the coast of North Africa, and not to extend to the American side of the Atlantic, a fact which may be illustrated by the following list of species.

European Miocene Shells found living on the Eastern, and not inhabiting the Western, Side of the Atlantic.

	Touraine.	Crag.	Living.
1. Cypræa coccinella - -	+	+	British and Medit.
2. Erato cypreola - - -	+	+	British.
3. Terebra plicaria - - -	+		North Africa.
4. Buccinum mutabile - -	+		Mediterranean.
5. Columbella (Bucc.) Linnei	+		Mediterranean.
6. Cerithium lima - - -	+		Brit. and Mediterranean.
7. Eulima Cambessedesii -	+		Brit. and Mediterranean.
8. Trochus fanulum - -	+		Mediterranean.
9. Trochus striatus - -	+	+	Mediterranean.
10. Siliquaria anguina - -	+		Mediter. and Atlantic.
11. Fissurella neglecta - -	+	+	Mediterranean.
12. Petricola ochroleuca -	+		Mediter. and Ireland.
13. Tellina crassa - - -	+	+	British.
14. Lucina columbella - -	+		North Africa.
15. Arca lactea - - - -	+	+	British.

No one of the above shells is found fossil in the American miocene strata, and this fact strongly confirms the opinion before stated respecting the high antiquity of the separation of the existing molluscous faunæ, which we see may be traced back to a period when about four fifths of the species differed from those now living on the globe. The large *Pyrulæ* of the sub-genus *Fulgur*, and several other forms above enumerated, list, p. 419-20., would enable a conchologist, only acquainted with recent shells, to distinguish a set of American from a set of European miocene fossils. The genera *Pholadomya* and *Gnathodon*, and several others found in the miocene beds of the United States, would also enable the conchologist to recognise the American type.

It is worthy of remark, that the recent shells found in the American miocene beds are not only in about the same proportion to the extinct as is observed in the Suffolk crag or in the faluns of Touraine, but they also agree specifically in most cases with mollusca now inhabiting the neighbouring Atlantic. Now most of the recent miocene species of Touraine agree with species now living on the western coast of France or in the Mediterranean, and those of our crag are identifiable with species living in the British seas. This result appears to me to confirm the accuracy of the conchological determinations, for if any one of those palœontologists who are unwilling to believe that species pass from one geological period to another, should maintain that the living species are so numerous, and often resemble each other so closely, that false identifications may easily have arisen, I reply, that in that case, according to a fair calculation of chances, nine-tenths of the American miocene species said to be *recent* ought to have been identified with exotic species, instead of being found to agree with members of that very limited fauna at present known on the American shores. The same argument is clearly applicable to the identifications which have been made of fossil and recent shells in the European miocene formations. With the exception of one *Calyptræa*, I find no one of the miocene shells which I have identified with recent species to be identical with shells of the Pacific. The analogy is to an Atlantic, not a Pacific fauna.

Among other points of analogy between the miocene fossils on the banks of the James River and those of Touraine, I ought not to omit mentioning the multitude of large shells of the genus *Pecten*, as *P. Jeffersonius* and others, occurring near Williamsburg, (Maryland,) just as the large *Pecten Solarium* occurs in the faluns of the Loire near Doué. Nothing similar is observed in the eocene fossils, whether European or American. The same may be said of the large and conspicuous shells of the genus *Panopæa*, found in our Suffolk crag, and in the American miocene beds, but not in the older tertiary strata.

As it is very rare to meet with any land or freshwater shells in the red and coralline crag of Suffolk, so are they almost unknown as yet in the American strata of the same age. The *Gnathodon*, an estuary shell, has been found in several places, and I met with two odd valves of a *Cyræna*, well preserved in the miocene strata of Petersburg, Virginia. The species is rather larger than *C. consobrina* from the Nile. The *Buccinum quadratum* of Conrad, doubtless a marine shell, might easily be mistaken for a *Melanopsis*.

Even in Touraine, where the bones of mammalia are not uncommon in the marine beds, extremely few land and freshwater shells are met with.

Climate of the Miocene Shells. — Upon the whole, the shells of this formation in Virginia and Maryland resemble those of Touraine and Bordeaux more than the fossils of the Suffolk crag, as we might have expected from their nearer correspondence in latitude. Thus, for example, the genera *Conus, Oliva, Marginella,* and *Crassatella* (represented by large species), with other forms of warmer seas, which are wanting in our crag, are common to the miocene beds of Virginia, Maryland, Touraine, and Bordeaux. Yet when we consider that the shelly deposits on the James River, in the United States, are in the 37th degree of north latitude, while the French faluns are in the 47th, we are surprised to see so great an analogy in those characters by which the climate of a conchological fauna may be inferred. The American shells do not seem to indicate a more southern latitude by 10°, and the same remark applies equally when we compare the most southern beds of North Carolina with those of Bordeaux. We find in all these localities a great admixture of northern forms, as if the isothermal lines in the climate of the miocene period took a curve to the south when drawn from Europe to America, as they do now.

Polyparia. — The fossil corals which I observed in different miocene localities were usually few in number, both in species and individuals, with the exception of the *Columnaria* (?) *sex-radiata,* which resembles an Astrea, and is very conspicuous, from its size, in the shelly marls near the banks of the James River. The scarcity of these zoophytes may be a local accident, depending on the general rarity of calcareous deposits of this age in the United States. The following is a list of ten species collected by me, and described by Mr. Lonsdale.*

	Miocene Species.	Localities.
1.	Columnaria? sex-radiata *Lonsdale*	Evergreen, on James River, Virginia; Petersburg, Virginia.
2.	Anthophyllum lineatum *Lonsdale* (Caryophyllia lineata *Conrad*)	Petersburg and Williamsburg, Virginia.
3.	Astrea hirtolamellata? *Michelin*	Williamsburg.
4.	Heteropora? tortilis *Lonsdale*	Petersburg and Williamsburg, Virginia.
5.	Cellepora informata *Lonsdale*	Petersburg, Virginia.
6.	C. quadrangularis *Lonsdale*	Williamsburg, Evergreen, Virginia.
7.	C. similis *Lonsdale*	Williamsburg, Virginia.
8.	C. umbilicata *Lonsdale*	Williamsburg, Virginia.
9.	Escharina tumidula *Lonsdale*	Petersburg, Virginia.
10.	Lunulites denticulata *Conrad*	Williamsburg, Virginia.

Two species of the above list, namely *Anthophyllum lineatum,* identical with a Touraine species, and *Lunulites denticulata,* agreeing with one found in the Suffolk crag and faluns of Touraine, correspond with European fossils of the same age.

With respect to climate, Mr. Lonsdale regards this collection as indicating a temperature exceeding that of the Mediterranean,

* *Vide* Quarterly Journal of Geol. Soc. Vol. i. p. 471.

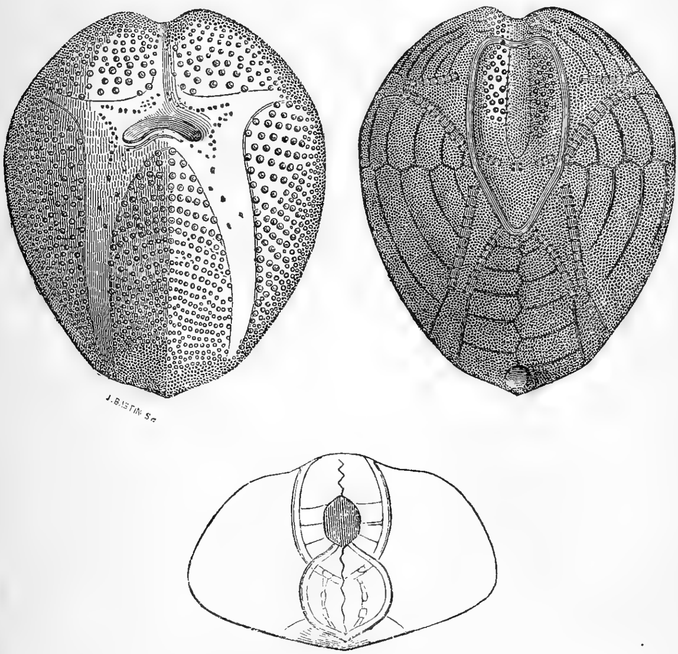
nearly corresponding with that of the faluns of Touraine, warmer than that implied by the polyparian fauna of the crag, and not so tropical as that of the Bordeaux tertiary beds.

Fossil Echinodermata.

In the shelly strata near Coggin's Point, on the James River, Virginia, I found a species of the *Spatangus* family, of the genus called by Agassiz *Amphidetus*, which also occurs in the English crag, and in the living fauna of Europe. I also found an *Echinus* at Williamsburg, and the spines of a second species. My friend, Professor E. Forbes, has favoured me with descriptions of these.

(*Family Spatangaceæ.*)

1. *Amphidetus Virginianus* Edw. Forbes.



Amphidetus Virginianus (natural size).

Body broadly ovate; elevated and truncate posteriorly. Back oblique; dorsal impression lanceolate-scutate, area very slightly excavated: ambulacral spaces broad, triangular, depressed; interambulacral spaces slightly convex. Anteal furrow broad, shallow; sides slightly gibbous; subanal impression broadly obcordate; post-oral spinous space broadly lanceolate.

Dimensions of the smaller but more perfect specimens.

Lon. unc. $1\frac{11}{12}$; Lat. $1\frac{8}{12}$; Alt. 1.

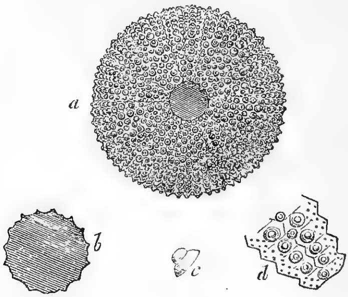
Number of pairs of ambulacral pores.*

Ant. lat. dors. amb. 8 + 10.
Post. lat. dors. amb. 13 + 8.

Loc. Petersburg.

(Family Cidarites.)

2. *Echinus Ruffinii* Edw. Forbes.



a, *Echinus Ruffinii*, viewed from above.
b, Ditto, mouth.
c, Ditto, a spinigerous tubercle.
d, Ditto, ambulacral plates and arrangement of pores.
(*a*, *b*, natural size; *c*, *d*, enlarged.)

Body subdepressed; ambulacral and interambulacral plates with several primary tubercles on each, closely ranged, having circles of secondary tubercles surrounding their (broad) bases; rows of pores very oblique, three pair of pores in each row, the uppermost distant from the other two. Beneath concave, mouth broad, widely notched, opposite each avenue. Anus narrow.

Lat. 1 unc.; Alt. $\frac{9}{12}$; Lat. apert. $\frac{5}{12}$.

The primary tubercles, being very numerous and of almost equal size, give the testa a very granulated appearance.

Loc. Williamsburg, Virginia.

3. *Spines of an Echinus from James River.* Virginia.

Ridges fine, numerous; interstices apparently smooth, broader than the ridges.

Fish.

The remains of fish consist chiefly of teeth of the shark family, all belonging to existing genera.

1. *Carcharias megalodon.* Evergreen, James River.
2. *Lamna xiphodon.* Evergreen, precisely like specimens I have seen from Touraine.
3. *L. hastalis* (*Oxyrhina*). Evergreen, Virginia, like a specimen from Martha's Vineyard, and in the molasse of Switzerland.
4. *L. cuspidata.* James River, also common to the molasse.
5. *Carcharias productus.* Evergreen, also from the miocene of Malta.

Several other shark's teeth, and the ossicles of the ears of fishes, which I found in the miocene strata of Petersburg, Virginia, were very analogous to European miocene fossils.

* In another specimen the number was found to be —

Ant. lat. dors. amb. 8 + 13.
Post. lat. dors. amb. 11 + 11.

And four pair additional on each side of the ovarian holes.

Mammalia.

The vertebræ of whales, apparently similar to those before described as found in Martha's Vineyard, occur in the miocene beds of Petersburg and other places.

In the museum at Baltimore, the grinder of a Mastodon was shown me, evidently distinct from that of *M. giganteus.* It had been recognised by Mr. Charlesworth as the *M. longirostris* Kaup, and had been so ticketed by him. Professor Ducatel had the kindness to allow me to take the specimen to Philadelphia, where Dr. Harlan identified it with the *M. longirostris* by comparison with casts sent to him by Mr. Kaup. The tooth is narrower than in the common *Mastodon giganteus*, and the parallel rows of transverse mammillary processes, instead of being divided by distinct hollows, are connected together by projecting spurs.

I was informed that this tooth was found at the depth of 15 feet from the surface of a bed of marl, near Greensburgh, in Caroline County, Maryland. Though I have not visited the place, I have little doubt that this Mastodon was a miocene fossil, and it occurs in beds of the same age on the Rhine.

APPENDIX.—*Extract of a Letter from* W. LONSDALE, Esq. F.G.S., *to* Mr. LYELL, *on the Indications of Climate afforded by the Miocene Corals of Virginia.*

"July, 1845.

"From ten fossil species of Polyparia belonging to different families, it is difficult to form an opinion respecting the climate in which they were produced. Nevertheless, as recent lamelliferous corals are well known to be markedly distributed as respects climate, the following notice is submitted for consideration. The district in Virginia whence the miocene polyparia were procured being situated in about 37° of north latitude, is on the same parallel with the southern coast of the Mediterranean westward of Tunis, and the northern portion eastward of that point; and as very little appears to be known of the distribution of recent corals on the coasts of the United States, it is proposed to compare the nature of the fossil genera with that of those living in the Mediterranean; it is hoped that no great objection can be advanced against this comparison, or mode of inferring climate, as species are disregarded, and as the polyparia of the Bermudas and the West Indies agree generically with those of the Red Sea and Indian Ocean. The ten species belong to seven genera, *Columnaria* (?), *Astrea, Anthophyllum, Heteropora, Cellepora, Lepralia,* and *Lunulites,* the first three being lamelliferous Anthozoa; and though *Columnaria* is an extinct genus, yet it is believed that its requirements may be safely inferred to have been analogous to those of *Astrea. Heteropora* is also only found fossil; but being considered to be a true *Tubuliporidæa*, its habits may likewise be inferred: and the three last are well-known genera belonging to *Bryozoa*. The ascertained lamelliferous Anthozoa of the Mediterranean exhibit, when tabulated, a marked character, consisting almost wholly of simple or ramose groups, not numerous in genera or species, though abundant in specimens, and occasionally of ample growth, with very diminutive representatives either in number or size of the great *Meandrinæ*, *Madreporæ*, *Astreæ*, *Porites*, and numerous allied genera which swarm in the Red Sea, the Bermudas, the West Indies, and the Pacific and Indian Oceans. A perfect distinction, as a whole, may therefore be stated to exist between the Polyparia of the Mediterranean and those of southern seas; while in more northern regions there are representatives, very limited as to species, of the simple and ramose polypidoms of the Mediterranean.

"On attempting to compare the miocene fossil Anthozoa of Virginia with those of the Mediterranean, it will be found that the *Anthophyllum* has no generic representative, all the existing species, as restricted by Ehrenberg, belonging to the Red Sea and Indian Ocean; and if the fossil specimens be regarded as young, their dimensions are not inferior to those of *A. musicale* in the same stage of developement — that the *Astrea* has an equivalent in the *Astrea mediterranea* of M. Risso, or in a *Porites* discovered by Prof. E. Forbes; but the *Columnaria*, an abundant coral, exhibits dimensions allied to those of analogous genera of warmer seas. Again, as respects the *Heteropora*, *Celleporæ*, and *Escharina*, no satisfactory inference can be formed regarding climate, *Tubuliporideæ* and similar *Celleporideæ* being universally distributed; but *Lunulites* have been found only in the Mediterranean and more southern latitudes. The comparison, therefore, would lead to the inference, that a climate rather exceeding the one which prevails nearly throughout the Mediterranean existed in the region where these fossils lived; and it must be borne in mind, that, as in plants so in corals, size cannot be assumed as the sole indication of temperature, but the abundant developement of species of peculiar genera and families, whether the first be of large or small dimensions.

"It is desirable next to allude briefly to the relative geological position of the Virginia deposit as respects some European miocene accumulations, to the extent which each may appear to justify a comparison. The formations referred to are the crag of England, the faluns of Touraine, the deposits near Bordeaux and Dax; and the characters of the Anthozoa in each district will be again considered as the principal test of temperature. The crag, according to Mr. S. Wood's extensive list*, contains only four species of lamelliferous Polyparia, with two *Lunulites* and one *Orbitulites*, the first including a *Fungia*, a *Turbinolia*, and two corals, believed to be allied to genera living in the Mediterranean: one of the

* Annals of Nat. Hist. January, 1844.

Lunulites is also considered to be identical with the species found in Virginia. The Polyparia of the crag exhibit, therefore, a marked absence of the genera characteristic of high temperatures. The Touraine miocene strata contain, according to the fine series collected by Mr. Lyell, about nine species of Anthozoa and three of *Lunulites*, the former including an Anthophyllum, believed to be the species found in Virginia, two *Turbinoliæ* and two *Astreæ*, the whole indicating a somewhat greater temperature than that of the crag. The Bordeaux and Dax deposits include, according to M. Michelin's work on the fossil corals of France, eleven lamelliferous Anthozoa and two *Lunulites*, the former comprising a *Dendrophyllia*, believed to be identical with a Touraine species; six *Astreæ*, one *Gemmipora*, one *Porites*, and two *Madreporæ*, or an aggregate representative of a Red Sea list of polyparia. Lastly, the Turin polypidoms, for a knowledge of which I am wholly indebted to M. Michelin's work, present no less than 73 species of lamelliferous Anthozoa, a tabulated list of which will bear a detailed comparison, as respects genera, with similar summaries of Red Sea, or tropical polypidoms. From these data it may perhaps be inferred, that the American deposit was accumulated in a climate superior to that of the crag, possibly equal to that of the faluns of Touraine, but inferior to that of Bordeaux."

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2. *Observations on the* White Limestone *and other* Eocene *or Older Tertiary Formations of* Virginia, South Carolina, and Georgia. By Charles Lyell, Esq., M.A., F.R.S., &c.

The tertiary deposits occupying a lower position than the Miocene strata described in the last paper, were first referred by Mr. Conrad to the Eocene period, in the "Journal of the Academy of Natural Sciences" for 1830. Some of these strata have been observed by Mr. Conrad on the Potomac at Fort Washington in Maryland ("Fossil Tertiary Shells," p. 30.); but the most northern which I myself examined were in Virginia, at Richmond, at Petersburg, and at several points on the James River. The formation in this region consists in great part of greensand and marl, containing green earth, so precisely like that which characterises the cretaceous strata of New Jersey, that were it not for the distinctness of the fossil shells, it would be impossible in many places to separate these deposits by mere reference to their mineral composition.

Farther south, in N. and S. Carolina, and in Georgia, the eocene formation acquires a larger development and a new mineral type, consisting of highly calcareous white marl and white limestone, and passing upwards, especially in Georgia, into red and white clays, ferruginous sands, with associated layers of burrstone and siliceous rock. This calcareous form of the eocene rocks on the Santee River and elsewhere, had led some geologists to consider the solid limestones as an upper secondary or newer cretaceous formation, and as forming an intervening link between the secondary and tertiary formations; but after a careful examination of several localities, presently to be described, I found the white limestone to contain exclusively tertiary fossils, without any intermixture of species belonging to the true and unquestionable cretaceous rocks of New Jersey or Alabama. It appeared to me that there was the same chasm between the cretaceous and tertiary rocks in that part of America which I visited, as has been observed in Europe generally, and those organic remains which have been supposed to be common to the two formations in the United States, have been almost all referred by mistake to the older group, in consequence of part of the white limestone of S. Carolina, which is tertiary, having been erroneously referred to the cretaceous epoch.

The largest number of eocene shells found in a good state of preservation, are those of Claiborne, Alabama, where a large collection was made by Mr. Conrad, and descriptions and figures of them were published in 1832.* At the same period, Mr. Lea, of Philadelphia, received from a friend a fine collection of the same fossils from Alabama, and referred them also to the period of the London clay of England, and calcaire grossier of Paris. In his work intitled "Contributions to Geology," he gave figures and descriptions of more than 200 species, but unfortunately, in consequence of these two eminent naturalists having laboured simultaneously, and independently of each other, almost every shell received a distinct specific name. For a list of synonyms, I may refer the reader to the appendix to Dr. Morton's "Synopsis of Organic Remains of the Cretaceous Group, Philadelphia, 1834," drawn up by Mr. Conrad.

I shall now offer a few observations on several localities of the eocene strata which I visited, beginning with the most northern, in Virginia, and then proceeding southwards to N. and S. Carolina and Georgia.

Virginia.—Below Richmond, near Coggin's Point on the James River, the *Ostrea sellæformis* occurs in one of the uppermost of the eocene beds; and this fossil I afterwards found to be widely characteristic of the formation in S. Carolina and Georgia. At the same place, *Cardita planicosta*, so common in the London clay and Paris basin, is also found. It cannot be distinguished from one of the common varieties of the European shell, and is accompanied by an oyster very nearly allied to *O. bellovacina*. Professors W. B. and H. D. Rogers, have described and figured several of these fossils in the fifth and sixth volumes of the American Phil. Trans. for the years 1835 and 1839. Near Evergreen, on the right bank of the James River, twenty miles below Richmond, I found, in the eocene marl, a large piece of wood in a state of lignite, 7 feet long, and about 1 foot broad, bored by teredo.

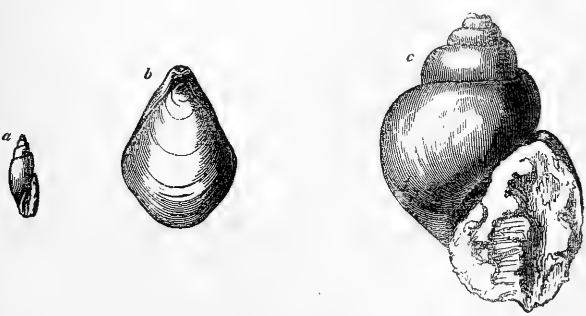
* For some account of the Claiborne strata, see Conrad's "Tertiary Fossil Shells," 1842.

At Petersburg, 30 miles south of Richmond, I saw the eocene strata, containing several characteristic fossils, distinctly overlaid by a large mass of miocene shell-marl. At no other point is the older tertiary formation more remarkable for its lithological resemblance to the greensand of the cretaceous series.

North Carolina. — Very different is the aspect of the rocks near Wilmington, N. Carolina, where they consist in great part of a limestone containing siliceous pebbles, and casts of shells and corals, with many fishes' teeth. This limestone is less white and more compact than the white limestone of S. Carolina; on the shore at the town of Wilmington it is 12 feet thick, covered with a shelly miocene deposit 6 feet thick. It is quarried in the neighbourhood of the town, and burnt for lime. I obtained, besides corals, 31 species of shells, exclusive of balani, from this rock, almost all in the state of casts, and many of them, therefore, only capable of being named generically. Those in italics in the following list have been identified with species found elsewhere in eocene localities: —

List of Eocene Shells from the Limestone of Wilmington, N. Carolina.

