THE

PROCEEDINGS

OF THE

Cotteswold Naturalists'

FIELD CLUB,

FOR 1865.

President.
SIR W. V. GUISE, BART.,
F.L.S., F.G.S.

Vice President.
T. B. LL. BAKER, ESQ.,
F.S.S.

Secretary.
W. H. PAINE, M.D., F.G.S.
F.M.S.

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VOLUME IV.

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CONTENTS.

Address to the Cotteswold Naturalists' Field Club. Read at the Annual Meeting, held at Elmore Court, on Wednesday, March 21, 1866. By the President, Sir W. V. Guise, Bart., F.L.S.

Gentlemen,—

The return of spring summons us again to the field; and as your President I claim the privilege of assembling you for the first meeting of the season under my own roof, where I hope the non-observance of one of our early rules, which forbad the acceptance of hospitality, may be condoned. The rule is a good one in its way, and it would be well that a too frequent infraction of it should not be encouraged. I have, however, taken upon myself occasionally the responsibility of dispensing with its too rigid observance; and perhaps there is no occasion upon which it may be so appropriately relaxed, or more gracefully dispensed with, than upon that of our annual gathering, when so much of our time must necessarily be occupied with routine business.

I am again happy to have it in my power to report most favourably upon our condition and prospects, which are in every respect satisfactory. Our numbers continue undiminished, our work maintains its usual high character, and the attendance at our field meetings has been, with one notable exception, good. To that exception I must call your serious attention. Upon the 19th of July last the Club accepted the invitation of our friend and colleague Professor Buckman to Bradford Abbas, upon which occasion your President found himself almost alone at the rendezvous, much to his own disappointment and that of our worthy associate, who had made most hospitable arrangements for the entertainment of the Club.

For the last four years the Club has, at my suggestion, adopted the practice of fixing one of our meets outside the boundary of the County of Gloucester. I have strongly urged the advantage of observing this custom, because it tends to enlarge our views, extend our knowledge, and widen our influence, while affording opportunities for much social and intellectual intercourse with students of science outside of our own limited circle, together with a field of observation, the very novelty of which should be a special attraction. But I have observed with regret, that the advantage of these opportunities has never received that cordial recognition from the Club which their importance claims. I can only attribute this to the fact that the utility of these meetings has never been thoroughly recognised among us; yet their manifest and intrinsic attractiveness would seem to need no expositor to recommend them to our acceptance. I know that other Field Clubs, not more wealthy nor more numerous than our own, find no difficulty in organising distant meets. I would instance the Woolhope, the Malvern, and the Worcestershire Field Clubs, amongst whom such excursions are popular and well attended. In spite, then, of previous failures, I feel it a duty to continue to urge upon you the practical value of carrying out my views in this respect; and I take leave to express a hope that your President may not again find himself in the unenviable position of sole representative of the Club in a remote district, amongst strangers who could not fail to form a depreciatory opinion of an Association thus feebly represented.

The statement of our financial condition, as submitted by our Secretary, will be found to be satisfactory. I must observe, however, that the balance is small; and, small as it is, it is due to the fact that Dr. WRIGHT has been unable, from pressure of other work, to complete another fasciculus of the Lias Ammonites, that we are able to show a balance in our favor at all. This is not as it should be; we are engaged in publishing a class of illustrated works, which tend greatly to exalt the reputation of our Society. It is only necessary to refer to the paper by Mr. ETHERIDGE, which will appear in the forthcoming fasciculus of our transactions, beautifully illustrated by numerous sections, and a map of the district treated of, to show that if we would not starve our work we must consent to a higher annual subscription than 10s. At our Annual Meeting last year, I gave notice of my intention to move a resolution to the effect that our annual subscription be increased from 10s. to 15s., which will I hope be accepted and confirmed by a vote at the present meeting.