Cyp æa, identical with a cast from Shell Bluff, Georgia
Cypræa, two other species
Oliva Alabamensis
Oliva, allied to O. Laumontiana *Lam.* (fig. *a*)
Oliva
Voluta, two species
Conus
Strombus
Fusus
Buccinum, three species
Paludina, allied to P. Desnoyerii *Desh.* (fig. *c*).
Natica ætites
Turritella, two species
Vermetus
Infundibulum trochiforme
Crassatella, agreeing with a cast from Eutaw
Corbula
Lucina pandata
Cardium, agreeing with one from Shell Bluff
Cardita rotunda
Cucullæa
Arca, two species
Nucula magnifica
Pecten membranaceus Mort.
Terebratula Wilmingtonensis sp. n. (*Lyell & G. Sowerby*) (fig. *b*)



a. *Oliva*, (cast,) Eocene limestone.
b. *Terebratula Wilmingtonensis* Lyell & G. Sowerby.
c. *Paludina*, (cast).

The two last-mentioned species of the above list, *Pecten membranaceus* and *Terebratula Wilmingtonensis*, alone preserve their shells, all the others being in the state of casts. The small Oliva (fig. *a.*), resembles in general form *O. laumontiana* Lam., or *O. nitidula* Lam., but is more slender than either. As it is only the cast of the inside, it cannot be fully described. It appears to have only two small folds in the columella, of which the anterior is the larger. The Paludina (fig. *c.*) is like *P. Desnoyerii* Desh. (a fossil of the white marl in the midst of the calcaire grossier), but it has six volutions, whereas the *P. Desnoyerii* has barely four and a half. In the Wilmington fossil, the spine is more acuminated and the volutions more distant, so that the suture must have been more distinct.

Terebratula Wilmingtonensis (Lyell and G. B. Sowerby), Wilmington, North Carolina. This shell resembles most nearly in general form *T. uva* Brod. (recent from the Gulf of Tehuantepec), and also approaches *T. bisinuata* Lam., a fossil of the Paris basin. The following are its characters: —

Terebratula, with an oblong, smooth shell, posteriorly acuminated, anterior margin nearly even, dorsal valve large, and posteriorly prominent.

I was informed that a species of Nautilus had been found in the Wilmington limestone. Among the *Polyparia* which I collected there, Mr. Lonsdale has observed the following species: —

1. Lunulites sexangula *Lons.*
2. Lunulites
3. *L. distans* Lons., also at Wantoot?
4. L. contigua *Lons.*
5. *Flabellum? cuneiforme* (*Anthophyllum* of Conrad), also found at Eutaw and Cave Hall
6. *Dendrophyllia lævis* Lons., also at Shell Bluff
7. *Caryophyllia? subdichotoma* Lons., also at Shell Bluff
8. Eschara tubulata *Lons.*

As four of these eight corals, those in italics, and ten of the thirty-one shells, occur elsewhere in eocene localities, I consider the age of the Wilmington limestone, on which some doubts have been entertained, as set at rest. Among the teeth of sharks in the same rock I found, together with the usual eocene forms, a species of *Galeus*. The claws of crabs are also numerous.

I observed the same formation, and some of the same shells and corals, at Rocky Point, which is about twenty miles from Wilmington, on the N. E. branch of the Cape Fear River, where a similar conglomerate occurs, with green pebbles. At some points the rock is partly siliceous, and strikes fire with steel.

South Carolina.

From the low country near the level of the sea, at the mouth of Cooper River, to the junction of the Santee Canal, and from that point to Vance's Ferry on the Santee River, a calcareous formation of the eocene period occurs. At the first point where I saw it, in Dr. Ravenel's plantation called "the

Grove," near the mouth of the river, it appears in the form of a soft pulverulent limestone, in which two species of Scutella, (*S. macrophora* Ravenel, and another,) are very abundant. The soft limestone had been cut through to the depth of five feet in digging a canal, situated near "the Grove," about seventeen miles north of Charleston; its thickness here is unknown. I found in it *Pecten Lyelli* Lea, a Claiborne shell, and the upper valve of an oyster, which seems undistinguishable from *O. bellovacina;* also a species of Lucina, and a large Pecten allied to *P. pleuronectes;* also a species of Spatangus common to the limestone of the Santee canal.

At the Rock Landing, near the Grove, the white limestone is composed of triturated shells, and assumes a very hard and solid form. It contains fragments of Echinoderms, casts of shells, and corals (*Lunulite?*): it sometimes passes into an imperfect oolite.

Between the Grove and Vance's Ferry on the Santee River, a distance of about forty miles, is a continuous formation of white limestone, which I examined in company with Dr. Ravenel, first at Strawberry Ferry and Mulberry Landing, then on the banks of the Santee Canal, and afterwards at Wantoot and Eutaw. I then followed it in a north-westerly direction for twelve miles, by Cave Hall and Streeble's Mill, to near Halfway Swamp. On reaching Stoudenmire or Stout Creek, a tributary of the Santee, we found the limestone and marl to disappear beneath a newer deposit, also referable to the eocene period, of which I shall afterwards speak as the burrstone formation.

The soft limestone varies in hardness, passing frequently into a white marl, and resembling in texture some of the *craie tufau* of the Loire in France. It consists almost entirely of comminuted shells or corals, but it rarely exhibits any laminæ of deposition, and even where it attains a thickness of twenty or thirty feet, there would be a difficulty in determining whether it were horizontal, if a bed of oysters, *O. sellæformis*, like that at Vance's Ferry, did not occasionally occur. Notwithstanding its slight elevation above the sea, the Santee limestone cannot be less than 120 feet thick at Strawberry Ferry, being vertically exposed to the extent of 70 feet on the low banks and bottom of Cooper River, and to the height of 50 feet above these banks in the neighbouring hills. Its upper surface is very irregular, and is usually covered with sand, in which no shells have been found.

At Eutaw and other points, corals of the genera *Idmonea*, *Dendrophyllia*, *Flabellum*, *Tubulipora*, *Hippothoa*, *Farcimia*, *Vincularia*, *Eschara*, and others, occur, with a species of *Scalaria*, and other shells. These fossils, and the rock containing them, reminded me so much of the straw-coloured limestone of the cretaceous formation which I had seen on the banks of Timber Creek in New Jersey, that I do not wonder that some error has arisen in confounding the tertiary and secondary deposits of the Atlantic border. The species, however, prove, on closer inspection, to be different. This lithological resemblance led to the admission into

Dr. Morton's otherwise most accurate list of the cretaceous fossils of New Jersey, of the six following species, viz. *Balanus peregrinus*, *Pecten calvatus*, *P. membranosus*, *Terebratula lachryma*, *Conus gyratus*, *Scutella Lyelli*, and *Echinus inflatus* (see pl. 10., Morton's Synopsis), which came from the eocene beds of South Carolina, now under consideration, and led to a belief of the existence of a deposit intermediate between the chalk and tertiary strata, and containing fossils common to both.

One of the characteristic features of the region of tertiary white marl and limestone in South Carolina and Georgia, is the frequent occurrence of lime-sinks, or funnel-shaped cavities, arising from natural tunnels in the subjacent limestone, through some of which subterranean rivers flow. At Wantoot, there is one of these sinks in the limestone, and a spring issues from the rock so much above the temperature of the air during a frost as to send off clouds of steam.

At Cave Hall, two miles south of the Santee River, there is a cavern about twelve feet high at its opening, at the base of a precipice of limestone sixty feet perpendicular. Large beds of the *Ostrea sellæformis* occur in the limestone, which contains green particles in the lower strata. A stream is constantly flowing out of the mouth of the cave, and there is a line of sinks communicating with the underground river-course, in which the undermining process is continually going on. I was informed that a new "sink" had opened fifteen years ago within 110 yards of the mouth of the cave, and that a mule fell into the hollow while drawing the plough in the field above. Among other fossils from this place, I found in the limestone the tooth of *Myliobates*, and in the lower beds of calcareous greensand the same shells and corals as in the incumbent white limestone.

On reviewing the fossil Invertebrata which I collected from various localities in the Santee white limestone of South Carolina, I find many which will at once be recognised as species known to belong to the eocene formation of Claiborne and other places, among which I may mention *Trochus agglutinans*, *Pyrula inaurata* (*Fusus* Conrad), *Natica ætites*, *Dentalium*, same as one from Claiborne, *Lucina pandata*, *Lucina rotunda* Lea, *Lucina lapidosa*, *Crassatella* agreeing with a Wilmington (North Carolina) fossil, *Chama*, like one from Jacksonboro', Georgia, *Pecten calvatus*, *P. Lyelli* Lea, *Ostrea bellovacina*, *O. sellæformis*. Besides these we find *Terebratula lacryma*, *Ostrea Carolinensis*, *Pecten* allied to *P. pleuronectes* Lam., and shells of the genera *Nautilus*, *Voluta*, *Turritella*, *Scalaria*, *Vermetus*, *Lucina*, *Cytherea*, *Corbula*, *Cardium*, *Lima*, *Pecten*, *Ostrea*, *Terebratula*.

The Echinoderms are referable to the genera *Scutella* and *Cidaris*, and I met with several nautiliform foraminifera. The corals, already alluded to generically, have been described by Mr. Lonsdale.*

* See "Report on the Corals," &c. Quart. Journal of Geol. Soc., Vol. i. p. 495. *et seq.*

Burrstone Formation.

I have before mentioned that the white limestone of the Santee River, on being traced in a north-westerly direction, disappeared at Stoudenmire Creek, a tributary of the Santee, beneath a newer deposit of considerable thickness. The latter consists of slaty clays, quartzose sand, loam of a brick-red colour, and beds of siliceous burrstone, in some of which fossil sponges, having a coarse fibre, have been detected. Some of the clays break with a conchoidal fracture, and become stony when dried. One of the beds is extremely light, and resembles in appearance some kinds of calcareous tufa, but does not contain carbonate of lime. I at first supposed it to be of infusorial origin, but some practised observers have been unable with the microscope to discover infusorial cases. There were casts of shells in this rock, and in several of the associated strata, referable to the genera *Cypræa*, *Voluta*, *Natica*, *Trochus*, *Corbula*, *Mactra*, *Cardita*, *Cardium*, *Lucina*, *Nucula*, *Pectunculus*, *Pecten*, and *Serpula*. Among these, a *Corbula*, *Cardium*, and *Nucula*, seem to agree with Claiborne species; the rest did not agree with fossils from that locality, nor with those from the miocene beds of Virginia, but I was afterwards shown siliceous casts of *Ostrea sellæformis*, *Cytherea perovata*, and other eocene fossils, from strata of the same formation at Orangeburg and near Aikin in South Carolina. I believe, therefore, that the larger portion of the ferruginous sands, red clays, and white beds of kaolin (often miscalled chalk by the inhabitants of South Carolina and Georgia) belong to the Upper Eocene or Burrstone deposit.

At Aikin, fifteen miles S. E. of Augusta, and near the left bank of the Savannah River, the inclined plane of a railway has been cut through strata, 160 feet in thickness, consisting partly of earth and sand of a vermilion colour, and containing much oxide of iron; partly also of mottled clays, and white quartzose sand with masses of pure white kaolin. This compact kaolin appears fitted to make good porcelain ware. The globules of iron give a pisolitic appearance to some of the beds of quartzose sand. These beds at Aikin yielded no fossils, but I suppose them to be all referable to the Burrstone or Upper Eocene formation.

Georgia.

The same Burrstone formation is continuous from Aikin and Stoudenmire Creek, South Carolina, to Augusta in Georgia, and to the junction of the tertiary with the primary or hypogene rocks above that city. It must attain there in some places a thickness of more than 200 feet, and is very variable in its aspect and composition.

At a place called The Rocks, six miles west of Augusta, it consists of a highly micaceous quartzose grit and sand, having much the appearance of certain kinds of granite, and having been by some writers improperly termed gneiss. The mass exhibits occasionally a distinct cross-stratification, and pieces of compact kaolin, sometimes angular, are imbedded in it. In other places, as at Somerville, red, vermilion-coloured, and white clays, 180 feet thick, are seen. These rest in horizontal beds on the edges of highly inclined strata of chlorite schist and clay-slate, which are exposed to view at the rapids of the Savannah River, three miles above Augusta. On Ray's Creek, near this point, the old schists, much charged with iron, are seen to decompose into materials so like the red vermilion-coloured clays of the tertiary deposits, that they would be undistinguishable, were it not that the veins of quartz, which have not decomposed, still remain running through them. The quartz itself, when broken up, would furnish a white sand such as that found associated with the red clays, so that we have here a most satisfactory explanation of the derivative origin of a great part of the burrstone formation.

Savannah River.—I shall now describe several natural sections which are seen in the bluffs or cliffs bounding the alluvial plain of the Savannah River, in its course of about 250 miles between Augusta and the sea. The river has an average fall of about one foot per mile, or 250 feet between Augusta and the delta of the river. Like the Mississippi and all large rivers, which, in the flood season, are densely charged with sediment, the Savannah has its immediate banks higher than the plain intervening between them and the high grounds, which usually, at whatever distance from the river, present a steep cliff or "bluff" towards it.

Near Augusta, the Savannah cuts through the red clays and sands before mentioned. Forty miles below the city, a section from 120 to 150 feet high, and half a mile in extent, is observed in Shell Bluff in Georgia, on the right bank. Unfortunately, at the time of my visit the waters were high, and covered the bottom of the bluff. The lowest exposed portion of the cliff consisted of white pulverulent marl, derived chiefly from comminuted shells, which passed upwards into a solid limestone, sometimes concretionary, and containing numerous casts of shells; and above this was again seen pulverulent white marl. Still higher, the calcareous deposit becomes more sandy and clayey, and encloses a bed of huge oysters (*O. Georgiana* Conrad), which are found growing one upon the other, and have evidently not been drifted into their present place. The total thickness of these calcareous strata is about 80 feet, above which, beds of red loam and yellow sand, such as prevail at Aikin and Augusta before mentioned, and without fossils, are seen at the top of the cliff 40 feet or more in thickness.

After a diligent search of several days, I obtained casts of no less than thirty-nine species of shells from the limestone of Shell Bluff, twenty-four of which I have been able to identify either with eocene species, known to Mr. Conrad to occur at Claiborne, or to species found by me in other eocene localities, and I have no doubt that I could have identified more had my own collection from Claiborne been more complete.

Shells found at Shell Bluff agreeing with Species in other Eocene Localities.

1. Conus, like one from Jacksonboro', Georgia
2. Cypræa, like one from Wilmington, S. Carolina
3. Oliva Alabamensis *Conrad*
4. Pyrula, apparently agreeing with one from Claiborne
5. Voluta prisca (Turbinella prisca, *Con.*)
6. Trochus agglutinans
7. Melongena alveata, very common
8. Infundibulum trochiforme
9. Natica ætites *Con.*
10. Bulla, like one from Jacksonboro'
11. Crepidula lirata *Con.*
12. Dentalium thalloides *Con.*
13. Crassatella protexta *Con.*
14. Lucina pandata *Con.*
15. Lutraria lapidosa *Con.*
16. Cytherea Poulsoni *Con.*
17. C. perovata *Con.*
18. Cardita planicosta
19. C. rotunda *Con.*
20. Cardium, like one from Jacksboro'
21. Nucula magnifica *Con.*
22. Chama, like one from Jacksboro'
23. Ostrea sellæformis *Con.*
24. Pecten membranosus

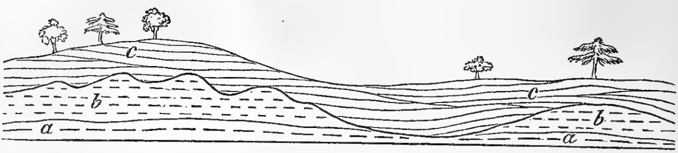
The remaining shells, chiefly casts, which I collected, belong to the following genera: *Conus, Voluta, Turritella, Fusus, Cytherea, Lithodomus, Solenomya, Cardita, Cardium, Pectunculus* (two species), *Pecten, Arca, Ostrea.*

One of the species of Ostrea, *O. Georgiana*, has been supposed to agree with the large fossil so common in Touraine, and called by some *O. virginica*, but this identification is doubtful. The Shell Bluff species is very remarkable for its enormous thickness and length.

About nine miles below Shell Bluff, in the Long Reach, is a cliff about eighty feet high, called London Bluff, where the same shelly white calcareous beds again appear, covered with red clay and loam. The horizontal stratification is evident here, as in the cliff two miles below, where the large oysters are seen standing out in relief. Below this, at Stony Bluff in Burke County, near the borders of Scriven County, the calcareous beds have quite disappeared, and siliceous beds of the burrstone series are seen occupying the cliff, and resting upon brick-red and vermilion-coloured loam. This superposition is important, as concurring, with other facts, to show that the burrstone of this region with its eocene fossils is an integral part of that great red loam and quartzose sand formation, usually devoid of fossils, which occupies so large a space between the hypogene (or primary) region and the Atlantic. The quartzose and siliceous rock of Stony Bluff was, during the last war with Great Britain, quarried for millstones. It passes into a sandstone with distinct grains of quartz, and is full of cavities and geodes, partially filled up with crystals of quartz and agates. Portions of it are filled with spiculæ of fossil sponges, some of them in a decomposed state, and there are also seen in the same flints, when thin slices are cut and polished, minute flustriform corals and foraminiferous shells, which were detected by Mr. Bowerbank, who has had the kindness to examine the specimens for me microscopically. Loose flints of this formation, containing spines of echini and other fossils, are scattered over the surface of the country, like chalk-flints in England. At Millhaven, in Scriven County, about eight miles from Stony Bluff, and five in a direct line from the Savannah River, the siliceous beds crop out on the banks of a small stream. In the flints here I found casts of several shells of the genera *Valvata, Pecten,* and *Terebratula,* with a species of *Cidaris.* It was evident to me that this millstone belongs to the same formation of red loam and sand which extends almost uninterruptedly from Aikin and Augusta to this region, for I observed near Millhaven, where the deposit has been pierced through to the depth of 26 feet in wells, pieces of white kaolin embedded, like those before mentioned near Augusta.

Jacksonboro', Scriven County.

Section of Eocene Strata on the Right Bank of Beaverdam Creek, Scriven County, Georgia.



a. Limestone. *b.* White marl. *c.* Yellow and red sand and clay of the burr-stone formation.

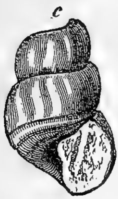
About eight miles from the Savannah River, and one mile west of Jacksonboro', a limestone occurs, covered with sand, in the fork of Briar and Beaverdam Creeks, which has been quarried for lime. This limestone (*a*) passes upwards into marl (*b*), which has an undulating surface, as represented in the annexed section, and appears to have been denuded before the deposition of the incumbent sand and loam (*c*). The height of the cliff is about 25 feet, the thickness of the calcareous formation varying from 10 to 15 feet, and the yellow sand which rests upon it from 3 to 10 feet.

From this limestone of Jacksonboro' I obtained, besides corals and echinoderms, thirty species of shells, the larger portion of which were kindly presented to me by Colonel Jones of Millhaven. Those in italics agree specifically with fossils from Claiborne, Alabama, or other eocene localities, which I have specified.

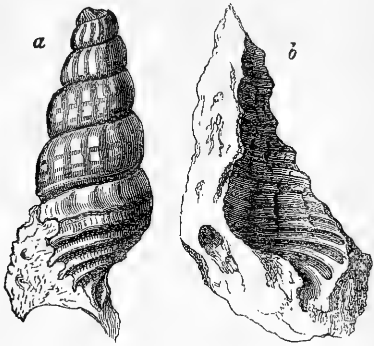
Fossil Shells of Jacksonboro', Scriven Co., Georgia.

Oliva Alabamensis
Voluta prisca
Conus, same as one from Shell Bluff
Rostellaria or Strombus (casts), four species
Fusus inauratus
Cerithium Georgianum *Lyell & G. Sowerby,* see fig. *a, b.*
Melania, see fig. *c.*
Paludina ?

Natica ætites
Turritella
Bulla, same as one from Shell Bluff
Trochus agglutinans
Infundibulum trochiforme
Solarium canaliculatum
Dentalium
Crassatella
Lucina pandata
Cytherea
Cardium, like one from Shell Bluff
Chama, like one from Shell Bluff
Cardita
Lithodomus dactylus
Modiola
Mytilus
Avicula trigona ?
Pecten
Ostrea panda



c. *Melania*, cast.



Cerithium Georgianum. Lyell & G. B. Sowerby.
a. Nucleus. *b.* Cast of exterior.

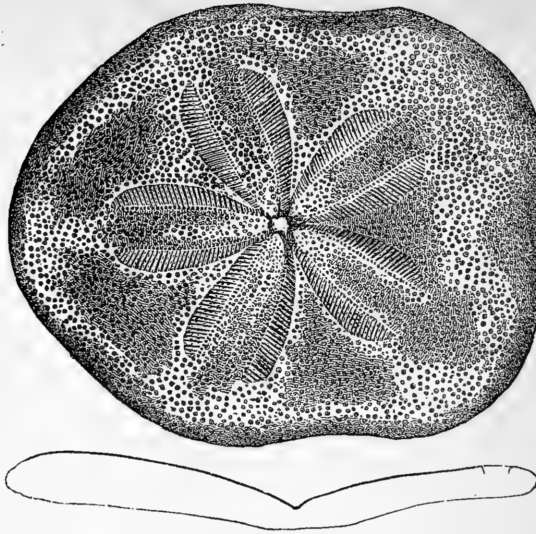
The shell named *Cerithium Georgianum* in the above list (figs. *a*, *b*.), is very abundant, and closely resembles *C. lamellosum* Lam., a tertiary species of the Paris basin. Its characters are as follows:—

Cerithium, with an acuminated turreted shell, volutions 9 or 10, rounded, with rather obsolete and irregular longitudinal ribs, and with 5 or 6 transverse ridges, of which the three anterior are very prominent, and lamellose near the aperture.

Of the next shell in the list, named Melania (fig. *c*.), there is only a cast of the inside preserved, so that its external characters cannot be distinctly known.

Of the *Lithodomus dactylus* I obtained a beautiful cast, both of the exterior and interior, from the cavity of a fossil coral. It resembles the West Indian variety, and is an eocene species well known in the Paris basin. As, according to Philippi, it is one of the most cosmopolitic of living species, we have the less reason to be surprised at its great vertical range in the geological series.

A species of *Scutella* differing from those found by me in other places was common at Jacksonboro'. For the following description of it I am indebted to Professor E. Forbes, and it has been named, after Colonel Jones of Millhaven, *Scutella Jonesii* :—



Scutella Jonesii Edward Forbes.

Body plane, shield-shaped, subpentangular, with sides and posterior margin undulated; angles obtuse.

Back centrally slightly convex, interambulacral spaces depressed; ambulacral spaces broad, somewhat convex, with parallel sides. *Avenues* petaloid, with their inner margins nearly straight. Pairs of pores in each avenue 37, united by oblique lines.

Oral surface concave, with five deep furrows radiating from the mouth to the margin.

Margin thick, rounded.

Lat. $2\frac{1}{12}$ lon. $2\frac{10}{12}$. crass. max. $\frac{4}{12}$.

This species appears to have been marked with spots.

Locality.—Jacksonboro'.

I have no doubt that all the sandy soil on which the long-leaved pitch pine grows in the neighbourhood of Jacksonboro' belongs to the burrstone formation, consisting of sand, ferruginous sandstone, and red loam, and although it is rare to find the limestone and marl exposed to view, I believe it to be everywhere subjacent. For we meet not unfrequently in Scriven, and several of the adjoining counties, with lime-sinks, or deep depressions, more or less circular in shape, in the vertical walls of which we observe sections of the horizontal beds of sand and mottled red and yellow loam and clay. As the water does not stand in these sinks, there is evidently a subterranean drainage, by which the loose sand has been carried down, and the surface undermined, as before described at Cave Hall. I saw several lime-sinks near Jacksonboro', and one about 16 miles south of Millhaven, on the east side of the road to Savannah, at Reeve's mill. It was 60 paces in circumference, and 80 feet in depth, and the beds gone through consisted of yellow and deep-red sand, in some parts ferruginous, with beds of mottled red and white steatitic clay.

All the bluffs which I examined on the Savannah River below Briar Creek belonged to the beds above the limestone, and are referable for the most part, if not entirely, to the burrstone formation. I observed several sections in the Long Reach in Scriven's County, where the red loam and yellow sand is conspicuous; and there is a fine section in Hudson's Reach, at a place called Tiger-Leap, where beds of fuller's earth occur. A few hundred yards below Tiger-Leap, where a small creek or brook enters on the right bank of the Savannah River, I found in some of the white clays impressions of *Mactra*, *Pecten*, and *Cardita*, with fragments of fishes' teeth, particularly of the genus *Myliobates*, several of the genus *Lamna*, and one of the genus *Galeus*. These bluffs of loam, clay, and sand are often 80 feet in height; and after passing Scriven I found, in the county of Effingham, similar sections, as at Sister's Ferry and Ebenezer. In the section at Sister's Ferry there is not only the brick-red loam, and the red and grey clay and sand, but layers of steatitic clay, which, although soft when moist, become hard and acquire a conchoidal fracture when dried.

On the whole it appears, from the information I obtained, that the less elevated part of South Carolina and Georgia, intervening between the mountains and the Atlantic, has a foundation of cretaceous rocks, containing *Belemnites*, *Exogyra*, and other fossils, above which are, first, eocene limestones and marls, and, secondly, the burrstone formation, with its red loam, mottled clays, and yellow sand. I am informed by Mr. Vanuxem that a tertiary lignite formation is sometimes interposed between the cretaceous beds and the eocene limestone; but I had no opportunity of verifying this fact in the sections which I saw, partly, I believe, owing to the swollen state of the rivers at the time of my visit. The remarkable difference of the fossils found in the eocene limestone at different points may lead some to the suspicion that there exists in this country a considerable succession of minor divisions of the eocene period, but I am inclined to ascribe the circumstance principally to two causes: first, that the number procured in each place is small, and therefore represents a mere fraction of the entire fauna of the period under consideration; and, secondly, that we have not yet any great eocene collection from any part of the United States. If we had 1000 shells from Alabama instead of little more than 200 (those, namely, which have been found at Claiborne), we should be able to form a more correct opinion respecting the mutual relations of the strata at distinct points, such as Shell Bluff, Jacksonboro', Eutaw, the Santee canal, and Wilmington, North Carolina.

The difficulty of classifying the tertiary strata of the southern states arises mainly from the wide extent of red and white clays, and siliceous sand, without fossils. The sterile sands which form the soil of the pine barrens in the lower plains of Virginia and North Carolina appear to belong to the miocene period, while those of a large part of South Carolina and Georgia are eocene. Some of the red ochreous and vermilion clays, as, for example, those of Martha's Vineyard and at Richmond, Virginia, are miocene. Others of similar character in South Carolina and Georgia, as at Orangeburg, Aikin, Stony Bluff, and Millhaven, belong to the burrstone formation, which is of the eocene period.

The species of eocene shells common to the United States and Europe appears to be very small. I have in my cabinet eighty-five species, in a good state of preservation, from Claiborne, Alabama, presented to me by Mr. Conrad; and I procured from the various localities already enumerated in this paper about forty species which I could not identify with the above, or with any which I have seen from Claiborne. Out of these 125 species I have been able to identify the following seven only with European eocene shells: namely, *Bonellia terebellata, Trochus agglutinans, Solarium canaliculatum, Infundibulum trochiforme, Cardita planicosta, Lithodomus dactylus, Ostrea bellovacina.* The proportion, therefore, of species common to Europe and the United States scarcely exceeds five per cent., and the proportion of species now living and identical with the American eocene shells appears to be still smaller. In regard to geographical representations, I found at least one fourth of the species to be very closely allied to European eocene fossils, while another fourth presented forms differing greatly from any species procured from the eocene strata of Europe, although belonging to genera which are abundantly represented in these formations.

March 12. 1845.

Sir Robert Burdett, Bart., of Ramsbury Park, Wilts, and Warington W. Smith, Esq. M.A. of Trinity College, Cambridge, were elected Fellows of this Society.

The following communication was read: —

On the comparative Classification of the Fossiliferous Strata of North Wales, *with the corresponding deposits of* Cumberland, Westmoreland, and Lancashire. By the Rev. Adam Sedgwick, M.A., F.R.S., Woodwardian Professor of Geology in the University of Cambridge.

The author referring to his memoir on the structure of North Wales, published in the first number of this Journal, for an account of the sequence of the rocks in that district, states that his object now is to bring the successive groups of the Cumbrian mountains into comparison with the three primary divisions of the whole Welsh series.*

* These divisions are: —

3. The uppermost slate rocks of the Upper Silurian age, consisting of a series of beds called by the author the '*Creseis* flagstone,' from the abundance of that fossil, overlaid by the Denbigh flag, &c.

2. Roofing slate and greywacke of great thickness, with alternating beds of contemporaneous porphyry.

1. Chlorite and mica slate, &c. of Anglesea and the S. W. border of Caernarvonshire.

The whole series of the Cumbrian slates, like that of North Wales, has been considered to admit of three primary divisions, but hitherto the separation has been chiefly made from a consideration of physical characters and superposition, and without reference to fossils; the uppermost only of the three being supposed to contain them. In this state the author left his maps in 1824, and they show the superficial extent of the igneous and intrusive rocks, of the lowest or Skiddaw slate, of the great mountain masses of green roofing slate and porphyry, alternating in vast parallel bands, and lastly, of the fossiliferous slates extending from the Coniston limestone to the highest beds on the banks of the Lune, near Kirby Lonsdale.

Of these beds the author considers that the Skiddaw slate has, perhaps, no true equivalent in N. Wales, and that the green slates and porphyries are probably the exact representatives of a portion of the great system of Snowdonian slates. The Snowdonian slates, however, contain fossils, and the green slates and porphyries of Cumberland are without them; a difference accounted for as the consequence of the greater abundance of igneous rocks among the green Cumbrian slates. It remains then to find the equivalent of the fossiliferous rocks in the third and highest division of the Cumbrian slates, and for this purpose the author discusses in its most limited form the following questions, namely:—Into what groups may we subdivide the slates expanded between the Coniston limestone, and the highest beds of the series on the banks of the Lune, near Kirby Lonsdale? and what are their equivalents in North Wales? Professor Sedgwick considers that, with the exception of the Coniston limestone, and two or three hundred feet of slate and shales surmounting it, the whole of the upper series is *Upper Silurian*, and in the parallel of the Denbigh flagstone, using this latter term in its most extended sense.

The author then enters into some detail with regard to the actual working out of the geology of this district, and his ultimate discovery that a great movement of the strata had brought up the Coniston limestone a second time, on the south side of the estuary of the Duddon, in a ridge called High Haulme, N. W. of Dalton in Furness. In this ridge the beds are nearly vertical, and are associated with trappean rocks and porphyries exactly like those under the Coniston limestone on the north side of the Duddon, which are several miles distant.

The calcareous bands of this ridge being nearly in the same line with a second or higher band of limestone, became confounded with it, and this has led to a wrong estimate of the geological equivalents of the second band of limestone. The mistake being corrected, it appears that the successive groups of strata will easily fall into their right places without the intervention of any great unconformable overlap. Thus the fossiliferous slates present—first, the Lower Silurian rocks in a very degenerate form; and secondly, the Upper Silurians in a noble series, more complete and far thicker than the Denbigh flagstones, and ending with the red flags or tile stones of the Lune. The author then proceeds to describe some of the lower groups of these rocks and their fossils.

1. *The Coniston limestone.* Most of the points of interest with regard to this bed have been described by the author in a former paper, of which an abstract has been given in the Proceedings of the Geological Society.*

It is of a dark blue colour, traversed occasionally by contemporaneous white calcareous veins, and its colour appears to be derivable from metallic oxides and not from carbon, as it burns to a dark-coloured lime, which is used for agricultural purposes, and as a cement stone. This limestone sometimes immediately overlies felspar rock and porphyry, and the bottom beds, although generally impure and siliceous and occasionally slaty, contain in some places 20 or 30 feet of beds fit for use. In Long Sleddale, however, a singular trappean rock with great balls of agate underlies the limestone, and in Kentmere the lower beds contain masses of coarse conglomerate; and although this is rare, yet as a general rule these beds exhibit no marks of metamorphosis, and the green slates and bedded porphyries below are so parallel to the limestone, that all have evidently been disturbed together, while the passage from the lower beds to the upper is almost instantaneous.

The limestone bands are variable in their character, and not strictly continuous, and the best beds are generally only a few feet thick. On one side of Long Sleddale they are good, on the other very degenerate, and occasionally they only form irregular rognons in a dark fossiliferous slate. Above the limestones are shales and soft slates, pyritous at the division of the beds †, and generally of dark colour; in these the rognons disappear gradually, but the fossils ascend into them for some distance. At Sunny Brow the slates are harder but too much jointed to be worked: at Ash Gill, however, they are extensively quarried and contain many fossils, one or two of them new species, but of Lower Silurian types. The thickness of this group, which terminates the Lower Silurian series, is probably upwards of 300 feet.‡

* Proceedings, &c., vol. i. p. 249.

† In consequence of this appearance, unsuccessful attempts have been made to obtain copper from these beds, but small veins and strings of sulphuret of copper have been partially worked to the east of Coniston.

‡ The author appends the following observations concerning the fossils of the Coniston limestone.

The Coniston limestone seems to contain all the characteristic fossils of the Llansaintfraid section combined with many of the Bala species. The following is the list of species:—

Polyparia.

Astrea, one or two species
Favosites polymorpha
F. spongites
F. fibrosa
Porites pyriformis, in abundance, and a nearly allied species of larger size
P. inordinata
Stromatopora concentrica
Turbinolopsis bina
Retepora, scattered pores of a large species
Catenipora escharoides
Tentaculites annulatus
Tentaculites, a new species

2. *Coniston flagstone.* This group the author has formerly described as *Brathay flagstone*, but now proposes to change its name to *Coniston flagstone* for the sake of symmetry. No group is better defined than this in the Lake country, and although the Brathay and Coniston quarries are several hundred feet above the preceding group, the series may be completed, in consequence of the regularity of the dip, by connecting a succession of quarries, and in this way the whole is estimated to be not less than 1500 feet thick.

The mineral character of the Coniston flags resembles that of the lower Denbigh flags, but is more altered by slaty cleavage *,

Mollusca.

Orthoceras, three smooth species, like those from the lower Bala limestone
Lituites cornu-arietis
Euomphalus?
Turritella, or Terebra
Turbo?
Leptæna depressa
Leptæna n. sp., decussated
L. sericea
L. transversalis and another
L. (Orthis) grandis, Sil. Syst.
Orthis canalis
O. alternata?
O. testudinaria
O. flabellulum β
Orthis vespertilio
O. virgata
O. actoniæ
Orthis n. sp. (named in MS. *crucialis*), perhaps two species under the same name
O. radians
Orthis n. sp. ? with fine simple ribs
Orthis n. sp., same as from Dudley, a curious rough species
Atrypa (Spirifer), resembling S. acuminata
A. (Spirifer), a smooth species, ? new
Atrypa affinis
Spirifer n. sp. named in MS.
S. n. sp. ? small variety of S. radiatus

Crustacea.

Cytherina lævigata
Paradoxides quadrimucronatus
Calymene Blumenbachii
Calymene n. sp.
Asaphus Powisi
A. tyrannus
Illœnus (*Bowmanni*, MS.; called *Bumastus Barriensis* in a former list)
Brontes, undescribed species (*vide* Portlock's report).

The corals, both as to species and numbers, are precisely similar to those north of the Berwyns.

In the abundance of *Leptæna depressa, L. transversalis, Orthis radians*, and above all, *O. inflata*, with spiral shells, and *Lituites cornu-arietis*, there is an analogy with the beds north of the Berwyns: but the presence of *Orthis Actoniæ* and *O. virgata*, with *Spirifer* (*crucialis*), which are also plentiful, approximates the group to that from Bala and the Coniston limestone; it resembles also these latter beds in possessing the smooth *Orthoceratites, Encrinites*, and *Illœnus* (*Bowmanni*), but it differs in the scarcity of *Orthis canalis, O. testudinaria*, and *O. vespertilio*, and the absence of *O. flabellulum, O. alternata, Spirifer radiatus, Agnostus pisiformis, Trinucleus Caractaci*, and *Asaphus tyrannus* (one doubtful specimen of this latter having been found), fossils characteristic of the lower group in Wales.

An undescribed *Paradoxides*, a tail of a new *Brontes*, a curious undulated fossil (perhaps crustacean), a new *Tentaculites*, and abundance of *Cytherina* (a marine *Cypris*) seem peculiar to the Coniston limestone; and the last is a very interesting fossil, not having been known before in rocks of the Silurian series.

* The author observes, with reference to this condition, that he has observed in the flags in question distinct cases of a second cleavage plane entirely distinct both from joints and bedding.

and is chiefly made up of a dark coloured coarse slate or flagstone, through which are distributed rounded concretions, (sometimes spoiling the slate,) in which, as well as in the colour and bedding of the rock, in the presence of small calcareous veins, and the appearance of a great bedded mass of ripple marked flagstones without slaty cleavage at the top of the group, there is seen a near resemblance to the Denbigh flags. In the upper flags just alluded to, there are also (in the gill above Hawkshead Fould) calcareous masses and lenticular beds of limestone not fossiliferous, and probably not continuous, and therefore not considered by the author as forming a second band of limestone.

The Coniston flags thus characterised extend from the extremity of Shap Fell to the top of the Duddon Estuary, and might readily be laid down on a good map. It only remains, therefore, to determine their relative position from the included fossils.

In the Brathay quarries were found *Graptolites ludensis* in considerable abundance, and at another locality, within a few hundred feet of the Coniston limestone, *Atrypa compressa* was also plentiful, and was accompanied by a *Creseis.* At Cold Well, considerably above the Brathay quarry, appeared *Asaphus caudatus;* and at Kent-mere in the same group *Astrea ananas, Creseis* being distributed throughout. All these fossils occur in the Wenlock shale, or Lower Denbigh flag. The author therefore concludes that the series in question represents the Lower Denbigh flagstones, and is the equivalent of the Wenlock shale.

3. *Coniston or Furness Grits.* This name is given to a group of bluish grey grits of great thickness, and very highly inclined, overlying the Coniston flags. It is on the whole a well defined group; but at its N.E. end is broken up by the interpolation of slaty bands, and loses its well defined mineral type. It may, however, be distinctly traced, and laid down on a map, from Bannisdale Head to Broughton; occupying a zone, on the average, more than half a mile wide. No fossils have as yet been discovered in it, but the author brings it into comparison with some hard grits which alternate with the lower Denbigh flags, north of the Holyhead road; he does this however only for the purpose of exhibiting analogies of structure in rocks of nearly the same epoch.

4. *Ireleth Slates, &c.* This is described as a great group possessing a considerable unity of character, and characterised by rocks with a good slaty cleavage distinct from the bedding, the slates being sometimes good enough for quarrying, and alternating with gritty bands, some of them very coarse, and rarely passing into a conglomerate form. The beds of this group are greatly contorted through their whole range, and especially at their north-eastern and south-western ends, and the thickness of the whole is very difficult to determine justly. For convenience of description, the whole series is separated by the author into three divisions, namely:—

a. The Lower Ireleth slates, a band of considerable width, made up of beds dipping at high angles, and steadily to the S.E. Being seldom contorted, these beds must be of great thickness. They produce workable slate, but no distinct fossil species have yet been found in them.

β. A thin zone of *calcareous slate with concretions of limestone.* This bed is only a few feet thick, and the *rognons* of limestone are sometimes replaced by a singular cellular calcareous slate with obscure casts of fossil shells. It ranges on the south of the Duddon, and has been traced from point to point; and after an interruption of two or three miles it appears at Tottle Bank heights, from which it may be traced over the neighbouring hills to a spot below Low Hall farm on the east side of Coniston water. A third obscure band of limestone is stated by the author to exist in the hills north of Nibthwaite.

The fossils of these bands of limestone are Upper Silurian; but though numerous they are very obscure.* In his letters on the lake district, the author states that he has described these fossils as Lower Silurian; but the specimens alluded to were obtained from High Haulme, three quarters of a mile S.E. from Ireleth village. "The limestone there forms a ridge not exactly continuous with the other limestone, which I accounted for by the interposition of a fault. But there is no fault of the kind I supposed. The High Haulme limestone is an independent ridge, the limestones and the slates are vertical, and associated with great masses of felspar rock and porphyry, exactly like the older slates below the Coniston limestone, and when brought up against the newer series of slates, these latter are thrown into most extravagant contortions."†

γ. The third subdivision of the great complex slaty group here described is termed by the author the *Upper Ireleth slates,* and exhibits remarkable examples of structure. These beds contain round concretions, like those of the Coniston flags. They are of great thickness, and alternate with beds of grit passing into coarse sandstone, and, rarely, into a conglomerate. Following them from Ireleth, where they are largely worked, to the Leven sands, they gradually pass into a coarser deposit without any regular line of demarcation. These coarser beds also contain concretions, and, though unfit for use, they continue to show a striped surface and slaty structure.

* The author adds in a note, "The enormous dislocation which throws forward the Coniston limestone at the Water Head seems to affect the whole chain of hills to the bottom of the lake. The corresponding beds on the opposite sides of the lake are not in the prolongation of the lines of strike. The lake therefore occupies a line of fault, on the eastern side of which is an enormous upcast of the whole series of rocks."

† The following is a list of the fossils collected at High Haulme from the dislocated Coniston limestone:—

Cyathophyllum	Turbinolopsis bina
Catenipora escharoides	Spirifer crucialis
Favosites fibrosa, and other species	Orthis Actoniæ
Retepora, very large	—— canalis
Porites pyriformis	—— inflata
Astrea	Calymene Blumenbachii.

This group may be traced to Shap Fells and Bretherdale, parallel to the lower beds; and in the hills composed of it on the sides of Kentmere, Long Sleddale, &c., several fossils were obtained, of which the following is a list:—

Leptæna lata.	North end of Potter's Fell, Helme Park, &c.,	Underbarrow.
Orthis lunata.	Ditto	Ditto.
Spirifer ? (S. octoplicatus of Mr. Sharpe's paper.)		Ditto.
Terebratula navicula (plenty).	Ditto	ditto.
Avicula retroflexa.	Ditto	ditto.
Cornulites serpularius.	Ditto	ditto.
Turritella conica. Underbarrow.		
Ophiura n. sp. Potter's Fell.		
Orthoceras ibex. Helme Park, &c., Howgill.		
&c.	&c.	&c.

5. *Group of coarse Slates, Flags, Grits, &c.*—The author has already noticed this group as a coarse development of the Ireleth slates, and the beds have been named by Mr. Sharpe, *Windermere rocks.* They are so far important that they are of great thickness, and pass downwards into the Ireleth slates. Upwards, they blend themselves insensibly with the sixth group; the singular slates, grits, and flagstones which commence a few miles north of Kendal, and continue southwards over the moors as far as Kirby Lonsdale, ending in red slaty beds like the tilestone of Shropshire, the geological place of which these slaty beds occupy.

The group now under consideration is greatly broken and shattered by faults, but no part of it can be considered non-fossiliferous, as the author found *Cardiola interrupta* in the very heart of it, and fragments of encrinites elsewhere.

The author is not aware of any evidence of want of conformity between the beds of this group and the other masses.

6th *Group, nearly on the parallel of the Upper Ludlow.*

The author is inclined to place the base of this group near Underbarrow, whence to the limestone of Kendal Fell there is a magnificent section. The fossils are very numerous, and some are peculiar to the neighbourhood. *Terebratula navicula* is only found in the lower part, but the whole upper part is full of fossils, the prevailing type being Upper Ludlow, although amongst these beds is a remarkable band with *Asterias.*

A great downcast fault in the valley of the Kent affects these beds, and on its south side is seen the "tilestone," separated from the other rocks by singular calcareous shales.

The siliceous, flaggy, and gritty beds of the Upper Ludlow are then carried with many breaks and undulations to the valley of the Lune, where they are overlaid by a thick mass of tilestone.

The uppermost beds of this tilestone are full of fossils, all of Upper Silurian species; and there is, in the opinion of the author, no true passage from the tilestone to the overlying old red sandstone.*

* The author's opinion seems to be grounded on the three following facts:—

(1.) As a general rule the conglomerates of the old red sandstone are perfectly unconformable to the upper slates of Westmoreland: of this there are many undoubted examples.

The author next alludes to the rocks of Howgill Fell and Ravenstonedale on the east side of the valley of the Lune; and he considers that these rocks, which offer considerable difficulties in their accurate determination, though separated by great faults from the higher parts of the Upper Ludlow series, are not to be considered as unconformable to that series, and probably contain a portion of it in their great folds and undulations. Through the eastern boundary of the district in which they occur, ranges the great Craven fault, described by the author in a former paper; and he has found, brought up apparently on one side of the fault, and appearing in the hills between Dent and Sedbergh and between Sedbergh and Ravenstonedale, a series of calcareous shales containing fossils, which mark the date of the series as not far from the parallel of the Coniston limestone; but he believes with Mr. Sharpe, that the greater part of Howgill Fells is made up of the coarse gritty Upper Silurian beds between the Ireleth slates and the Upper Ludlow rocks.

Returning then to the comparison which was the great object of his communication, the author states as his general result,—

1st. That the chlorite and mica slates of Caernarvon and Anglesea have no parallel in Cumberland, being of a distinct epoch from the other rocks in the district, and evidently older. The same cannot be said of the metamorphic and crystalline rocks of Skiddaw forest, which rest on the granite, and pass gradually into the coarse Skiddaw slate. These may have assumed their present structure after the epoch of the Skiddaw slates.