I must not conclude these prefatory remarks without recording the loss which we have incurred by the death, within the past year, of one of the original founders of the Cotteswold Club, Dr. SAMUEL P. WOOODWARD, of the British Museum. In 1845 he was appointed Professor of Botany and Geology in the Royal Agricultural College at Cirencester, in which capacity he first joined our ranks, and by his amiability and geniality of disposition won the esteem and regard of all who were brought within the circle of his acquaintance. In 1848 he removed to the Metropolis, having been appointed first-class assistant in the department of Geology and Mineralogy in the British Museum. Subsequently he became Examiner to the Council of Military Education, Examiner in Geology to the University of London, and Member of the Council of the Geological Society. The University of Göttingen had recently conferred upon him the degree of Doctor of Philosophy, in consideration of his eminent scientific services. He was the author of a popular work on Conchology, known by the title of "A Manual of Recent and Fossil Shells," which is recognised as one of the best text-books in that department of science. He was a large contributor to various scientific and literary periodicals; and the Reports of the British Association from 1841 to 1856 contain many valuable papers from his pen. Though never a contributor to the published papers of the Cotteswold Club, he was from the first among its warmest friends and supporters. His great stores of knowledge, and practical acquaintance with all branches of Natural Science, caused his aid to be frequently sought by enquirers, to whom it was always ungrudgingly given, and never with heartier readiness than when sought by young enquirers, especially of the Cotteswold Club. During many of the latter years of his life he was a pitiable sufferer from acute chronic asthma, which wasted him to a shadow, and finally caused his death, by the bursting of a blood-vessel.

I will now record the proceedings of the Club at its different meetings during the past season.

Wednesday, 29th March, 1865. The annual meeting of the Club was held at the Bell Hotel, Gloucester, when Mr. Lucy, to the great regret of the Club, announced his inability any longer to continue the aid of his valuable services as Secretary; and Dr. Paine, of Stroud, having intimated his willingness to perform the duties of the office, he was unanimously chosen to fill the vacant post. The President read his address; after which he vacated the chair, and on the motion of the Rev. W. S. Symonds, was re-elected to the office. The President then read a translation of the official report to the Belgian Government, by Mons. Edouard Dupont, of a scientific examination of certain ossiferous caves on the river Lesse, in the province of Namur, made during the year 1864, which have yielded a mass of important evidence on the antiquity of man in those regions, through the discovery of a vast quantity of bones of our species, associated with those of the reindeer, chamois, elk, bear, bison, &c., under conditions which show that they had been subjected to the action of a vast cataclysm of waters. The vast abundance of bones of the reindeer point to climatal conditions very different to those now prevailing, and to an antiquity commensurate with the altered geographical and terrestrial relations which the surface of Northern Europe then, in all probability, bore to that which it exhibits at the present day. The only implements found with these "reindeer men" were of flint of the rudest type; no trace of metal of any kind having been found associated with these remains.

The picture drawn by Mons. Dupont, of Belgium as it existed in those remote ages, is worth transcribing, and claims attention on the ground that it is not the wild vision of an enthusiast, but the calm and studied deduction of a cool-headed philosopher, drawn from an accumulation of facts most carefully observed, and presenting such a remarkable association of phenomena as to afford a basis of comparison in the case of other and analogous deposits, in which the evidences may be less complete or less perfectly preserved.

M. DUPONT says: "I picture to myself our mountainous regions as they existed at that period, with their frosts, their forests, their inhabitants, so different from those of the present day. The fine rivers, furrowing the diversified surface of our country, were covered with ice during many months of the year. The oak, the birch, the pine, and the hazel, decked with their dull greens the broken precipices, and were covered with frost and snow during a long winter. The reindeer in great herds; the elk, with broad and palmated antlers, roamed in the forests; the horse and the ox cropped the grass which was never harvested by man; the chamois bounded from rock to rock; the ungainly bear fed during summer upon the juicy roots and young shoots of trees, and passed the winter in a state of lethargy—the rapacious glutton; wolves and foxes innumerable carried havoc among the peaceful denizens of our forests: and amidst these conditions of nature, partaking at the same time of those of the Alps and of Sweden at the present day, appeared Man; not endowed with those wondrous gifts of civilisation, which render him to some extent master of all the elements, but in a state of the most extreme barbarism; the rocks provided him with shelter in their dark cavities, the skins of beasts served him for clothing; perpetually in search of food he passed the day in forests white with frost, hunting the wild animals. His works of industry represent a condition of civilisation wholly rudimentary; neither copper, iron, nor any of the metals which are the mainspring of society as it is at present constituted, were known to him; flints rudely worked, and sharpened bones, supplied him with arms and with household implements."