Of the Skiddaw slate also, the author finds no exact representative in North Wales. It is not traversed by contemporaneous beds of porphyry, &c. Though composed of a fine, dark, glossy clay slate alternating with coarse bands, (sometimes, though rarely, passing into very coarse grit,) and though containing in one or two places a quantity of carbonaceous matter, it does not effervesce with acids, and no fossils have yet been obtained from it. Should fossils be discovered in it, they must belong to some of the oldest Protozoic types of our island.

2. That the green slates and porphyries of Cumberland cannot be separated from the rocks of the same mineral structure in Snowdonia. One, however, contains bands of fossils, and the other does not. The porphyries abound so much in Cumbria, that organic beings were unable to exist among them, or their remains have become obliterated.

3. The Coniston limestone represents the top of a series which passes into the *Creseis* and *Graptolite* flagstone, and so also does the Llansaintffraid limestone. The list of fossils from these two groups is also nearly identical, and they both contain some Wen-

(2.) The beds of old red conglomerate on the Lune are not exactly parallel to the beds of "tilestone."

(3.) The conglomerates contain many fragments of the "tilestone," which must have been solid before the conglomerates were formed.

lock fossils and shells. Hence the Coniston limestone does not represent the great limestone east of Bala Lake.

4. The Upper Silurian beds form a very distinct system or group of formations, and the lowest division of the system seems to coincide exactly with the lower Denbigh flags. In all other parts of the upper series there are only analogies of structure, and the groups do not physically represent the groups of the same system in Siluria proper. The upper groups in Westmoreland are more largely developed in North Wales, and contain a fine tilestone, and so far they conform to Mr. Murchison's types.

5. The list of fossils taken as a whole conforms also very exactly to the Upper Silurian lists of Mr. Murchison, but the distribution of the species is very different, because the physical conditions of the deposit were different.

Between the distribution of the species in the upper system of Wales and Cumberland there is a close analogy, because the conditions of deposit were, especially in the lower part, very analogous.

6. The fossils of the lower or Protozoic system form but one group, although some species are found in the Coniston and Llansaintffraid bands which do not appear in the lower beds, and *vice versâ*, and the fossils disappear altogether in descending order.

The author promises to resume the subject, and to give fuller details, and a more copious list of fossils, in a future communication.

April 2. 1845.

The following gentlemen were elected Fellows of this Society:—Waller A. Lewis, Esq., B.A., Capt. Washington, R.N., Albemarle Bettington, Esq., Robert Stephenson, Esq., George Stephenson, Esq., Lieut. Baird Smith of the Engineers, Capt. Thomas Hutton of the Bengal Army, John M'Clelland, Esq., of the Bengal Medical Service, and the Earl of Auckland.

The following communications were read:—

1. *On a supposed* Aerolite, *said to have fallen near* Lymington, Herts. By R. A. C. Austen, Esq., F.G.S.

In this communication the author described a fragment of stone supposed to have fallen from the air, and stated the evidence on which the supposed fact of its being an *Aerolite* was founded.

2. *On the Junction of the Transition and Primary Rocks of* Canada *and* Labrador. By Capt. Bayfield, R.N., F.G.S.

The country to the northward of Lakes Superior and Huron, and of the St. Lawrence River and Gulf, is for the most part a wilderness of primitive or granitic rocks. These rocks, from the northern shores of the two lakes just mentioned, pass close to the northward of Lake Simcoe, and are met with in ascending all the streams tributary to the Rice Lakes, and to Ontario from the north. Sending off a spur to the southward, they are seen at the N. E. extremity of the last-named lake on the immediate shore of the St. Lawrence, which they cross some miles below, forming many of the Thousand Islands, and uniting with the primary region in the northern part of the state of New York.

From Kingston and the Thousand Islands the primitive beds may be traced to the N.E., until they cross the Ottawa River near Lake Chât. Thence, continuing in the same direction, they form the northern side of the valley of the St. Lawrence, and the rapids and falls a few miles up its tributary streams, till they abut upon that river at Cape Tourment, nine or ten leagues below Quebec. From the point last designated, the granitic rocks continue without interruption to form the northern shore of the St. Lawrence river and gulf to the strait of Belle Isle.

To the southward of this wild country, inhabited only by fur-traders or scanty bands of roving Indians, succeeds one of comparative fertility, which it owes principally to the presence of transition rocks, or to the beds of clay and sand that frequently overlie them, and which, in some cases, have been found to belong to the newer pliocene or post-pliocene era.

The object of the present memoir is to trace very generally, but accurately, as far as it is yet known, the line of junction of the fossiliferous transition strata just alluded to, with the primary rocks on which they repose; to point out briefly the fossils and minerals which have been found in each; and to offer such inferences as may fairly be drawn from the cursory examination of a region of such wide extent. It is only the rough outline, and so far as regards the northern district, which is here attempted; the filling up of the picture in all its details, notwithstanding the great progress made by the American geologists, and recently by Mr. Lyell, must be the work of years and of many hands.

Commencing from the extreme west of the line which has been indicated, the magnificent Lake Superior first claims attention. Referring for a description of its rocks and minerals, as far as they are yet known, to the first volume of the Transactions of the Literary and Historical Society of Quebec, it will be sufficient here to notice very generally its principal geological features. The height of land surrounding this immense lake, and on which its numerous tributary streams have their sources at an elevation not exceeding 700 feet above the lake, may be considered as forming an irregularly oval basin, and is every where composed of primitive rocks. The highest hills do not rise beyond 2000 feet above the lake, whose surface is 623 feet above and its extreme depths perhaps as far below the tidal waters of the Atlantic. Primitive rocks form much of the steep and mountainous north coast, and are also occasionally seen on its southern shore. They consist of various granitic compounds, almost always containing hornblende, either as a fourth constituent mineral, or as replacing the mica. Frequently the mica and quartz are both absent, and the rock becomes a syenite, which, by a gradual diminution of its felspar, passes into crystalline greenstone, and whilst in some parts there is thus a complete passage from granite to greenstone, in others the different varieties alternate in immense beds, whose general direction is to the N.E. Basaltic dykes, often of enormous size, traverse these beds, sometimes passing from one to another unaltered, and ranging up the hills for miles.

Associated with these rocks, penetrating them in veins and dykes, or reposing on them, are various trap-rocks, occurring on both sides of the lake and on its islands, but most extensively developed on the northern coast. They consist of various porphyries and amygdaloids, syenites, greenstones, and basalts, the last being occasionally prismatic, with pitchstone in thin layers between the interstices of the columns. Many of these rocks pass into each other, forming endless varieties.

In the primitive rocks, besides the usual constituent minerals, including hornblende, we find schorl, garnet, amethyst and rock crystal; epidote and purple fluor spar associated in veins of quartz in granite; chlorite and green earth, with calc-spar in veins, in granitic and greenstone rocks; sulphate of barytes, with fluor and calcareous spars in a vein of greenstone. The magnetic black and brown oxides of iron, specular and micaceous iron, and iron pyrites, occur abundantly; copper pyrites rarely, in veins in greenstone.

The trap-rocks are rich in minerals. I noticed calcedony, carnelian, jaspers, various and beautiful agates, zeolites (mesotype and stilbite), epidote, augite, olivine, green-earth, fibrous prehnite, fluor-spar, satin-spar, calc-spar, amethystine quartz, and felspar crystals; graphite, and the oxides of iron before mentioned; also copper pyrites, malachite, and native copper. The last occurs, with prehnite, quartz, and calc-spar, in veins in a dark brown porphyritic trap; also in amygdaloid in veins, nests, and wires, which sometimes penetrate fortification agates.

Reposing on the granitic rocks which have been mentioned, there occurs a horizontal sandstone, forming nearly the entire southern shore of the lake, which may be traced in detached portions from one end to the other of its northern shore, and also on most of its islands; the almost unknown Caribou Island, which is so far from the shore that it can only be seen from the mountains in a clear day, being also formed of it. It may, therefore, be considered as a general formation over the basin of Lake Superior. It rises to about the height of 400 feet above the lake, and rests on granite on either shore, excepting where amygdaloids or other traps may have been intruded between. It has been only occasionally upheaved by the granite; but it is often much shattered by the trap-rocks, nodules of which enter largely into the composition of its conglomerates. It is often extensively overlaid, especially in Mepigon Bay, by immense beds of greenstone several hundred feet thick, and sometimes also by amygdaloid, with which it is occasionally, although rarely, interstratified. Large rounded fragments of the trap rocks of the lake, especially the porphyries, occur abundantly in its conglomerates, and sometimes form entire beds near the parent rock. Hence we perceive that volcanic energy was active, or at least had not ceased, during the period of its deposition.

In general, however, this sandstone is composed of fine grains of quartz and felspar, together with rounded particles of primitive and trap rocks; and it is important to remark, that no fragment of the Silurian fossiliferous limestones, known to occur to the northward towards Hudson's Bay and extensively on Lake Huron, was ever noticed in its conglomerates.

Grains of mica are sometimes abundant, especially near its contact with granite. It is sometimes calcareous, the carbonate of lime occurring also in veins. It is often ferruginous, and there are sometimes between its strata thin layers of a black sandstone, which crumbles easily into a black, heavy, and highly magnetic sand, very plentiful on the beaches, and which Mr. Tennant informs me is the titaniferous oxide of iron. On the islands called "the Twelve Apostles," on the south coast, there are beds of ferruginous red marl. In colour this sandstone is often variegated — being red, white, grey, yellow, and dark reddish-brown. The only metallic minerals found in it are iron and copper ores.*

No organic remains having as yet been found in this sandstone, and its junction with the Lake Huron limestone in the river St. Mary's below the rapids being hidden by drift, water, or an almost impervious forest, so as hitherto to have escaped notice, it is difficult to determine with any confidence its place or age. There seems no reason to think that it can be more recent than the old red sandstone; and when it is considered that it appears in the St. Mary's at low levels, forming nearly horizontal strata at the bottom of Lake George, whilst the horizontal fossiliferous limestone of Sugar Island and St. Joseph's rises into higher ridges, so as to make it appear *highly probable* that the sandstone occupies the inferior position; and that, moreover, a sandstone is known very generally to underlie transition limestone in Canada and the United States: when all this is taken into account it is, perhaps, not unlikely that the sandstone in question may belong to the Silurian rather than the Devonian period. On the other hand, its appearance in unworn slabs, that must be near their parent rock in the neighbourhood of Michilimackinac, where great beds of gypsum occur, would seem unfavourable to this conclusion; as may also, perhaps, the red marly beds of the Twelve Apostles.

This sandstone, although not observed in the river St. Mary below

* The principal locality of the copper is about seven miles westward of the eastern extremity of Port Keewawonan, where there is a vein of malachite, with brown and earthy-blue copper, five or six feet wide. This occurs in conglomerate; but the same minerals are found in trap-rocks near the same places.

Lake George, is succeeded to the eastward by the fossiliferous limestone of Lake Huron, which rests in like manner on the primary rocks of the north coast, excepting for a few leagues at La Cloche, where quartz-rock is interspersed between it and the older rocks. This quartz-rock forms a range of hills, which are considered to rise at least 1000 feet above the lake, and can be seen towering over the Manitoulins from a distance of many leagues. It also forms some of the islands between the Great Manitoulin and the main land, where the limestone may be seen overlying it in nearly horizontal strata. Although in some parts highly crystalline, in others it is arenaceous, and passes into a conglomerate of great beauty, being studded with nodules, both rounded and angular, of various coloured jaspers, quartz, calcedony, carnelian, &c. This rock occurs in immense cubical blocks; its stratification is obscure; and its prevailing direction to the N.E.

Dr. Bigsby, in a paper read before the Geological Society in 1823*, has given a description of the rocks and minerals of Lake Huron. A recapitulation is here unnecessary. I shall merely observe, that the primary beds and accompanying traps do not occur on the same scale of grandeur as on the shores of Lake Superior; they are less elevated, more shattered, and less uniform in direction, although the predominating strike is still to the N.E. An obscure dip to the S.E., at a high angle, is discoverable occasionally, but only when the structure of the rock is gneissose, which is more often the case than on Lake Superior. The granitic compounds very frequently contain hornblende.

But the limestone of Lake Huron, like the sandstone of Lake Superior, is a general formation over the whole lake. It is found, as already observed, reposing on primary rocks at many points along the northern shore from one extremity of the lake to the other. It forms the large island of St. Joseph's, and the point of land that separates the river St. Mary from the strait of Michilimackinac; the S.W. coast as far to the south as Sagana Bay; the entire range of the Manitoulin Islands; the great promontory of Cabot's Head; and the eastern coast fifty or sixty miles to the southward and eastward of it; and it probably extends much further in that direction beneath the beds of sand and clay so prevalent in western Canada. In Dr. Bigsby's paper already referred to, and in a paper read before the Society in 1837, will be found an interesting description by Mr. C. Stokes of some of the most characteristic fossils of this limestone, especially of the *Orthoceratites*, and the museum of the Geological Society contains many specimens from various localities. These, although probably far from comprising a complete series, seem nevertheless sufficient to enable us to assign to this limestone its analogous place among European strata. Among those fossils we may point to the *Spirifer lynx* (?) and *Pentamerus oblongus*, as indicating a considerable ascending range in the Silurian system of Mr. Murchison; and the numerous corals which were mostly found in the upper

* Geol. Tr. 2d Ser. vol. i. p. 175.

beds of Drummond Island and the other Manitoulins, would lead us to the same probable conclusion.

And this is what we ought to expect when we consider that this limestone, although termed horizontal, is not strictly so. In the comparatively small space which the eye can take in at a near view it appears so; but when we view the islands with their cliffs as a whole, from a distance, or observe the gradual ascent of the limestone plains as we proceed inland over the barrens on the south side of the Great Manitoulin, and their gradual descent under the waters of the lake in the contrary direction, we perceive that there is a dip to the southward of some feet in a mile, which, continued for 100 miles or more, must give a very considerable thickness of strata.

From the eastern extremity of Lake Huron, and still advancing eastwards, we trace the Silurian limestone with similar fossils, across to Lake Simcoe, to the Rice Lakes, and, on the north of Ontario, to Kingston and the Thousand Islands*, and thence again, north-eastward by Perth, Bytown, and Lake Chât, across the Ottawa River † to Montreal and Quebec. It may also be seen at various intermediate points along the northern side of the valley of the St. Lawrence. At Port aux Trembles for instance, about six leagues above Quebec, we find it containing, among other fossils, *Calymene Blumenbachii*, and a species of *Chætetes*, which M. de Verneuil informs me is allied to *C. petropolitanus*. The limestone here dips to the S. E. conformably to the grauwacké, which contains *Leptæna sericea*, on the opposite or southern shores of the river. This latter circumstance, together with the statements of an anonymous writer in the Canadian Review ‡, that the limestone near the falls of Montmorenci declines gradually from the horizontal position till it finally dips at a high angle beneath the grauwacké ; and that a conglomerate, wholly composed of re-cemented fragments of limestone containing the organic remains peculiar to Beauport, the falls of St. Charles, and Indian Lorette, is one of the alternating members of the grauwacké and slate series, incline us to assign to this limestone a position inferior to the grauwacké and slate, and low down among the Silurian strata. This view is strengthened by the occurrence of a similar limestone on Lake St. John underlying clay slate, and containing *Isotelus gigas* and an *Ormoceras*, like those of Lake Huron, &c. Considerable difficulty, however, has been felt in admitting this, because the limestone has so very generally been found in nearly horizontal strata, resting immediately on primitive rocks in very near neighbourhood to the highly

* Here, and also near Kingston, masses of sulphate of strontia and calc-spar, with disseminated iron pyrites and sulphate of zinc, are found in the limestone.

† On the Ottawa, above Lake Chât, and also on the St. Lawrence, near Gananôqui, primary white granular limestone occurs extensively, associated with green serpentine, steatite, compact and fibrous asbestus, and occasionally containing, as I am informed by Mr. Tennant, brucite, tremolite, plumbago, and mica.

‡ In an article in the second number attributed to Dr. Bigsby, and published some years ago.

inclined grauwacké and slate; but, on the other hand, it must be remarked that it has never, as far as we know, been found overlying the latter unconformably, although sandstone or conglomerate is occasionally interposed between it and the granite or gneiss, as among the Thousand Islands, and on the rivers St. Maurice and Montmorenci.

The northern shore of the St. Lawrence River and Gulf, from Cape Tourment, ten leagues below Quebec, eastward to the Mingan Islands, is composed of primary rocks; the limestone and the grauwacké which form the islands and southern shore of the river, appearing in immediate contact with them only at St. Paul's and Murray Bays, and, more extensively, on Lake St. John, up the Saguenay River, as already mentioned.

For a more particular description of the primary rocks of this coast, and also of the Mingan Islands, with their raised beaches, limestone columns, &c., I must refer to a paper read before the Geological Society in 1833, and printed in their Transactions*, which was accompanied by specimens of the fossils which I have now added to, and which have been examined by M. de Verneuil, to whom I am indebted for their specific names, and many valuable remarks respecting them. On this occasion it will be sufficient to state, that the Mingan Islands extend for about fifty miles along the north coast of the Gulf of St. Lawrence, opposite the great Island of Anticosti, from which, at the nearest point, they are distant about nine miles. None of them are more than three miles distant from the main land, where the limestone may be seen at various points resting immediately on granitic rocks.

The Mingan Islands are entirely composed of limestone, having a slight dip to the southward. So also is the Island of Anticosti, which, from its relative position to the southward, and similar dip, may be expected to be higher up in the Silurian series. The limestone of these islands resembles that of Lake Huron, in being very nearly horizontal; although there is a slight dip, which, continued for many miles, must give a very considerable thickness to the whole range, measuring from the lower beds that rest on the granite of the mainland to those that dip gradually beneath the sea on the southern coast of Anticosti, or form the summits of the unvisited ridges of the interior of the island, five or six hundred feet above the sea.

The following are the most abundant fossils of the islands of Mingan:—

1. Illœnus crassicauda.
2. Orthoceras duplex.
3. Orthoceras annulatus.
4. Euomphalus.
5. Terebratula plicatella (not Sow.).
6. Euermis ?
7. Leptæna Humboldtii.
8. Pleurotomaria.

And of the Island of Anticosti:—

1. Spirifer lynx (Eichwald), var. of S. biforatus (Schlotheim).
2. Orthis, allied to O. elegantula.
3. Leptæna Humboldtii (De Vern.).

* Geol. Tr. 2d Ser. vol. v. p. 89.

4. Leptæna sericea.
5. Orthoceras.
6. Favosites gothlandica.
7. Atrypa reticularis ; (syn. A. affinis & A. prisca).
8. Turbo.
9. Pentamerus oblongus.

These, although doubtless far from comprising all that may be found, will be sufficient to establish the Silurian character of the limestone of these islands, and to show the general resemblance of the fauna to that which is indicated by the organic remains of similar formations occupying an analogous position in Europe.

From the Mingan Islands to the Strait of Belle Isle, the coast of Labrador consists exclusively of primary rocks, but on the east side of Bras d'or Harbour we meet with transition sandstone, which at one point appears to pass distinctly into gneiss. The sandstone extends about thirty miles along the northern side of the Strait of Belle Isle, from Bras d'or to the eastward, and forms table-lands 400 or 500 feet high, with cliffs towards the sea, and terraces ascending one within the other to considerable distances inland. These seem due to aqueous denudation, and, like the inland cliffs and flower-pot columns of the Mingan Islands, may mark, although less distinctly, successive periods during the emergence of the sandstone from the sea. This sandstone occurs in nearly horizontal strata, dipping, if at all, very slightly to the southward, and resting on granite. On the eastern point of Fortean Bay, a red and white limestone * underlies the sandstone, and contains *Cyathophyllum ;* which fact, together with its position, immediately reposing on granite, affords the only data from which to infer the relative age of this formation.

The opposite, or Newfoundland side of the strait is of limestone ; containing, at Cape Norman, *Orthoceras duplex*, *Orthoceras* allied to *O. annulatus*, *Euomphalus affinis*, *E. gualteriatus*, and *Clymenia ?* or *Lituites*. I observed this limestone, which is in nearly horizontal strata, as far to the southward along the west coast of Newfoundland as Port Saunders, and it probably extends still further in that direction. It is then succeeded by sandstones, and perhaps by other rocks in ascending order to the coal, which is reported to occur in St. George's Bay.

At Chatian Bay, and also at Table Point, opposite Belle Isle, we met with columnar basalt † capping granitic hills, at an elevation of about 200 feet above the sea. The basalt is in vertical prisms 25 or 30 feet high, having from five to eight sides. It is black, ferruginous, magnetic, and contains crystals of olivine. It rests, at Table Point, upon a conglomerate of rounded pebbles of quartz and felspar, with oxide of iron and silvery mica, the whole so changed by the contact that, in some hand specimens, we might almost take it for granite. It has also acquired an irregularly prismatic structure, large columnar masses of it breaking away

* It is worthy of remark that a somewhat similar limestone, but destitute of organic remains, was observed by Dr. Bigsby underlying and alternating with sandstone at Thunder Cape on Lake Superior.

† Literary and Historical Society of Quebec, vol. i. p. 71.

from the cliff from the effect of the severe frosts of winter. It occurs in a horizontal bed or stratum, about ten feet thick, forming, together with the incumbent basalt, a tabular oval mass, about three quarters of a mile in diameter, with cliffs 40 or 50 feet high, resting on granite. Both its irregularly prismatic and partially crystalline structure seem due to the effect of the basalt which has flowed over it. There is also an altered sedimentary rock under the basalt of Chatian Bay, where the change from sandstone into a ferruginous shale has been nearly completed.

These isolated patches of basalt and conglomerate, capping granitic hills at the same elevation, and at the distance of fifteen miles apart, appear to be the denuded remains of an extensive formation.

In the mica schist which occurs on the north side of Henley Island, near the basalt just mentioned, there occurs a large vein, containing a beautiful aggregate of green and white felspar, with quartz, oxide of iron, mica, and garnets. Chlorite, with specular iron and hornblende, occurs in the same locality.

It would swell this paper to an inconvenient length to enter into a particular description of the primary and trap rocks of the region, or the minerals which they contain; but we may mention briefly that mica-schist prevails most near St. Paul's Bay, where it abounds with garnets, and where chlorophane was found. Further eastward hornblende and felspar predominate, forming, with or without quartz and mica, various compounds. Between the Seven Islands and Mingan, bronzite or hypersthene, hornblende, felspar, and the magnetic black oxide of iron, form a rock which occupies many miles of coast.* Shorl, epidote, garnets, and micaceous iron were noticed in the various granitic compounds which occur on this long line of coast.

Having thus, very generally, traced the line of junction, doubtless once continuous, of the transition strata with the primary rocks, from the head of Lake Superior to the Strait of Belle Isle, and having pointed out the occurrence of Silurian limestone at the northern extremity of Newfoundland, and shown that the intervening rocks up to the coal may probably be found along the western coast of that island, I shall conclude with some brief and very general remarks on the ascending succession of the rocks of eastern Canada, as exhibited along the shores of the district of Gaspé.

At Cape Rozier the grauwacké and slate rocks which were observed forming the southern shore of the St. Lawrence below Quebec, at every point where we had an opportunity of landing, are succeeded by the Cape Gaspé limestone, forming cliffs 900 feet high, and dipping conformably at an angle of about 25 degrees to the S.S.W. It contains *Orthoceratites*, *Producta*, *Encrinites*, and corals, of which I regret that the specimens have been lost. Thin veins of galena and blende also occur in it, but are not worth the working.

* The felspars are often striated, and sometimes opalescent.

This limestone is succeeded in ascending order by a series of shales and sandstones all highly carboniferous. The sandstone on the north side of Gaspé Basin is calcareous, and contains, according to Mr. De Verneuil, *Orthis*, *Leptæna* (*Chonetes*) *sarcinulata*, approaching to the Eifel species; *Terebratula*, a large variety, and two other smaller species; and *Chonetes affinis* (*C. papilionacea* of the coal measures), described by Phillips as a *Spirifer* (*S. papilionacea*).

The shales and sandstones are much disturbed, but nevertheless preserve a general dip to the southward. Proceeding in that direction across Mal Bay, we find a variegated reddish, yellowish, and white crystalline limestone, with concentric concretions, and without organic remains, supporting conglomerate and red sandstones; the latter forming the summit of Percé Mountain, 1300 feet above the sea. The general dip is here also to the southward, or S.W. Organic remains are reported to have been found in the adjacent Percé rock, but I have not seen them.

Bonaventure Island is of conglomerate nearly horizontal. As we proceed up the Bay of Chaleur we may notice the red sandstone forming cliffs in nearly horizontal strata in the bays, whilst the points are in general formed of harder rocks. These are sometimes trap-rocks; at others, hard conglomerate, whose nodules seem glazed, as if they had been dipped in the siliceous and calcareous fluid, which in cooling had formed the cementing agent in the formation of the rock. I also noticed reddish and greyish limestone abounding with the stems of Encrinites; but other fossils appeared very rare; and I only found a *Terebratula* allied to *T. ferita*. These limestones occur principally at Port Daniel, and, together with the associated conglomerates and sandstones, are very much disturbed; but the red sandstone is less so than the rest, and is doubtless the uppermost of the series. We have now arrived near the southern extremity of the district of Gaspé, and I have communicated all the scanty information as yet possessed respecting this interesting part of the country, where the rocks that intervene between the Silurian strata and the coal may perhaps be best studied. The limestone of Cape Gaspé has hitherto been considered analogous to the mountain limestone; but the fossils of the calcareous sandstone of Gaspé Basin which I have enumerated, and which Mr. Lyell, I believe, considers Devonian, will render it necessary to reconsider this subject. The highly carboniferous sandstones and shales that succeed to the southward, the occurrence of petroleum springs, and of an impure coal in small quantities near Percé and at Port Daniel, assist us in referring the rocks of this part of the country to the carboniferous period, thus indicating our approach to the coal measures of New Brunswick, on the opposite side of the bay where coal fossils are found.

April 16. 1845.

On the supposed Evidences of the former Existence of Glaciers in North Wales. By Angus Friend Macintosh, Esq., F.G.S.

The author states, that having noticed some remarkable phenomena in a part of North Wales, which seemed to militate strongly against the theory advanced by Prof. Agassiz, and supported by Dr. Buckland, on the subject of glaciers, he was induced to examine carefully the district in question, and that, after long investigation, he has formed a decided opinion that the district affords no sufficient proof of the former existence of glaciers in any part of it. He then considers *seriatim* the different points of evidence that have been adduced and their value.

1. *Rounded Surfaces of Rock.*—These appearances, which have been referred to by Dr. Buckland * as having been caused by glacial action, abound in several of the Welsh valleys, in some instances (near Bedd-gelert and the pass of Llanberis) at the height of 800 and 1000 feet, and in others at a very much more considerable elevation. If, however, it was by the agency of ice that such rounded surfaces were produced, the valley must have been entirely occupied by the glacier, which in some cases it would seem must have had a thickness of at least 2500 feet. This indeed is according to M. Agassiz' theory, that the ice extended downwards to the plains, and covered the surface; but the modified form of it adopted by Dr. Buckland does not in the author's view account for the existence of the rounded masses, since they are promiscuously dispersed in some of the valleys, occurring in numerous and very different directions, and often where no true glacier could be supposed to have reached them.

The want of height in the Snowdonian hills is adduced by the author as an argument that such vast bodies of snow and ice could not have been formed on them, since the length of glaciers is known to be in the ratio of the height of the mountain whence they proceed; and he further observes that the glacial theory with regard to these rounded surfaces is also strongly opposed by appearances which occur on both sides of the lower Llanberis lake on the old Bangor road, near the south end of the Penrhyn quarries in the valley of Nant Francon at its upper extremity, and in several other places. Here the rounded surfaces are seen immediately in contact with, and directly under cover of, other masses higher than themselves, these latter standing immediately before them in the line of descent, and yet having their edges, over which the glacier must have passed (if it rounded the rocks below), angular, and

* Proc. Geol. Soc. vol. iii. p. 579.

occasionally even sharp. Other rounded surfaces are met with in the deep sharp angles of rock, and in recesses where it is not to be conceived that a glacier could have forced its way, and produced this effect, leaving the inner sides of these recesses unworn by friction and their edges angular. In some of these cases the rounding of the narrow parts is perfect, and they are occasionally even fluted in a manner identical with that of other flutings in the exposed and open parts of the rock.

The author then refers to another example of rounded, grooved, and striated rocks seen in the valley of the Ogwyn near the bridge, where the river as it issues from the lake forms a cascade at a spot close to the high road. The rounded rocks here are described as weathered; but "quartz veins which traverse the masses, and project two inches above the surface, are polished and rounded on the edges;" and in this group of rounded, dome-shaped bosses, some of the surfaces are fluted, the furrows being regularly parallel and equidistant, and as nearly as possible of the same width and depth.

At first sight the appearance here presented seems to be referable to glacial action; but the author observed that the direction of the flutings is opposed to that of the valley; that the striæ or furrows which are not parallel are likewise not in the direction of the line of the valley, but range at all points of the compass, many of them crossing one another irregularly, and others having a radiated appearance, and that in the midst of the parallel furrows on the rounded smooth faces of rock are projecting portions of the same rock, some of them rounded, fluted, and striated at the tops, but angular at the edges, and not rubbed at the sides, while smaller portions, scarcely an inch thick, stand fully exposed in the line of descent which a glacier must have taken, presenting the appearance of thin portions of schist full two feet in height, and almost as much in breadth, perfectly unaltered. Although the rounding of the general surface has taken place on each side of them, the flutings are in absolute contact with them, and there are striæ between and even upon them. It seems clear, that had the rounding of the rock been effected by the passage of a glacier, these fragments must necessarily have been swept away, and thus the rounding of the rocks must be due to some other process.

It is the opinion of the author that this rounding took place beneath the sea, and that the repeated undulations of the strata parallel to the principal mountain chain in the district, forming a succession of anticlinal and synclinal axes, have been the original cause of the formation of the oblong bosses and rounded rocks, while the fracture of the beds has produced the furrowed appearance. It is also suggested as explanatory of this view that, at the time of the disturbances which produced these undulations, the rocks may have been only partly consolidated, and that thus the long parallel lines at first produced might readily be acted on by the marine currents, which were sufficiently powerful to clear off the sharp edges, but not to remove the projecting quartz veins.

The author concludes this part of his memoir by stating his belief that even where this view of the origin of the bosses does not apply, he believes that sub-marine, and not glacial, action must be referred to, since many of the rounded rocks possess features which render it extremely unlikely that they could have been rounded by glaciers, while others are so circumstanced that it would seem to have been absolutely impossible.

2. *Fluted and striated Surfaces.* — Having shown that the rounding of rocks was in all probability not effected by glacial action in North Wales, the author proceeds to show that the fluted and striated appearances, also referred to the passage of large bodies of ice, are really due to other causes; and he first considers an example referred to by Dr. Buckland, and situated about 100 yards below the bridge of Pont-aber-Glasslyn, near Bedd-Gelert, on the right bank of the river.

At this spot the rocks are rounded and polished, and covered by flutings and striæ generally parallel to the course of the valley; but the author observes that such is not always the case, some of the striæ being very oblique, and some actually opposed to this direction.

The flutings in the instance now under consideration are also considered to be more regular, more accurately parallel, and more symmetrically placed than could be the case had they been produced by the passage of a glacier. These flutings in the Snowdonian schists rarely vary in any perceptible degree on the same surface; there is little or no distinguishable difference in their depths or breadths; and however numerous the lines, they are uniformly and strictly parallel. They are also at equal distances from each other, and are so similar in different valleys that the resemblance is striking. Phenomena of such a kind must, it is concluded, be *structural;* and the author believes that not only do the furrows but also the striæ — which are not parallel, but more or less oblique and irregular — owe their existence to the internal structure of the rocks.

The flutings and striæ of the rocks in the valley of the Llugwy between Pont-y-Gyffing and Capel Curig, described by Dr. Buckland, are next alluded to. In this case the fluted lines on some of the rocks on the Bangor or western side of the large dome-shaped masses mentioned by Dr. Buckland, are stated to be in actual opposition to the direction of the valley, although such flutings agree in all their characters with others in the direction of the valley, being parallel to one another, equi-distant, and as nearly as possible of the same width and depth. That these flutings are natural furrows, and not due to glacial action, the following facts are then adduced by the author as sufficient proofs.

In the first place it is stated that close to the large dome-shaped masses at about 200 yards from their western base, nearly opposite the road which leads to Capel Curig, there are certain low rounded rocks or bosses marked with furrows at right angles to one another, and that the same occurs on a small mass of schist about midway on the north side of the lower Llanberis Lake. These rocks also are regularly furrowed in continuous parallel lines, not only from top to bottom, but on each of the sides accessible to view. The furrows must, therefore, be structural phenomena.

Secondly, that the parallel markings on the conglomerates opposite Capel Curig to the north are broader, deeper, and wider apart than those of the schists which they overlie, agreeing apparently with their wider and larger lines of bedding.

Thirdly, that in these conglomerates are contained fragments of the schist, some of them about half a foot square, marked with regular parallel flutings at equal distances, exactly in the same manner as the rocks *in situ*. These marks are by no means in the direction of the valley, but indifferently in every direction according to the position of the fragment in the conglomerate; and the matrix in which they are contained is entirely free from such markings, while the furrows are not merely to be traced on the exposed parts, but are continued within the substance of the conglomerate, the lower or buried sides being fluted in the same manner as the upper portion.

Hence it appears from the condition of these bedded fragments, first, that glacial action could not have produced the flutings and furrows observed upon them, since the direction of the furrows is not that of the valley; next, that such glacial action could not have been the cause of the rounding of the rocks, since, in that case, the fragments in question would have been carried away, instead of left standing, as they are, half an inch above the surface; thirdly, that the rounding in question must have taken place after the consolidation of the schists, but while the conglomerates were still comparatively soft; fourthly, that the furrows were produced before the formation of the conglomerates, and were for that reason independent of any glacial action, and, in all probability, structural; and, lastly, that the furrowing and the rounding of these rocks are entirely distinct and independent phenomena, due to very different causes.

Another example of furrowed rocks is seen on the right bank of the lower Llanberis Lake, close to the quarry railway, and rather more than midway from the upper end of the lake, where a low oblong rock, consisting of a coarse bluish slate, passes somewhat abruptly into a conglomerate. This rock is rounded and fluted, but the flutings cease exactly where the conglomerate begins.

The *striæ* or markings not parallel to one another observed on many rocks, and referred by some to glacial action, are likewise considered by the author to be structural phenomena, since they occur in situations where the passage of a glacier could hardly have produced them, as in narrow recesses of rock, the edges of which are angular, and on the projecting fragments of beds, the rest of which have been denuded. These striæ are generally narrow and shallow lines, seldom more than a quarter of an inch in breadth but usually less, and some of the thinner ones, having the appearance of straight scratches, seem to be parts of weathered cleavage lines, appearing interruptedly here and there.

The author believes that other striæ, more or less oblique and irregular, and occasionally intersecting the former, have arisen from cracks. The markings of this kind are rarely if ever curved, differing in this respect from the glacial striæ described by M. Agassiz, while they are often bent at an angle, and occasionally in such a manner that it is difficult to understand how a descending body could have produced them. They also, many of them, have flat surfaces, unlike the scorings produced by the pressure of angular fragments. That such striæ, or at least a large number of them, were originally mere open splits or cracks, to which exposure has given their present appearance, is suggested by the author as probable, since, in many instances, they bear an almost exact resemblance in width, length, angular character, and general form to certain open cracks appearing on the surface of schists which have been only a few years exposed, and of which examples may be seen in the Penrhyn quarries on the south side, and again, very strikingly, close to the Ogwyn Lake.

Referring once more to the furrows or flutings before described, the author next states that, according to his observation, these markings are always parallel to the cleavage, and correspond to one of the sets or series of narrow lines or joints, called by the quarry-men "Water-splits," which are also parallel to the cleavage, and are about half an inch apart. These water-splits are in some cases quite open, in others they are seen partially filled up, and in others, again, the process is farther advanced, and the furrowed or fluted appearance is distinct. There is also a striking agreement in the general width of these open lines with those of the flutings, so that, on the whole, he concludes that the water-splits or what he denominates "open cleavage joints," have been the origin of the parallel flutings *; and open cracks that of most of the striæ. He also states that the existence of scratches, properly called "structural," can be distinctly proved on a small scale, since even the weathered coatings of the schists, thin as they sometimes are, have their own peculiar striæ; and although it requires the aid of a magnifying glass to see them, they then show clearly as minute delicate lines of an inch or two in length, very numerous, more or less straight, and often intersecting one another. They are, however, resemblances in miniature of certain apparent scratches belonging to the rocks.

The author then adverts to similar phenomena of striated and furrowed rocks, described as occurring in America, and which have been explained by Prof. Hitchcock on the glacial hypothesis, but which neither that hypothesis nor the passage of ice-floes over the surface are sufficient to explain satisfactorily. The view advocated above, of the structural nature of such markings in the

* Examples of open parallel lines occur on the right bank of the lower Llanberis Lake, and in the large adjoining quarries of Mr. Assheton Smith.

Welsh slates, is also suggested as the probable explanation of similar appearances elsewhere.

3. *Polished Rocks.*— The surface of rocks of various kinds and at very different elevations, has frequently been observed to exhibit a polish, which has usually been attributed of late to the action of ice. The author considers that some of these cases are doubtful; that the polish is not of long endurance when the surface is exposed; and that in some, at least, of the examples in North Wales, the polish has been produced by the sliding of boys on the smooth rock. This latter explanation he considers as sufficient in the case mentioned by Dr. Buckland at Bedd-Gelert, near Pont-aber-Glasslyn, where a portion of surface, measuring about 15 feet by 2 feet, is obviously polished, but where the rock is weathered, and does not exhibit the appearance except at this spot. Another example at Bedd-Gelert, at the north-east of the village near the turnpike, also quoted by Dr. Buckland, is considered by the author insufficient to support the glacial theory; since, although in this case the rock is intersected by numerous quartz veins which project about two inches above the surface, but preserve their polished and rounded outline, other similar appearances, which could not have been produced by ice, occur also in rounded rocks, as, for instance, in narrow recesses having angular edges which no glacier could have touched. The author considers that, as such apparent polish is not seen in the great majority of cases, it may be due to varying mineral conditions *; but he expresses his conviction that, as the surface apparently polished has, in every case that he examined, been manifestly a weathered surface, it cannot possibly have been produced by glacial action, since the actual surface would in that case be exhibited, and not the weathered coating, which is necessarily of much newer date. At any rate, whether, as he believes, the polishing of rocks is *in no case* attributable to ice, in any shape, but always to some other mechanical causes, or to atmospheric exposure; or whatever the cause may be, the polish cannot have been retained unaltered during so long a period; and even if it could, since this appearance belongs, not to a freshly exposed surface, but to a surface covered by a film of decomposed rock, it certainly was not that over which the ice passed.

4. *Moraines.*—The instances adduced by Dr. Buckland in North Wales as referable to this class of glacial phenomena are considered by the author as unsatisfactory; and he refers, first, to the elevated plain of Pentre-Voelas, said to present large accumulations of unstratified detritus having the aspect of moraines, but supposed to have been afterwards modified by the action of water. It is objected, that in this detritus there are no true rounded and striated blocks nor rounded pebbles, neither are there mixtures of different fragments of all forms and sizes, such as usually belong

* The author here observes, as an additional argument against the probability of glaciers having formerly existed where this so-called polished rock appears, that the rock abounds with concretions standing in relief above its general surface.

to moraines. It is also observed that the physical structure of the country round Pentre-Voelas is that of an open and widely extended plain, — Snowdon being twenty miles off, and there being no height of any consequence much nearer; so that it is impossible to conjecture whence such enormous masses of ice could be derived, or how they could have been urged forwards to distribute the detritus.

The next instance alluded to is between Pont-y-Gyffing and Capel Curig, and consists of a mound of gravel close above certain dome-shaped hummocks, in front of the confluence of the upper valley of the Llugwy with that of Nant-y-Gwyrd. In this case, however, the author discovered, on examination, that what appears to be a mound of gravel is merely a low wavy ridge of schist, whose ragged and weathered surfaces seem, at a little distance, as if covered with fragments; although, in fact, they are nearly bare. The author therefore believes that no such gravel exists on the spot alluded to.

Another of the supposed moraines referred to by Dr. Buckland occurs near the elevated lake of the Flynnon Llugwy, north of the road leading from Capel Curig to Bethesda. It consists of two principal streams of blocks, one extending downwards in a S.W. direction from near the lower end of the lake for about two miles and a half; the other taking an opposite course, and reaching partly across the upper end of the valley, a distance of nearly half a mile. The former of these groups is marked by no glacial feature, and is chiefly remarkable for its length and its general conformity to the curves of the river; but the latter or smaller group exhibits at its further extremity four or five detached piles of angular blocks about twenty feet in height. Near its point of commencement also, on the west side of the valley, it passes over two mounds, 20 or 30 feet high, covered with peat and herbage; and a similar mound, somewhat larger and higher, occurs at the other end of the line, having also blocks upon its top.

The author considers that the blocks forming this group have descended from the mountain on the western side of the valley, but that, since there are no rounded blocks and flat-sided pebbles, such as are seen in Alpine glaciers, and indeed no traces of glacial action, the deposit must have found its way from the mountain, traversing a distance of nearly half a mile, and that some of the blocks, after crossing the little stream of the Llugwy, have ascended for perhaps 20 or 30 feet above it. This transit, it is considered, may have been effected by the aid of snow and ice, though not in the form of a glacier; and in support of this view, two occurrences are described bearing upon the point. One of these took place in the winter of 1813-14, when drifted snow had so accumulated in the course of several weeks near the mountain stream called the Affon Bertham, in the valley of Nant Francon, that it formed a deep broad sloping talus, above a quarter of a mile in length, so compact that men and horses and fully-laden carts frequently passed over it; and the other, in the same valley, only five or six winters ago, at a spot called Cefn-y-Orsidd, where the slope of the mountain ridge is about 15° or 20°, and where numerous blocks frozen together became suddenly disengaged by a thaw, and moving downwards on sheets or sledges of ice, they travelled over a space of nearly 400 yards, and were there checked by the resistance of a wall, part of which, however, was broken through and removed. From these instances, occurring in our own country at a moderate elevation, it will be seen to be possible that boulders, even of considerable size, may be removed without glacial action.

With regard to the Flynnon Llugwy boulders, therefore, as there appears no evidence of their being due to glacial action, their presence may be better accounted for in some such manner as this. The author concludes by observing concerning them, that they do not, as Dr. Buckland considers, repose on small gravel, except near the river, and where this gravel has been subsequently washed under them.

April 30. 1845.

On the PALÆOZOIC DEPOSITS *of* SCANDINAVIA *and the* BALTIC PROVINCES *of* RUSSIA, *and their relations to Azoic or more ancient crystalline Rocks; with an account of some great features of dislocation and metamorphism along their northern frontiers.* By RODERICK IMPEY MURCHISON, V. P. R. S., V. P. G. S., Pres. Roy. Geog. Soc., and Cor. Mem. Inst. Fr.

THE views of my friends, M. de Verneuil, Count Keyserling, and myself respecting the geological structure of large portions of Russia, particularly in reference to the palæozoic succession of that country, have been already laid before the Society. In those communications allusions were made to the absence of a well-defined base line for the Silurian rocks of the Baltic and the eastern governments of the empire, owing in some instances to the interposition of arms of the sea, or great interior lakes; in others, to great masses of detritus, which occupy the surface along the boundary line; and in others again to the prevalence of eruptive rocks, which have to a great extent metamorphosed the sedimentary masses conterminous with the crystalline rocks of Lapland.

To remedy, if possible, what would have been serious defects in a work on the structure of Russia which is about to be published, and to satisfy myself as to whether the great masses of crystalline rocks which range from Scandinavia over Finland and Lapland, were truly more ancient than any thing to which the term "Silurian" could be applied, or were simply metamorphosed portions of the Silurian system, as some geologists had supposed, I last year visited Norway, Sweden, and Finland, and again revisited St. Petersburg. Having now adopted definite views on this subject, having also completely satisfied myself respecting those tracts which are referable respectively to lower and upper Silurian rocks, and having observed a copious development of old red sandstone in Norway, as well as a very remarkable junction between its Devonian equivalent and the lower Silurian rocks of the government of St. Petersburg, I now lay the result before the Society, communicating both those general views which will appear in the forthcoming work on Russia, and also some details respecting Norway and Sweden which do not appear therein. The remarks which I now make on Scandinavia are, however, to be simply considered as the first of a series of communications which I hope to be able to continue by subsequent surveys of that region, in which I have the promise of being joined by M. de Verneuil.

The present memoir is therefore to be regarded as an outline sketch only of certain broad lines of demarcation to which it is essential that geologists should attend when investigating similar phenomena which have not yet been sufficiently worked out.

It will readily be understood when a few of the more prominent facts of the case are laid before the reader, that in order to give a history of the whole series of sedimentary deposits of Russia, we must commence with a sketch of the adjacent Scandinavian regions, which, chiefly occupied by highly crystalline rocks, are in many places covered with patches of ancient strata containing organic remains.

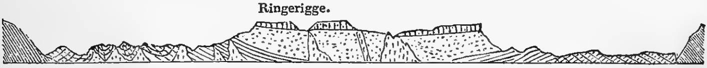
The fossils, indeed, described by several writers, had shown that true Silurian deposits existed in Sweden and Norway, and it was therefore necessary for us to see and describe the absolute contact of the lowest sedimentary strata with the crystalline rocks of that region. We have come to the conclusion that the lowest of these beds that are fossiliferous are the exact equivalents of the lower Silurian strata of the British Isles, and that they have been formed out of and rest upon slaty and other rocks which had undergone crystallisation before their particles were ground up to compose the earliest beds in which remains of organic life appear. We apply to these crystalline masses, therefore, the term *Azoic*, simply to express that, while as far as research has hitherto gone no vestiges of living things have been found in them, so also from their nature they seem to have been formed under such accompanying conditions of intense heat and fusion, that it is hopeless to attempt to find in them traces of organisation.

The great extent of the crystalline rocks in Scandinavia is one of the features which first strikes the ordinary observer with surprise. They occupy the great bulk of Sweden, and are at present undergoing very careful examination and minute description by several able mineralogists in Norway. They rise into mountains, and form the flanks of troughs containing palæozoic strata, which have in their turn been invaded by granitic, porphyritic, and trappean rocks of another epoch. Although extremely broken up and diversified by various plutonic rocks, and very much dislocated, the lower members of these ancient strata consist of quartzose sandstone and hard slaty schists, the former visible in some tracts only, as at Vigersund on the Drammen, the latter being the well-known fucoid alum-shale of the country, and forming the prevalent base in the Christiania fjord. These lowest strata are surmounted by black limestones and shale, charged with fossils, which leave no doubt that the inferior group represents the lower Silurian rocks of the British Isles.*

As a whole these lower Silurian rocks of Norway have very little of the arenaceous character which the same group assumes in certain tracts of Britain, but are most analogous to the schists and calcareous flags of Llandeilo, where those masses have not assumed a slaty structure. This lower division is overlaid by shales and massive coralline limestones, containing many of the typical species of the Wenlock limestone in the British Isles, and these again by calcareous flagstones and schists, which from their fossils and position may be taken to represent the Ludlow rocks.

The Silurian strata of Norway are thus clearly divisible into an upper and a lower group, with an intermediate limestone loaded with *Pentamerus oblongus*, and corresponding, therefore, to the Woolhope or Horderly limestone of the British Isles : but these two groups constitute one inseparable and closely connected system, the uppermost beds of which, composed of calcareous sandstones containing *Leptæna lata*, a peculiar *Spirifer*, and a shell closely allied to *Terebratula Wilsoni*, are overlaid in the mountainous tract called the Ringerigge (see annexed section), by red

Ringerigge.



quartzose sandstone and shale that forms a deposit of great thickness (perhaps 1000 feet), lithologically undistinguishable from the old red sandstone of the British Isles. Thus the beds of this latter group (the old red sandstone) broken through by great tabular masses of porphyry, are separated from the ancient gneiss on either side, and occupy a lofty tract in the centre of the trough, having the Christiania fjord on the one side, and the Steens fjord and Drammen on the other, both of which depressions are filled with the Silurian rocks in question.

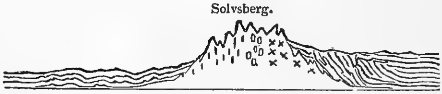
In the Steens fjord the symmetry with which the upper Silurian flagstones and tilestones rise out from beneath the great mass of the old red sandstone, is very striking ; and in carrying the same section across to the gneiss range on the west bank of the Drammen, the upper calcareous coralline formation is separated from the black Silurian flags by the same limestone, containing *Pentamerus oblongus*, which forms the intermediate bed between the upper and lower Silurians in many parts of the British Isles. But whilst

* Among the fossils from the inferior members of the series (the lowest beds of which contain fucoids) are found the genus *Battus* or *Agnostus* with *Paradoxides* or *Olenus*, and in other beds *Trinucleus Caractaci*, *Asaphus Buchii*, and *A. tyrannus*, with various *Orthoceratites* and other chambered shells and some *Orthidæ*, including *Orthis alternata* and *O. virgata*; all forms highly characteristic of the Lower Silurian rocks in the British Isles. With these, and in still greater abundance, are found *Illænus crassicauda*, *Asaphus expansus*, and *Chætetes petropolitanus*, *Orthoceratites duplex*, and *Sphæronites aurantium*, all of which specially distinguish the Lower Silurian rocks of Sweden and Russia.

there is an undoubted parallel between the different members of the Silurian rocks of Norway and those of the British Isles, they are in many parts, especially on the sides of the bays of Christiania and Drammen, so perforated by eruptive rocks of posterior age, that, except in such very typical localities as those of Steens fjord and Krokleven, it is difficult to distinguish a clear order of superposition.

Metamorphosed Silurian Rocks of Norway.—Intending to revisit Scandinavia in company with my friend M. de Verneuil, and then to work out in greater detail the exact contents of each of the Silurian strata, I shall no longer dwell on that point, but proceed to describe some of the most striking effects produced on those beds by the eruption of the igneous rocks which traverse them. The general section will convey an adequate idea of these intrusions, a small portion of which only, as well as a limited number of the flexures and cracks of the sedimentary strata, are there represented.

It is sufficient for my present purpose to state, that whether consisting of granites, porphyry, greenstone, or hypersthene rock, these igneous masses all play the same part as the trap rocks, porphyries, modern granites, and syenites of the British Isles, sometimes producing great dislocation with little alteration, at other places very perceptible changes, and in extreme cases a complete metamorphosis of the invaded strata. Of the first of these results of intrusion, it is unnecessary to speak; nor, indeed, is it essential to dwell at great length upon the second, since the phenomena are completely analogous to thousands of examples in our own Isles, and other parts of the world. In the Silurian tract



In this diagram the peaks of Syenitic Greenstone ('), Greenstone (o), and Porphyry (×), are represented throwing off and altering the Lower Silurian rock on each side.

extending north-eastward from the Steens fjord to the insulated mountain called the Solvsberg, examples of greenstone, porphyry, and syenite, intruding upon the Silurian beds, are, indeed, countless. The Solvsberg, which lies to the east of the Lake Rands fjord, is the most prominent and loftiest of these eruptive masses which I visited. Rising to about 1200 feet above the adjacent lake, its summits are seen to consist in parts of a syenitic greenstone, with crystals of labradorite and hornblende, in others of coarse-grained greenstone, and in a third of porphyry; and its flanks are of black schist and impure limestone, which near the points of contact are in a highly compact and indurated condition, and are thrown up in vertical or dislocated masses, occasionally containing trilobites, orthoceratites, and fragments of other organic remains, all of Lower Silurian age.

In the lower undulating country to the south of that hill, the same strata (including the Pentamerus limestone) are cut through by many courses of eruptive rock, some of which (as at Velo) consist of a reddish rhombic porphyry, having a base of granite and compact felspar, and others of hornblendic greenstone, flanked by highly allied subcrystalline ferriferous red strata, which, at a little distance from the intruding masses, assume the aspect of the ordinary *red rab* of Pembrokeshire. The chief of these bands and dykes of eruptive matter (some of which having a felspathic base, are changed into crystals of felspar and lime) usually traverse the Silurian beds from N. N. E. to S. S. W.

Following these porphyritic and greenstone rocks to Klekken, they are seen in some places to cut through, and in others to throw up into domes the Silurian strata. Struck with the apparent multitude of these little undulations, and desirous of ascertaining what was the real geological equivalent of the band marked "harte schiefer" on the map of Keilhau, my friend Professor Forchhammer and myself made a traverse from the village of Klekken on the west to the mountain chalets of Hong on the east, where large masses of granitic and porphyritic rocks rise to the same table land as that of which the section (p. 469.) exposes a part. In the lower undulations we observed a number of greenstone dykes trending from E. by N. to W. by S., every little ridge being characterized by a nucleus of such rock, and its flanks composed of jet-black anthracitic schist, and some impure limestone. Parallel to these dykes and nearer to the mountain side, is a strong band of rhombic porphyry, whilst other dykes (apparently traversing those of which I have been speaking) constitute a network of intrusive matter.

Owing to the short time at our disposal, we could not then determine whether the rhombic porphyry or the greenstone were the last ejected, but our observations in the country of Ringerigge, where greenstone cuts through the porphyritic plateau, led us to conclude that as the porphyry was unquestionably formed posteriorly to the old red sandstone, so the greenstone was the most recent of these eruptive masses. As we ascended the mountain side, the calcareous shale and limestone which forms a mural and slightly altered mass in the valley with a strike conforming to the direction of the chief eruptive bosses (E. by N. to W. by S.), becomes more and more indurated, and in one place, where the beds resumed their prevalent strike of N. by E., and S. by W., they are cut through by transverse east and west dykes of greenstone. On approaching the summit called the Rong Stein or the summer pastures of the village of Hong, the sedimentary mass may there be considered as a great flap of the granitic and porphyritic mountain, and is then in a still more altered state, assuming what geologists used formerly to call a very ancient aspect. The schist becomes brittle, crystallised, and compact, and is the "Harte Schiefer" of Keilhau; whilst the calcareous nodules have disappeared, leaving cavities in the schist, which still distinctly mark the original lines of deposit; until finally in parts still nearer the eruptive rocks the whole is a dense, compact, subcrystalline mass.

It was, therefore, evident that the "Harte Schiefer" of M. Keilhau, marked by that author by a distinct colour in his geological map, was nothing more than a portion of the lower Silurian shale with its overlying bands of Pentamerus limestone, which we had followed from Solvsberg by Velo to the tract between the falls of the Drammen and Steens fjord, and which, unaltered in the plain and considerably modified in the undulating grounds, had become metamorphic on the side of the granitic and porphyritic mountains.

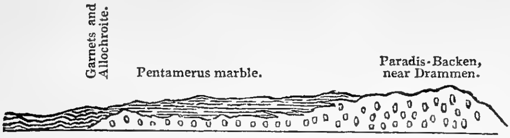
Having passed over a considerable tract of ancient gneiss, which occupies all the region to the west of the Drammen river, we found, on traversing that river in a boat at Vigersund, a repetition of similar phenomena; for there the lower Silurian sandstone beneath the fucoid shale (which is rarely seen in this region of Norway) is thrown up into vertical masses and converted into quartz rock in contact with a dyke of greenstone, whilst the alum schist which succeeds is traversed by a white porphyry, and is highly brittle and anthracitic.

The same relations are, indeed, seen all along the frontier of the gneiss between Vigersund and the port of Drammen, quartz rock or altered lower Silurian sandstone, of which I shall speak at greater length when describing Sweden, there forming the lowest Silurian course, and being surmounted by black schists and flagstone with calcareous nodules, from some of which we obtained specimens of *Asaphus expansus* and *Orthoceratites*, &c.

To the north of the Drammen the Silurian escarpment is strikingly affected by the eruption of granite and greenstone, the latter apparently forming the lower boss near the town, the former rising into a little eminence at the foot of the hill side. We could, however, draw no sort of geological separation between the greenstone and the granite, as to their age or effects. The granite is indeed most distinctly seen to protrude through the sandstone, which in many parts folds over it as a cap or dome, and is of a red colour, and indented like quartz rock. Still higher up, the sides of the escarpment are composed of amygdaloidal trap, in which are included separate angular fragments of flags and sandstone, one of which 50 feet long, and 12 to 15 feet high, appears as a highly altered, reddish, micaceous flagstone.

In the next example which we visited, or that which occurs at the hamlet of Dielebeck, a few miles north of Drammen, the metamorphism of the strata has been carried to a greater extent than in any case previously cited. Rose-coloured, large-grained granite there occupies the hill called Paradis Backen, on the northern slope of which the limestone and shale repose in slightly inclined strata.

At this spot the limestone, in the beds of which at a certain distance from the granite the *Pentamerus oblongus* has been occasionally found, is in the state of marble; and the fact of its having been formerly much laid open by quarries, has led to a thorough acquaintance with the nature of its junction with the granite.



Among other geologists, Professor Naumann of Saxony observed this junction some years ago, and showed that just in proportion to its contiguity to the granite, has the limestone been altered; *veins of granite* having actually been found by him *intruded into the calcareous mass.* Though such a junction was no longer visible, we had great satisfaction in observing the extent to which so large a mass of limestone (laid open in extensive quarries 40 to 50 feet deep) had passed into a state of marble, particularly in its lower parts, and still more in detecting in one of the depressions adjacent to the quarries, and not far from the intrusive rocks, portions of the limestone which were thickly impregnated with crystals of garnet, and other parts where the sandy shales and calcareous courses are welded as it were together, with few or no traces of bedding; the mass having assumed the aspect of a compact garnet rock similar to a variety with which I am acquainted in the Ural Mountains.*

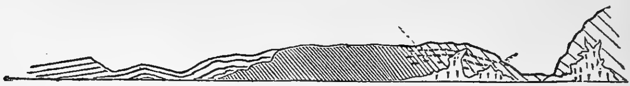
On receding from these promontories of granite, the strata resume their natural characters: the beds of limestone are clearly divided, other included Pentameri appear, the flinty slates become ordinary black schists, and the whole group, though never free from great undulations, resembling in this all the Silurian islands of the bay, puts on all the characters which are peculiar to it in Christiania fjord, to which I have now reconducted my readers, after a rapid traverse across the high plateau of Ringerigge, and a survey of the eruptive rocks as seen around its external edges.

Conversion of Lower Silurian Schist into mock Gneiss. — If the granite of Drammen has altered sandstone into quartz rock, and Pentamerus limestone into marble with garnets, the greenstones and porphyries of Christiania, particularly on the eastern side of the bay, have produced a still more remarkable change on fucoid shale, transforming it into a rock which might very well be mistaken for old Azoic gneiss.

The spot where I first observed this phenomenon in company with Professor Forchhammer, is on the sea-shore at the southern foot of the Egeberg, where a little promontory stands out in advance of the mountain of ancient gneiss, and juts out into the bay, in which there are several little islands as well as a low tongue of Silurian schists and flagstones.

* Some of this rock was in the mineral condition of "*Allochroite*," according to Professor Forchhammer.

Approaching the spot in a boat, it was interesting to observe the very gradual and perceptible change, from the unaltered schists and



a, Black alum schist passing into chlorite schist and gneiss.
b, Lower Silurian rocks.

flagstones of the low neck of land, to the highly contorted and metamorphosed masses which rise up into the little promontory. The flags and limestone being first contorted and deflected, are succeeded by black alum shale, in which is disseminated a great quantity of iron pyrites mostly in a decomposing state. Gradually this rock, in vertical strata, is seen to pass from the black shale (which is a fine alum schist on the other face of the Egeberg) into greenish micaceous schists, which, as they approach nearer to the mountain, and to the focus of eruptive greenstone, become more and more crystalline, until they might pass for a good primary schist, not easily distinguishable from much of the old gneiss of the adjacent country. In the upper portion of this mass, or that nearest to the black shale, the rock is loaded with little crystals of iron pyrites, evidently formed by an aggregation of the loose and scattered particles in the altered shale. In the most crystalline portion, however, or that which is nearest to the bosses of intrusive greenstone, are veins of the crystallised pyrites. A singular feature in this conjunction of appearances is, that long and slender veins of quartz radiate as it were throughout the rocks, traversing the greenstone and mock gneiss, and also passing from that into the black and contorted shale. I have specially described this spot, both because it affords the best evidence with which I am acquainted of the conversion of alum shale into a gneissose rock with chlorite, &c., and because the chemical process followed by nature in operating this change has been admirably explained by Professor Forchhammer, who has endeavoured to show that as no argillaceous schistose rock could undergo similar melting and metamorphosis without the medium of a flux, so there was potash existing in the alum-shale, derived from the decomposition of fucoids, and which, therefore, originally deposited in considerable masses in the rocks, had served as the flux whereby the whole mass was fused and metamorphosed.

In referring geologists to the paper by Professor Forchhammer on the conversion of fucoid alum shale into a gneissose rock, published in the volume for 1844 of the Reports of the British Association for the Advancement of Science, I ought to state that M. Forchhammer is quite as intimately persuaded as myself, that however such metamorphosis may have been brought about, there is no doubt that the converted palæozoic rock can never be mistaken, except in isolated specimens, for the ancient Norwegian gneiss; since the former, however much altered, can always be traced without any unconformable junction from the crystalline strata into a slightly altered rock, and then from that into wholly unaltered and fossiliferous Silurian bands. On the other hand, no such example of transition from the great masses of ancient gneiss into Silurian rocks has ever been seen in any part of Scandinavia; and however an example like this, where the converted rock resembles the more ancient gneiss, might tend to mislead a young observer, I shall show in the sequel how these fucoid strata, or oldest Silurian rocks of other parts of Scandinavia, repose on previously formed gneissose rocks.

If some geologists should contend, that as fucoids are comparatively of rare occurrence in strata, the theory of Professor Forchhammer is not based on adequate data to account for more than a partial phonomenon, I beg entirely to dissent from such scepticism. No one can ever have looked at the forests of algæ and fuci which are living in many sea bottoms (and I was powerfully struck with their profusion in the deep and clear fjords of Norway), or have reflected on the enormous bands of such vegetables which extend through many degrees of latitude, as described by Mr. Lyell, without admitting that many, if not by far the greater portion of our sea-formed strata, which now constitute the chief masses of our continents, may have originally contained fucoids, although, from their ready decomposition, and the great changes which the sediments have undergone, distinct evidences of their existence are comparatively seldom to be met with. And, as in huge masses of the fucoid schists of Scandinavia, where the form of the vegetable has disappeared, the rock is only distinguished either by its anthracitic or bituminous qualities (parts of it being sometimes so carbonaceous as to be used as fuel for roasting the other portions of the alum slate), so I can very well conceive how many of the schists and slates of England, from the lower Silurian to the Lias and superior rocks inclusive, have derived their pyritous, aluminiferous, and often inflammable properties from the ancient diffusion therein of a large proportion of fucoids. The very seas in which the azoic rocks themselves were formed may in like manner have contained abundance of fucoids, whose decomposition may have afforded a flux for the metamorphism of those the most ancient deposits in the crust of the globe.

Passing, however, from these theoretical considerations, I will now merely add, that besides the case observed at the foot of the Egeberg, I also remarked what I conceive to be similar phenomena in the cliff on which the Agershuus, or fortress of Christiania is built. M. Von Buch directed my attention to what he considered to be an anomaly in the appearance of that singular outlier which is separated from the main mass of gneiss by a broad trough of Silurian schists and flagstones on which the town and environs stand. On examining the seaward face of this promontory, I found it to be also composed of black schists and flagstones unquestionably of Silurian age, having, where not much fractured, the usual strike of N.N.E. and S.S.W., and cut through by masses of porphyry and greenstone. Near some points of contact, these schists are highly indurated, becoming almost a Lydian stone, with pyritous crystals; and in other larger masses, particularly those which form the north-western rock on which the north-western and southern bastions stand, the rock is a gneiss, which, folding round points of greenstone, can scarcely, if possibly, be mineralogically distinguished from the oldest gneiss in the country. In receding, on the contrary, a few paces only from the most metamorphosed parts, you pass into masses in which the lines of bedding and concretions are distinctly visible, though the whole are much broken up, dipping away to the E. and W. in truncated fragments of the harder flagstone, wedged unconformably into the surrounding matrix of schist. Transverse quartz veins are here nearly as abundant as in the example at Bugten near the Egeberg.

In taking leave of the sedimentary and metamorphic territory of Christiania, with its encircling mountains of older or azoic gneiss, I may state that, according to the views of modern geology, all the extensive tracts within that boundary, not merely in the Christiania fjord, but also in the fjords of Drammen, Steen, and Rand, and extending southwards to Frederiksvärn, compose parts of a great palæozoic basin, the base of which is the lowest Silurian fucoid band, and its summit the old red sandstone. This idea would, indeed, hardly strike any observer who looked at M. Keilhau's map; for, faithful as it is in respect to general boundaries, the varied colours with which he represents the different granites, porphyries, and greenstones within the basin, and the vast spaces overspread by those colours, necessarily withdraw the mind from true historical considerations to features purely mineralogical.

The truth then is, that in some parts of this palæozoic basin, the strata of Silurian and Devonian age are abundantly developed, though almost every where traversed by innumerable eruptive dykes, and thrown about in rapid undulations, whilst in other and still larger tracts, the eruptive rocks have usurped nearly the whole surface, leaving mere shreds and patches only of the original sedimentary masses which once occupied the basin. Thus, the granite which I have spoken of as piercing and metamorphosing the Silurian rocks of Drammen, rises into mountains, and extends over nearly the whole large promontory between Launig and Frederiksvärn, ranging down to the sea in low and gnarled headlands, exactly resembling those of Cornwall. Now, indeed, that we know these intrusive Norwegian rocks to be posterior to the old red sandstone, the analogy between them and the rocks of Devonshire and Cornwall is very nearly complete. In both countries eruptions have predominated, which I would venture to call "palæo-plutonic," to distinguish them from these more ancient granitic eruptions which are subordinate and confined to the azoic rocks strictly so called. The latter, therefore, on the same principle, I would term 'Azo-plutonic.' In the construction of geological maps, there must, I conceive, be an adherence to the principle embodied in these names, if we desire to mark chronologically the changes which have affected the earth at successive periods. The necessity of this distinction between the older and more recent granites will be made still more manifest when I have described their relations in Sweden.

*Silurian Rocks of Sweden, and their Relation to the older Crystalline Rocks.**—In this notice it will be convenient first to describe the relations of the lower Silurian group to the subjacent crystalline rocks, and then say a few words concerning the fossils of the upper Silurian group of Gothland.

In the Hills of Hollaberg and Hunneberg to the east of the Falls of Trollhætten, which are covered by a thick mass of basaltic greenstone, one subordinate member only of the Silurian series is visible, namely, the alum-slate; but no one who knows from numerous other sections that this band is very near the Silurian base, can glance his eye over the lower adjacent lands, all composed of gneiss and granitic rocks, or look up from the latter as they appear on the banks of the river, near the Falls of Trollhætten, without being convinced that the horizontal band of black schistose Silurian rock lies high above the crystalline granitic rocks of the low country, though the absolute junction of the two is hidden by a talus of detritus.

Advancing to the next Silurian oasis at Kinnekulle and the hills of Billingen, the same general relations of a *low surrounding country of gneiss and granite, to high tabular plateaux of horizontal Silurian strata,* usually capped by trap, present themselves to the traveller. In ascending the hills of Kinnekulle, from the low gneissose country of Lidkoping, he is no sooner above the low level of those crystalline rocks, than he meets with a terrace composed of quartzose sandstone, already mentioned as frequently forming the lowest Silurian stratum in Scandinavia. This rock, here arranged in beds from a few inches to a foot and a half thick, is light-grey, whitish and fine-grained, in parts freckled with ferruginous stains, and assumes at intervals a quartzose character, with divisions of chloritic shale. Its lowest beds, or those which, as we shall presently show, rest upon the adjacent gneiss of the valleys, are not here visible, owing to a talus of detritus, but in those which are visible, were found branching fucoid-like bodies. This sandstone is, in fact, seen to constitute the prevalent base of all the Silurian strata, and in the hill of Kinnekulle is surmounted, first, by the black alum schists and limestone; next by red Orthoceratite limestone; and, lastly, by Graptolite schists with some calcareous courses and Orthoceratites. Though irregularly denuded over a very considerable area, the Orthoceratite limestone

* See "Russia and the Ural Mountains," &c., *ante cit.* p. 15.

occupies a prominent step on the sides of the plateau, and standing out high above the surrounding gneiss, is in its turn covered by black schists, through which basaltic trap has pierced, occupying only a small upper portion of the central part of the tract. In descending from this summit we were much struck with the perfect symmetry of the Lower Silurian beds. To the north, or on the side of the Wettern lake, the crystalline and gneissose rocks being in a depression, the fucoid sandstone ranges down to the water edge, surmounted by the alum-slates, but on the south-eastern face of the hill of Kinnekulle the gneiss is again seen to present exactly the same inferior relations to the lower sandstone as on the western side, and the Orthoceratite limestone is there strikingly developed by extensive quarries, which form the first great step-like terrace between the basalt-capped schists above and the low country of gneiss beneath. Descending from these limestones, and passing over beds of alum-slate and black limestone, the fucoid sandstone is seen in horizontal masses, perfectly conformable to all the overlying strata, and distinctly superposed to the gneiss below; and indeed although the absolute junction of the sandstone and gneiss is not seen, the two rocks are within a hundred paces of each other, and without the slightest indication of any other substance between them. The gneiss also here is not merely in a lower position than the contiguous sandstone, but, besides its crystalline structure, is at once seen to belong to rocks of an entirely different class, and to be quite independent of the overlying Silurian formation, so that the one must have assumed its direction and structure before the other was accumulated.

It appears therefore that the gneiss, including many varieties, must be considered the fundamental rock of Sweden, which existed and was even highly inclined before the very lowest Silurian beds began to be formed.

If however, after examining the section of Kinnekulle, there could be any doubt on this point, it would be dispelled by what appears in other localities, where the lowest of the Silurian strata are not only absolutely superimposed on the granitic gneiss, but are proved to have been derived from it, and are composed of its very materials. Examples of this phenomenon may be seen at Lugnos, near the northern end of the Billingen Hills, where the Lower Silurian beds (as at Kinnekulle), being deprived of their cover of basalt, which has protected them from denudation over a considerable area to the south, are worn down, so as only to exhibit their lowest portion, the alum-slate being partially visible above the slopes of the rising ground, and the fucoid sandstone lying beneath it.

Here, at least, there can be no ambiguity; for the whole of the adjacent low tract is composed of rolling hillocks of granite or granitic gneiss, which assume exactly that appearance of bell-shaped masses so happily illustrated by M. von Buch.

Again, in exploring the eastern shore of the great Wettern Lake, to the south of Wadstena, among other phenomena of great interest, we found that along the steep shores of the Omberg, one of the few hills in Southern Sweden where the granitic gneiss occupies a tract of any considerable height, the relations of the Lower Silurian strata are, if possible, still more strongly indicative of their having been derived from the adjacent pre-existing crystalline rocks.

The Orthoceratite limestone is largely quarried at the village of Borghamm, near the northern end of the Omberg; but by coasting that mountain in a boat along its western face, the granitic rock of which it is composed is seen to occupy the whole surface for some distance, in cliffs rising to 400 or 500 feet above the lake. In about a mile, however, broken masses of the Lower Silurian rocks occur in nearly vertical positions, plastered as it were against the great wall of crystalline rock. Still further on, or southwards, the chief mass of granitic gneiss retires somewhat inland, laying open coombs upon its inclined surface, and in these are very considerable masses of Lower Silurian strata with an occasional Orthoceratite, but with little calcareous matter and few fossils. These strata occupy a considerable thickness, both in a slightly inclined, almost horizontal terrace, and also in vertical and highly inclined positions. The inclined strata are chiefly composed of soft argillaceous shale entirely unaltered, even when they are in absolute contact with the granitic rocks, and in them, and also in certain alternating courses of calcareous grit, are many included small pebbles and fragments of the crystalline rock. Across the edges of one group only of these beds near their southern extremity, where the mass of the granitic rocks retires inland, and which are inclined at about 35° to the north for upwards of 800 paces, their lower part consisting of black shale (alum-slate) wholly unaltered, we came to the lower fucoid sandstone. Here again there could be no misgivings; for this sandstone having been considerably eroded and worn away by the stormy action of the waters of the lake, the lower granitic gneiss beneath it has been exposed as a nucleus, around which the white, sandy and regenerated sandstone has been wrapped, and is still in a wholly unaltered state!

These facts completely demonstrate what we are contending for, that the granitic gneiss and associated rocks of Sweden formed the solid materials of that country before the earliest vestiges of palæozoic deposits were called into existence. They further prove, that as the Lower Silurian strata in question which are actually adherent to the granitic rocks, though highly dislocated, occur in the state of soft shale and unaltered impure limestone and sandstone, the crystalline ridge of the Omberg must have been upheaved as a hard and solidified mass, long after the period when it had undergone the fusion and metamorphism which gave to these ancient slaty rocks their crystalline aspect.

Other phenomena, proving that the lowest Silurian sandstone of these tracts has been formed out of the ancient crystalline rocks, are also to be found in many other parts of Sweden, and we particularly noted them still further to the south, on the high eastern banks and slopes of the Wettern Lake near Grenna, where, as well as in the large isle of Visings, the strata are composed of a sandstone which is simply a continuation of the base of the lowest Silurian stratum, its red colour being derived from adjacent red felspathic and quartzose rocks out of which it has been formed and on which it rests. Judging from what we observed in some districts we should say that this sandstone, although the lowest member of the Silurian system over large tracts in Vestrogothia and Ostrogothia, is not so universally in Sweden.

In certain quarries of argillaceous limestone at Freberga, to the north of Motala, we met with beds absolutely loaded with *Echinosphærites*, of the same species as those near St. Petersburg. They are there clustered together like bundles of enormous grapes, and are associated with one of the small *Orthidæ* so common in the Russian deposits of the same age. Here again the beds, though entirely unaltered, are tilted at the high angle of 70° to the north, in the proximity of a hill of ancient granitic or syenitic rock, which had doubtless been heaved up *en masse* like the Omberg, whilst in all the lower flat beyond the slope of the limestone hillocks, and extending for many miles along the north-western shores of Wettern See, the lower or fucoid sandstone lies in grand horizontal sheets, and is extensively quarried as a building stone.

The total absence, with very few exceptions, of all Upper Silurian rocks in the main land of Sweden, and the fact of the existence of such rocks exclusively in Gothland, being well-known by the examination of fossils, it was not considered necessary to visit this latter island. The chief rock in it is a limestone very similar to that of the upper deposits of Christiania, and is loaded with corals, many of which, including *Catenipora escharoides*, *Favosites labyrinthica*, *F. gothlandica*, are well known species in the Wenlock and Dudley limestone of England. With these are associated *Leptæna depressa*, *L. euglypha*, *Atrypa tumida*, *Pentamerus* (*Atrypa*) *galeatus*, *P. conchidium*, *Delthyris cyrtæna* (*Spirifer radiatus*), *Terebratula Wilsoni* Sow. (*T. lacunosa* of the Swedish authors), *T. marginalis* Dalm. (*T. imbricata* Sil. Syst.), *T. reticularis* Linn. (Silur. variety of *T. prisca*), *T. nucula*, *T. plicatella* Dal., *Euomphalus sulcatus* His., *Posidonia alata*, *Avicula retroflexa* His., *Tellina prisca*, *Orthoceratites communis* Wahl. (*O. Ludense* Sil. Syst.), *O. imbricatus* Wahl., *O. annulatus* His. (*O. ibex* Sil. Syst.), *O. annulatus* Sow. (*O. undulatus* His.), *Phragmoceras*, *Lituites*, *Calymene Blumenbachi*, *C. variolaris* Brong., *Asaphus caudatus*, and a number of other Trilobites, among which is a rare example of the genus *Brontes* (Goldfuss).*

* We also observed among other Crinoidea the remarkable *Hypanthocrinites decorus* as well as the *Actinocrinites moniliformis* of Dudley.

The coincidence of many of these fossils with those published as Upper Silurian types in England is so truly remarkable, that no sort of doubt can be thrown on the inference, that the rocks in the two countries are of exactly the same age. The actual examination of the fossils has also enabled us to see, that certain British species which, judging from the published figures of Hisinger, were supposed to be distinct, are, in fact, identical with forms previously named by that author, whose terms will necessarily in all such cases be adopted.

Whilst the whole Gothlandian group is thus unquestionably proved to be Upper Silurian, a large part being undoubtedly in the exact parallel of the Wenlock limestone, we might (judging from certain fossils, such as the *Avicula retroflexa* and a species of *Brontes**, both found with certain Orthoceratites in a sandy rock at Mount Homberg in the southern part of the island) be led to think, that the true equivalent of the Ludlow rocks is also there present. This is, indeed, rendered highly probable from what is found to be the case in the Russian island of Oesel.

In the Swedish Upper Silurian group there are, indeed, a few species unknown to English geologists. But even these, though wanting in England, are found in rocks of the same age in other countries. Such, for example, is that peculiar shell the *Cytherina Baltica*, or a variety of it, which has been detected in Normandy and Brittany, and also in the Timan range of north-eastern Russia. Such also is the *Posidonia alata*, which is, if we mistake not, a fossil of the Clinton division of the Silurian rocks of North America. We cannot make the last allusion without observing, that several of the species enumerated, viz. *Leptæna depressa*, *L. euglypha*, *Atrypa tumida*, *Pentamerus galeatus*, *Orthis elegantula*, *Delthyris cyrtæna*, *D. sulcata*, *Avicula retroflexa* and *Hypanthocrinites decorus*, as well as *Calymene Blumenbachi* and other Trilobites, together with many corals, are identical, not only with English but also with North American species of the Upper Silurian rocks,—a striking illustration of the wide diffusion of similar conditions in the early stages of the formation of the earth's surface.

To whatever extent, therefore, future researches may prove that English subdivisions are practicable in it, the Gothlandian group is at any rate a most unequivocal example of true Upper Silurian types, which in Sweden are quite as distinct from those of the Lower Silurian rocks before described, as in the best known districts of the British Isles.

Silurian Rocks of the Baltic Governments of Russia. Lower Silurian at once covered by Devonian Strata—Upper Silurian of the Isles of Oesel and Dago.—Referring to a forthcoming work on Russia and the Ural mountains for details concerning the Silurian rocks of the Baltic provinces of the Empire, I will now

* Though not published in the Silurian System, the genus *Brontes* has been found by Dr. Lloyd in the Ludlow rocks, and even in their lower division. The genus is, therefore, common to the Upper Silurian and Lower Devonian strata.

simply state some broad facts with which I became better acquainted on my last visit to St. Petersburg. Previously, indeed, to that visit, my colleagues and myself had convinced ourselves that all or nearly all the Silurian deposits in the governments of St. Petersburg and Reval belonged to the Lower Silurian group only, an inference derived both from a more correct examination of these fossils than had been made when the earlier communications on this subject were made to the Geological Society (Proceedings, vol. iii. p. 398. 717.,) and from a better acquaintance with the Scandinavian palæozoic succession, which, in reference to the lowest group, is of great importance, by exhibiting an intermixture of well-known English Lower Silurian types with forms abundantly common to that country and Russia. In this manner, though the British typical species thin out and decrease in number, as the deposits are followed from west to east, their place in the series is distinctly and unequivocally preserved.

As a whole, then, I now beg to state, that the Silurian deposits of the Baltic governments of Russia, which consist in ascending order of (1.) clay, (2.) Ungulite sandstone, (3.) bituminous schist, and (4.) Pleta or Orthoceratite limestone, unquestionably constitute the very same group as that which has been shown to be Lower Silurian on the main land of Sweden; for amid certain new forms they are charged with the same characteristic fossils—*Asaphus expansus, Illænus crassicauda, Orthoceratites duplex, Echinosphærites* in abundance, and the coral *Chætetes petropolitanus.* When, however, we enter into details, there are considerable variations both in mineral and zoological development. Thus, whilst in Sweden the lowest stratum is a sandstone, in Russia it is a shale of great thickness; though in both tracts the analogy is preserved by the lowest band containing fucoids only. The second Russian stratum or Ungulite sandstone, is peculiar to Russia in containing that remarkable horny shell, the *Obolus* of Eichwald or *Unguolite* of Pander, but the overlying *pleta* limestone or great centre of animal remains is full of the characteristic shells of the lower limestone of Scandinavia. And here it is curious to observe, how in receding from our typical regions in Britain certain generic and specific forms gradually disappear, though the families of fossils remain the same. Thus the two most common of the Lower Silurian trilobites of England, the *Asaphus Buchii* and *Asaphus tyrannus,* which are not unfrequent in Norway, begin to be scarce in Sweden, and in Russia have only been very rarely discovered.* The *Trinucleus,* so very prolific in Great Britain,

* Professor Eichwald had previously observed that the *Asaphus dilatatus,* which is, we conceive, identical with the trilobite called *Asaphus Buchii* of the British Isles, occurs at Oduisholm, an isle adjacent to Esthonia. More recently H.I.H. the Duke of Leuchtenberg has found both the *A. Buchii* and *A. tyrannus* in the quarries of Grafskaya Slavenka, to the south of Czarskoe Celo, where they are associated with many other typical Lower Silurian fossils, and some new genera and species which the Prince has named. (See "Beschreibung einer neuen Thierreste aus den silurischen Kalk-schichten von Tzarskojé Celo von Maximilian Herzog von Leuchtenberg.")

is scarce in Scandinavia, and as yet has never been discovered in Russia. On the other hand, forms which are rare in England, such as the *Illænus crassicauda* (published as the *I. perovalis* in the Silurian system) and others, become very common both in Scandinavia and Russia. Again, *Orthoceratites*, usually so scarce in the lower division of the English series, are most prodigiously disseminated through the deposits of the same age both in Scandinavia and Russia; while the *Orthidæ*, with simple ribs, are here as characteristic of the Lower Silurian age as in England, and among them is the *Orthis calligramma*, which occurs in some of the very oldest strata of N. Wales.

In the Russian Baltic provinces, as in Scandinavia and England, the Lower Silurian group is terminated in the ascending order by a limestone containing *Pentamerus*, in which some of the Upper Silurian corals begin to show themselves, but the prevailing species, though closely approaching to the *P. oblongus* of England and Norway, is one which must be considered a new species, and which we formerly named *P. Letticans*, from the tract in which we found it.*

Numerous sections to the south of Czarskoe Celo and on the rivers Ishora, Volkof, Siass, &c. demonstrate that the Lower Silurian group, as clearly defined by its fossils, and without the presence even of the intermediate band of Pentamerus limestone, is at once overlaid by true Devonian strata laden with ichthyolites. Such a junction was formerly described on the river Volkof, but at that period the precise equivalent of the underlying Silurian rock was not pointed out. In my last visit to St. Petersburg, I visited one of these junctions in company with my friends, Count Keyserling and M. Wörth, who had shortly before described it in a memoir read before the Mineralogical Society of that capital. The Pleta or Orthoceratite limestone, which occupies the great plateau of Czarskoe Celo, is surmounted, to the south, at the village of Ontolova, by reddish sandy and marly beds, in which a few fishes' scales were found by M. Wörth; and on following these beds up the course of the Slavenka, to the villages of Marina and Porites, they are seen to become hard cream-coloured marlstones in which the remains of Ichthyolites are most abundant.†

These remains have, in the hands of M. Agassiz, to whom I referred them, thrown much additional light on the Devonian fauna. Among them there are, it is true, certain forms belonging to genera known in the Old Red Sandstone of Scotland and England, but these are accompanied by several genera new to

* Since our former notices were read it has been published as *Pentamerus borealis* by Eichwald.

† In his accurate *coup d'œil* of the environs of St. Petersburg, Strangways was the first who had noticed and even marked in his map this *red earth* on the Slavenka; but he found no fossils in it, and at the period when he wrote could not be expected to compare it with the Old Red Sandstone.

science, and some which had hitherto never been found lower than the carboniferous limestone. Of the genus *Onchus*, found by myself in the Old Red Sandstone of Worcestershire (see Sil. System, pp. 589, 596.) two species are described by M. Agassiz as the *Onchus heterogyrus* and *O. sublævis*, and of the new genus *Byssacanthus* to which the *Onchus arcuatus* of Bromyard in Herefordshire is now referred, that author describes two Russian species, *B. crenulatus* and *B. lævis*. From the other placoids from this locality Professor Agassiz determines the new genera *Homacanthus, Hoplacanthus, Odontocanthus* (one of the latter having previously been called by him a *Ctenoptychius*), *Narcodes*, and *Naulos*.

Among the Cestraciont family of Placoids he places two of the Russian forms in the genus *Ctenodus*, no species of which has hitherto been found lower than the Carboniferous system. Of this genus, two new and very remarkable species occur in the lower Devonian beds of Russia, and these have been named *Ctenodus Keyserlingii* and *C. Wörthii*, after Count Keyserling and Dr. Wörth, who discovered them. Among the family of Hybodonts, M. Agassiz has recognised the new genus *Cladodus* and others of which I have yet received no account from him.

As these ichthyolites are about to be published in his "Monographie des Poissons du Système Devonien," and as their relations will be also illustrated by a short description of the fossils in the work on Russia already referred to, it is unnecessary that I should further advert to them. As a geologist, however, I may be permitted to remark, that most of the genera being entirely unknown in the overlying deposits (the underlying Silurian deposits of Russia never having afforded the trace of a fossil fish), and as the species of Ctenodus are entirely distinct from any forms of that genus in the carboniferous limestone, these fossils strongly sustain the view of M. Agassiz, that each great formation or system has been the tomb of a peculiar group of fishes.

On the river Siass, my colleague, Count Keyserling, has observed a succession from Lower Silurian to Devonian, analogous to that which I have just described. The lower beds, consisting of arenaceous limestone with small white concretions, and calcareous flags alternating with red and green marls, contain numerous true lower Silurian types, including the *Orthis calligramma* Dalm, *O. plana*, *O. inflexa*, and *O. extensa* of Pander, together with *Asaphus expansus, Orthoceratites vaginatus, Favosites petropolitanus*, &c. These are at once, and quite conformably, overlaid by other calcareous flags, and also with red and yellowish marls, in which certain typical shells never yet found in the upper Silurian rocks, but eminently characteristic of Devonian strata, are intermixed with true Devonian ichthyolites. Among the shells are, *Orthis striatula* Schlot. *Terebratula Livonica* Von Buch, *Spirifer muralis* nob., *Orthoceras cochleatum*, and *Serpula omphalotes*, whilst the fishes belong to the genus *Dendrodus* and the family of *Coccosteini*. This union in the very same beds of the ichthyolites of the Scottish and English Old Red Sandstone with the shells of Devonshire and the Eifel, we had, indeed, previously observed in other parts of Russia; and I will now only add that, since the former abstracts on Russia were published, the question has been unequivocally set at rest even in Western Europe. In a recent letter, M. de Verneuil informs me that in a collection which he made at Gerolstein in the Eifel, M. Vogt, the friend and assistant of Agassiz, has distinctly recognised the ichthyolites *Coccosteus* and *Osteolepis*.

To persons not well acquainted with the palæozoic succession the apparent passage above alluded to (for the overlying Devonian beds really much resemble the lower Silurian beneath them) might seem to be very anomalous; but extended examination, and a due consideration of the causes which have operated in elevating and depressing different portions of the country in question, remove the difficulty. Thus, for example, in advancing from the government of St. Petersburg, on the east, to Lithuania and the shores of the Reval on the west, the true lower Silurian group, as above defined, is first found to be overlaid by the Pentamerus limestone; the uppermost member of the lower group which in St. Petersburg and to the east is entirely absent. This overlying band, in which the *Pentamerus borealis* Eichw., is intermixed with a few shells common to the lower and upper groups, ranges by Wissenstein, Oberpahlen, Shavli, Pocroo, and other places; and finally, though no true upper Silurian rocks occur on the main land, they are clearly and copiously exhibited in the isles of Oesel and Dago. In these islands there is not only a full development of most of the corals of Wenlock and Dudley, but also of many shells, which, entirely distinct from those of the lower group, are to a great extent the same as those which characterise the Wenlock and Ludlow rocks of the British Isles, as appears by the following list, for which I am indebted to M. Pander: — *Catenipora escharoides, C. labyrinthica, F. Gothlandica, F. basaltica, F. polymorpha, Syringopora reticulata, Aulopora serpens, A. conglomerata, Millepora repens, Astræa Cyathophyllum*, &c., *Orthocera lineatus, Tentaculites annulatus, Calymene Blumenbachii* var. *pulchella, Terebratula diadonta, T. tumida, T. canalis, Atrypa depressa, A. reticularis, A. affinis, A. didyma, Orthis orbicularis, Delthyris sulcata, Avicula reticulata, Mya rotundata, Cardium striatum, Cyathocrinites.*

This list indicates, not merely the existence of Wenlock and Ludlow rocks, but also of the very uppermost beds of the whole Silurian system, or those tilestones that form a passage into the Old Red Sandstone, and which I formerly connected with that deposit, but which for several years I have considered with Professor Sedgwick, Professor Phillips, &c., as the upper termination of the Silurian system. For in the uppermost strata are found *Orthis orbicularis, Turritella obsoleta*, and *Turbo Williamsi*, all published British species of the highest Ludlow beds.

Although in Norway, therefore, there is a consecutive succession from lower Silurian through upper Silurian to the Old Red Sandstone inclusive, the continents of Sweden and Russia (at least that central portion of Sweden which I examined), are void of any true upper Silurian strata ; the latter being confined, as far as I now know, to the Isle of Gothland on the one side, and the isles of Dago and Oesel on the other. These facts can, it appears to me, be best explained by supposing that these continental areas were elevated above the waters after the completion of the lower Silurian beds, which were thus placed beyond the influence of the depository action under which the rocks of the Baltic Isles and of Norway were accumulated ; and also that after their accumulation, the Swedish continent remaining stable, the Russian masses were subjected to a broad, equable, and general depression beneath the sea, whereby the Devonian strata were conformably superposed to the Lower Silurian.

At the same time it is difficult to conceive that such extensive operations of upheaval and depression could have taken place without occasioning some dislocations. In describing Sweden I have already adverted to such, proving that, although the lower Silurian rocks of that region are for the most part horizontal, still there are tracts wherein they have been considerably deranged. And even in the Baltic provinces of Russia, which lie at so low a level above the sea, and in which no intrusive rocks are visible, there are transverse dislocations, the importance of which must not be passed over in coming to a right conclusion on this subject. I will therefore give a brief description of the nature of the junction of the Silurian strata, along their northern or Finnish and Lappish frontier, and after referring to the eruptions by which they have been there affected, will show how such operations and their accompanying elevations have extended their influence by producing transverse dislocations in the slightly consolidated lower Silurian rocks of the Baltic governments of Russia.

When viewing the great features of the earth, the geologist who compares the northern frontier of the palæozoic deposits of Scandinavia and Russia with that of British North America, recently described before this Society by Captain Bayfield*, cannot avoid being struck with the great similarity of succession in these two vast regions. In both the general range of the rocks is from S.W. to N.E., in both the same type of lower Silurian deposits occurs, and rests upon more ancient crystalline rocks ; and in both are these strata succeeded in similar ascending order by upper Silurian, Devonian, and Carboniferous deposits. We may still further pursue the analogy by stating that in both regions great sheets of water range more or less along the older frontier line, and lastly, that in both large quantities of erratic blocks have been transported from N. to S., or from N.N.W. to S.S.E.

* See *antè*, p. 584.

In respect to the close parallelism of the different sedimentary masses of the two continents, I must refer to my opinions and those of my coadjutors in our forthcoming work, and will now merely say that as the succession in N. America has had its base line defined for about 2000 miles, so do the observations of myself and friends apply in the same general manner to an extent not far short of that space, or from the western headlands of Norway to those which separate the White Sea from the glacial ocean.

In Sweden, as has been shown, the absolute junction of the lower Silurian strata with the pre-existing crystalline rocks, is quite as clear as it can be in any part of N. America, but it is not so in Finland or Russia, where two powerful causes prevent our making the necessary observations. The first of these is the protrusion of much eruptive matter, and the consequent metamorphism of the conterminous strata; the other the prodigious accumulations of erratic blocks and detritus which obscure the fundamental rocks. It is not my intention to enter on this occasion into any details respecting either of these operations, which are treated of elsewhere, but merely to call attention to some great physical features along this frontier line, and to explain the probable causes of their production.

On inspecting the geological map of Russia, which is now published, it will be seen that, excluding the Gulf of Bothnia, the frontier line, of which I am now speaking, is marked by a great line of waters from S.W. to N.E. The Gulf of Finland is, in truth, but the north-eastern prolongation of the Baltic, and the White Sea is the north-eastern termination of this great and extended line of fissure; whilst intermediate between these two marine gulfs, lie the enormous freshwater lakes of Ladoga and Onega. On further inspecting the map, we are struck with the fact that the longer axis of each of these two great freshwater lakes is at right angles to the main direction of the rocks, and of the White Sea and Finland Gulf; and, further, that a multitude, we may say thousands of minor lakes in Finland, Carelia, and Lapland, are parallel to the great lakes, and also, consequently, transverse to the general bearing of the sedimentary masses in their relation to the subjacent crystalline rocks. Pursuing the inquiry, we see that other gulfs, some occupied by salt-water, as that of Riga in the Baltic, and those of Onega, Kandalaska, and Archangel in the White Sea, are also transverse in the same sense.

Let us then inquire if the structure and geological phenomena of the region will help us to explain such geographical outlines.

In a former communication I briefly pointed out the chief relations of the rocks on the banks of the great lake Onega, and showed, that wherever the eruptive matter (whether in the form of greenstone, syenite, or trappean conglomerate) had come to the surface, it had formed bands parallel to the great lake Onega, and that in the vicinity of such eruptions Silurian limestones had been metamorphosed into marble, and soft sandstones (which at some distance from the eruptions contained Devonian fossils) into hard siliceous and quartzose rocks. These facts, and the coincidence of the form of the lakes with the outlines of the land, as determined by eruptive forces, led me to conclude that the one had been produced at the same time as the other ; or in other words, that the extravasation of so much igneous matter, or in its absence the upheaval of so much of the solid strata, had occasioned corresponding lateral and parallel depressions. This idea is supported by a general review of all the phenomena along the great frontier line in question, the whole of which afford, I think, a striking confirmation, and, on a very grand scale, of the theory worked out by Mr. Hopkins in the British Isles, from the close examination of smaller areas.

In the first place it is clearly determined by the general strike or bearing of the older palæozoic deposits and the boundary which they form with the Azoic rocks on the one side, and with overlying systems on the other, that the great line of their upheaval has been from S. W. to N. E., or rather, more correctly speaking, that they occupy a portion of a grand curve which has accommodated itself to the subjacent crystalline mass on which their lower edges rest—the direction of the Gulf of Finland being from W.S.W. to E.N.E., and that of the White Sea from S.W. to N. E. To this line so defined, the Silurian, Devonian and Carboniferous deposits strictly conform. The longitudinal upheaval of these deposits has, I conceive, been the chief original cause of the formation of the Gulf of Finland and the channel of the White Sea. These great depressions have been, in fact, produced along the line of junction of the sedimentary deposits with the crystalline rocks, or just where we might look for a physical separation at that period when the crust of the earth was subjected to great movements. Now, according to the mathematical demonstrations of Mr. Hopkins, no great portions of the solid crust of the globe could be upheaved without being accompanied or followed by great transverse rents; just such as those that appear at so many intervals along the line we are considering. And if, as we may believe, the original elevation was due to the expansive power of intense heat, and gases struggling to reach the surface, so may we well imagine that where the action was the most powerful, and the cracks the deepest, such action would give vent to linear bands of molten matter that would rise up and form ridges similar to those accompanying the transverse Russian lakes. I was strongly confirmed in the adoption of this view by my last excursion to St. Petersburg. The Gulf of Finland itself exhibits clear evidences of emission of plutonic matter transverse to its chief axis in four small isles, composed of porphyry and greenstone rocks ; for though these isles trend on the whole parallel to the axis of the gulf, or from W.S.W. to E.N.E., the rocks, of which they are severally composed, have been erupted athwart this line, or from N.N.W. to S. S. E. This is best exbited in the chief of these islands, called Hochland, which, rising to a height of about 600 feet above the sea, and stretching for a few miles from S. S. E. to N. N. W., in the form of an elongated rugged ellipse, is chiefly composed of porphyry, on the shoulders of which are various patches of metamorphosed limestone and sandstone, thus presenting the most complete analogy to the phenomena of Petroyavodsk and the Lake Onega.

Now if such elevating forces had really produced abundant transverse fissures along the chief line of upheaval, or near the junction of the palæozoic and azoic rocks, we might naturally expect that their effects would be extended for some distance to the south and south-east, or in other words, into the conterminous sedimentary deposits, even in those tracts where no eruptive masses rend the surface, and where, owing to the repression of such eruptions, the original strata are in a very slightly coherent and unsolidified condition. And such is the case. If I were to point to general features only, it might indeed suffice to show that the rivers Narva, Luga, Ishora, Tosna, Volkof, and Siass, flow through chasms which are in fact fissures in the Silurian limestone, all more or less transverse to the strike of these strata, and coincident with the direction of the porphyries and trap rocks of the northern frontier, and all the northern lakes. Again, the long lake of Peipus, ranging from N.W. to S.E., is as near as possible at right angles to the major axis of the Gulf of Finland, and parallel to the direction of Hochland. Without, however, appealing to these general physical evidences, the effects of such transverse dislocation can be clearly traced even in the usually horizontal and unsolidified Silurian rocks in the immediate vicinity of St. Petersburg. On a former occasion, when speaking of the general horizontality and broad undulations of the palæozoic rocks of the low plateaux and plains of Russia, I still contended that certain breaks and contortions in the environs of Czarskoe Celo, or between that place and Palkovka, could not be referred (as M. Pander had supposed) to local subsidences caused by the spontaneous decomposition of pyritous schist on which the limestone rests, but must have resulted from those general causes of disruption which are so common in our own country, and indeed in nearly every part of the globe. In again calling the notice of the Society to these dislocations on the Palkovka brook, I can now give additional facts which so corroborate my former opinion, that no sort of doubt can be attached to it. The little brook of Palkovka is one of those streams which, escaping from the calcareous plateau of Czarskoe Celo, lays open on its banks beneath the village of Pulkova, first a great arch of the strata, next breaks and faults, and then masses of limestone more or less horizontal, from beneath which the Ungulite sandstone and lower shale are brought out in highly inclined strata. Examining the banks of another brook which flows through similar strata, by the village Popofka, at not less than 15 or 20 versts to the S. S. E. of the former, and therefore in a line directly transverse to the general bearing of these Silurian rocks, I found the phenomena so nearly the same, that my old section of Palkovka might really have been applied to

Popofka, thus demonstrating that wherever these usually horizontal strata have been really affected by a line of transverse fissure, their effects are by no means limited, but have extended athwart the sedimentary masses for considerable spaces.

In truth this is just what we might expect to see at intervals, even in sediments like these, which, on the whole, have been so equally upheaved and depressed, that, as before observed, the lower Silurian are conformably overlaid by Devonian beds—the relative age of the masses being alone determinable through a close and rigid examination of the organic remains. In general, however, such abrupt curvatures and breaks are very rare, broad undulations only being the predominant features of movement in the unaltered palæozoic deposits of Russia. This general horizontality of the strata was formerly sufficiently dwelt upon, and it was even shown that limestones of the Permian age, on the Vaga and the Dwina of north-eastern Russia, are so perfectly conformable to certain pleistocene deposits, that a person unacquainted with organic remains might suppose the upper palæozoic rock to have been there actually succeeded without any interval by those accumulations in which the shells are to a great extent undistinguishable from those now living in the sea. Such very conformable appositions of strata of different age are however most apparent wherever the country is flat, and the deviations from such rules are usually found where the ground rises. Thus the plateau of Czarskoe Celo, with its conterminous hills of Duderhof, is high in relation to the adjacent plains. Thus, again, in the Valdai Hills, which constitute the only considerable elevation in the region south of St. Petersburg, such transverse fissures are still more striking in the carboniferous limestone, though difficult to observe from the great masses of superficial detritus; thus seeming to prove that in proportion to the strain to which the strata were exposed in the process of elevation, so were they disrupted at right angles to the chief line of tension. After these allusions to the probable connection between the transverse fissures and breaks observable in the palæozoic strata of the Baltic provinces of Russia, and their elevation, I will conclude this memoir by stating as one result of the examination of the fossils of Scandinavia, that as the lowest fossiliferous rocks of that tract are unequivocally of the same age as the lower Silurian rocks of Great Britain and America, so the deposits which occupy the governments of St. Petersburg and Reval are the same as those of the continent of Sweden; in the latter country (I speak now of its central mass) no Upper Silurian having yet been discovered.

In both countries it would appear (the central mass of Sweden only being alluded to) that this group, proved to be protozoic by its having been deposited on antecedent crystalline and azoic rocks, is uncovered by Upper Silurian, though the latter deposit is copiously and unequivocally exhibited in the great island of Gothland on the Swedish side, and in the smaller isles of Dago and Oesel, near the Russian shores. Thus it would seem that immediately after the completion of the Lower Silurian group, these two continents were elevated and placed beyond the reach of the depositary influence of the sea in which the isles were formed, and therefore that in ancient times, as at the present day, a great trough existed between these opposite continental masses of land. This early elevation was probably unaccompanied by any great fractures; for the lower Silurian rocks of both lands have still preserved a general horizontality, which is the more remarkable in the case of Russia, as it has been shown that the sediments, after having been raised, must again have been depressed to permit of copious marine accumulations of Devonian age upon their surface. In like manner, we must believe from the evidences of conformable apposition of the Devonian and carboniferous deposits of Russia, that no sort of disturbing influence could have existed in these regions when the one formation succeeded to the other. The uppermost beds of the Devonian, loaded with *Holoptychius* and *Onchus*, *Coccosteus*, *Placosteus*, and *Dendrodus*, are at once conformably surmounted by strata containing the most universally diffused carboniferous types. In short, fishes identical with those of the Old Red Sandstone of Scotland are invariably surmounted by the *Stigmaria ficoides* and the large Producti of our British mountain limestone; and thus the examination of Russia has taught us, not only in this instance, but also in the overlying Permian succession, that the great changes in animal life have not been dependent on physical revolutions of the surface, but are distinct creations, independent of any such proximate local causes; though I would by no means deny that the grand operations of change which have affected the conterminous regions of Russia did not tend to produce these results.

The first elevation and depression of the Lower Silurian strata having been moderate, and probably not extensive, and those strata having, during the long succeeding Devonian and carboniferous periods, remained beneath the sea, in which these sediments were accumulated, we next reach that period of disturbance which is so strongly marked in nearly every part of Europe, or that which followed the close of the carboniferous epoch. Then it was that the whole of the older palæozoic series of Northern Russia was raised up in lines extending from S. W. to N. E. And, although even then their elevation must have been infinitely more equable than any of those upheavals which have determined the strike and escarpments of rocks of the same age in Western Europe, we cannot imagine the upward movement of such enormous masses from beneath the sea to some height above it, without the accompaniment of some of those transverse fissures and breaks, which, though feeble in the slightly elevated tracts, increase in intensity with the amount of upheaval.

TABLE I.

LOWER SILURIAN FOSSILS OF SCANDINAVIA,

AS COMPARED WITH THOSE OF OTHER REGIONS.

NOTE. In this Table the Subdivisions of the Swedish Lower Silurian series are thus denoted: A. S., Argillaceous slate; Al. S., Alum slate; O. L., Orthoceras limestone.

		Sweden.	Norway.	Russia.	England.	America.	Remarks.
Crustacea.							
Calymene bellatula *Dalm.* - -	O.L.	+		+			
ornata *Dalm.* - -	O.L.	+	+?		+?		
(Paradoxides bimucronatus *Sil. Syst.*)							
Fischeri *Eich.* - -	O. L.	+	+				
sclerops *Dalm.* - -	O. L.	+					
clavifrons *Dalm.* - -	O. L.	+					
centrina *Dalm.* - -	O. L.	+					
verrucosa *Brong.* -	A. S.	+					
laciniatus *Dalm.* -	A. S.	+					
Trinucleus Caractaci *Sil. Syst.*	Al. S. & O. L.	+	+		+	+	
Lloydii *Sil. Syst.* -	Al. S. & O. L.	+			+		
brevis sp. n. -	Al. S. & O. L.		+				
asellus *Bœck.* -	Al. S. & O. L.		+				
Asaphus platynotus - - -	A. S.	+					
? cyllarus *His.* (Trinucleus)	A. S.	+					
raniceps *Dalm.* - -	O. L.	+					
seticornis *His.* (Trinucleus)	O. L.	+					
angustifrons *Dalm.* -	O. L.	+					
palpebrosus *Dalm.* - -	O. L.	+					
(Symphisurus *Goldf.*)							
mucronatus - -	O. L.	+					
extenuatus - - -	O. L.	+					
Buchii (dilatatus var.) -	O. L.	+	+	+	+		
heros (tyrannus) - -	O. L.	+	+	+	+	+	
expansus - - -	O. L.	+	+	+		+	Cryptonymus *Eichwald*, Hemicrypturus Razumofskii *Green.*
——— var. cornutus -		+		+			
Ampyx nasutus - -	Al. S. & O. L.	+	+	+	+[1]		[1] Occurs in Ireland.
Illænus crassicauda - -	O. L.	+	+	+	+	+	
centrotus - - -	O. L.						
laticauda - - -	O. L.	+				+	
Olœnus scarabæoides - -	Al. S.	+	+		+?		
(Anthes *Goldf.*)							
paradoxides - -	Al. S.						
vesiculosus							
Tessini - - -		+	+		+?		
(Paradoxides *Br.*)							
Agnostus lævigatus - - -	Al. S.	+	+				
(Battus *Dalm.*)							
pisiformis *Brong.* -	Al. S.	+	+		+		
Mollusca.							
Orthoceras duplex *Wahl.* - -	O. L.	+	+	+			
vaginatus - -	O. L.	+		+			
trochlearis *His.* -	O. L.	+	+		+		
tenuis - - -	O. L.	+	+?		+		Ireland and Wales.
centralis - - -	O. L.	+	+				
Lituites convolvans *His.* - -	O. L.	+	+?	+			
lituus *His.* - - -	O. L.	+	+	+			

TABLE I. — *continued.*

	Sweden.	Norway.	Russia.	England.	America.	Remarks.
Orthis pecten *Dalm.* - - O. L.	+			+		
polygramma *Dalm.* M.S. -	+	+		+?		
caligramma *Dalm.* - - O. L.	+	+	+	+		
alternata *Sow.* - - O. L.		+		+		
virgata *Sow.* - - - O. L.		+		+		
testudinaria *Dalm.* - - O. L.	+	+	+?	+		
Pentamerus oblongus - Pent. L.st.	+	+?		+	+	
——— var. borealis Pent. L.st.			+			
Terebratula (Atrypa) crassicostis *Dalm.* A.S.	+	+				Near to a Coniston species *Sedgwick.*
nucella - - -	+	+	+			
canaliculata - - Al. S.	+	+				
Lingula longissima - - - O. L.						
Leptæna sericea - - - O. L.						
Spirifer lynx var. - - - O. L.	+	+	+		+	Group of S. biforatus *Schloth.*
(Atrypa dorsata *Dalm.*) porambonites - -	+	+	+			
Avicula orbicularis *Foralsberg.* -	+			+		
Euomphalus Gualteriatus - - O. L.	+	+	+		+	
Crinoidea.						
Sphæronites (Echinosphærites) aurantium. O L.	+	+	+	+[1]		[1] Occurs in Ireland.
(Fam. Cystideæ *Von Buch.*)						
Polyparia.						
Chætetes (Favosites) petropolitanus O. L.	+	+	+	+	?	
Graptolites sagittarius, &c. - - A. S.	+	+	+	+	+	
Fucoideæ.						
Ceramites Hisingeri *Liebmann* - Al. S.	+	+	+?			

TABLE II.

UPPER SILURIAN FOSSILS OF SCANDINAVIA,

AS COMPARED WITH THOSE OF OTHER REGIONS.

	Sweden.	Norway.	Russia.	England.	America.	
Crustacea.						
Calymene Blumenbachii - - -	+	+	+	+	+	
var. pulchella - -	+	+	+	+[1]		[1] Occurs in Ireland.
punctata - - - - -	+	+				
Downingiæ - - - -	+[2]		+	+	+	[2] Occurs in Capelham.
Phacops macropthalmus - - -	+	+		+	+	
Asaphus caudatus - - - -	+			+	+	
Stokesii - - - -	+			+		
Brontes flabellifer ? ? - - -	+?			+?		
Cytherina Baltica - - - -	+			+		Nehou, France.
Mollusca.				+		Timan Chain.
Orthoceras ibex (annulatus *His.*) - -	+	?		+		
crassiventris *His.* - -	+	?				
(nummularis *Sow.*) - -	+					
undulatus *His.* - -	+	?		+		
(annulatus *Sow.*) - -						
tenuis - - - - -	+	?		+		
communis - - - -	+	?		+		
imbricatus - - - -	+	?				
Gomphoceras pyriforme *Sow.* - -		+		+		
Phragmoceras compressum *Sow.* - -		+		+		
Terebratula marginalis *Dalm.* - -	+			+		
imbricata - - -	+			+		
plicatella *Dalm.* - -	+	?		+		
Wilsoni - - -	+	+		+	+	
(lacunosa *His.*)						

TABLE II.—*continued.*

	Sweden.	Norway.	Russia.	England.	America.	Remarks.
Terebratula bidentata *His.* - - -		+		+		
semisulcata - - -	+	+		+		
(lacunosa *Sow.*)						
sublamellaris (Münster) -		+		+ [1]		[1] Occurs in Ludlow ?
reticularis - - -	+	+		+	+	
(affinis *Sow.*)						
aspera - - -	+	+		+	+	
nucula - - -	+			+		
Atrypa tumida *Dalm.* - - -	+	+		+	+	
(tenuistriata *Sil. Syst.*)						
Pentamerus galeatus - - -	+	+	+	+	+	
conchidium - - -	+	?		?		
(Gypidia *Dalm.*)						
Leptæna depressa - - - -	+	+	+	+	+	
euglypha - - - -	+	+	+	+	+	
transversalis - - -	+			+	+	
Orthis (near rugosa ?) - - -		+		+		
orbicularis - - - -	?	?	+	+		
rustica - - - -		+		+		
Chonetes sarcinulatus - - -	+			+		
(Orthis striatella *Dalm.*)						
Spirifer radiatus *Sow.* - - -	+	?		+		
(Delthyris cyrtæna (*Dalm.*)						
ptychodes *Dalm.* - - -	+	?				
pisum - - - -		+	+	+		
trapezoidalis - - -	+	+		+		
crucialis sp. n. *Sow.* - -		+		+		
biloba (sinuata *Sow.*) - -	+	+		+	+	
(cardiospermiformis *His.*)						
——						
Cypricardia cymbæformis *Sow.* - -	+			+		
(Cardium carpomorphum *Dalm.*)						
Mya rotundata - - - -	?			+	+	
Lucina prisca (Tellina sp. *His.*) - -	+					
——	+					
Trochus ellipticus - - - -		+				
Turritella obsoleta - - - -	?		+	+		
Turbo Williamsi - - - -	?		+	+		
Euomphalus funatus - - -	+	?		+		
sculptus - - -		+		+		
alatus - - -	+	+		+		
carinatus *Sow.* - -	+			+		
(Inachus sulcatus *His.*)						
Crinoidea.						
Hypanthocrinus decorus - - -	+			+	+ ?	
Actinocrinus moniliformis - -	+			+		
Tentaculites ornatus - - -	+	+		+		
Caryocystites granatum (Cystideæ *Von Buch*).	+					
Incert. sed.						
Cornulites serpularius - - -		+		+		
Polyparia.						
Catenipora escharoides - - -	+	+	+	+		
labyrinthica - - -	+	+	+	+	+	
Favosites gothlandica - - -	+	+	+	+	+	
polymorpha - - -	+	+	+	+		
spongites - - -	+	+	+	+		
alveolaris - - -	+	+		+		
Porites pyriformis - - - -	+	+	+	+		
Cyclolites lenticulata - - -	+			+		
(numismalis *Esmarck*)						
præacuta - - -	+			+		
(numismalis *Hisinger*)						
Syringopora reticulata - - -	+ ?	+	+ ?			
Ptilodictya lanceolata - - -	+		+	+		
Stromatopora concentrica - -	+	+	+	+		
Aulopora serpens - - - -			+	+		
conglomerata - - -			+	+		
Cyathophyllum turbinatum - -	+ ?		+	+		
dianthus - -	+			+		
ceratites *Goldf.* - -	+		+			
Millepora repens - - - -	+			+		

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Those to which no name is annexed as Donor were presented by the respective Societies and Editors.

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American Journal of Science and Arts, conducted by Prof. Silliman. Vols. xlv. xlvi. and xlvii. *Presented by Prof. Silliman.*

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* This list includes all those Books, Maps, &c. presented to the Society after the publication of vol. vi. 2nd ser. of the Geological Transactions, and between that time and the close of the year 1844. The list of Donations will for the future be published in the Quarterly Journal of the Geological Society.

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Zeisznera, L. Carte Géologique de la Chaine du Tatra et des Soulèvemens Parallèles.

INDEX TO VOL. IV.

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