A more recent report of M. DUPONT to the Belgian Government brings the record up to the end of last year, and confirms in all respects the conclusions arrived at from his previous examinations. He says: "The man of the caves of the Lesse inhabited the country before an immense inundation covered all Belgium and the North of France; I find manifest proofs of it everywhere. The earth of *La Hesbaye*, the yellow clay of our fields, are the results of this great event; and the remains of the inhabitants of the caverns are buried under a thick mass of earth left by the torrential waters. Of extreme violence at its commencement, this inundation abated by degrees its disastrous effects, and covered the surface with fertile earth. Man to-day draws life and wealth from that which to his ancestors brought only death and destruction."

"This inundation," he adds, "whether regarded from a historical or geological point of view, carries back the antiquity of the aboriginal population of the Lesse to a period of several thousands of years." *

After dinner, Mr. ETHERIDGE, Palæontologist to the Geological Survey of Great Britain, read an admirable paper on the *Rhætic* or *Avicula contorta* beds at Garden Cliff, Westbury-on-Severn, which he illustrated by some beautiful sections made by him and Mr. BRISTOW, of the Geological Survey. He gave an explanation of the sections, and referred to the leading fossils characteristic of each bed, which for the occasion had been furnished from the Museum at Gloucester, and from the collection of Mr. LUCY. This paper is now included in the published transactions of the Club, and will hereafter form the standard authority respecting the beds of which it treats;—beds which, though they occupy but a small and apparently insignificant space in this country, never exceeding one hundred feet in thickness, are the representatives of deposits of vast extent and importance in Austria, Italy, France, Hanover, Savoy, Saxony, Bavaria, and Switzerland, throughout which extensive area this group is everywhere characterised by the cosmopolitan *Avicula contorta*, the name of which, as applied to the beds in question by Dr. WRIGHT and others, is truly typical of the zone.

Mr. ETHERIDGE concluded by arguing from the insignificant outlier at Garden Cliff, the importance of the careful study of local sections, as furnishing the connecting link with distant and more extensively-developed masses which constitute an important feature in the structure of Europe, and to which we

* From a Translation by JOHN JONES, Esq.

must refer for the solution of certain problems, and for the connecting links in time and space which are wanting in our own thinner but not less important sections.

A paper was next read by Professor BUCKMAN, "On some Flints found near Bradford Abbas." This paper had reference to certain flints bearing evidence of man's handicraft, which had been picked up on the surface of the Professor's farm in Dorsetshire, and was illustrated by well-executed representations of the various forms under which these articles present themselves.

The following dates and places of meeting for the season were agreed upon:—

Wednesday, May 24 . . .	Stroud.
Wednesday, June 21 . . .	Aust.
Wednesday, July 19 . . .	Bradford Abbas.
Wednesday, Aug. 16 . . .	Tortworth.
Wednesday, Sept. 27 . . .	Beckford.

By a vote of the Club it was agreed that retired Presidents should be *ex-officio* Vice-Presidents. T. B. LL. BAKER, Esq., therefore becomes Vice-President.

The First Field Meeting of the Club was held at Stroud, on Wednesday, 24th of May. I was myself unavoidably absent on this occasion, and am indebted to our Secretary for a report of the proceedings of the day.

The members assembled at the Midland Railway Station at Stonehouse, shortly before 11 a.m., and first proceeded to inspect some objects of interest at Stonehouse Court, where they were met by Mr. HENRY MARLING, who afforded them every information. The party then separated: some of the Geologists, headed by Mr. WITCHELL, taking their course for the quarries on Doverow Hill, where the sections exhibit the "Cynocephala stage" of Dr. LYCETT. The other detachment made their way across the fields to Stanley St. Leonards, and spent two hours very pleasantly, inspecting the ancient and interesting church in that village, with the remains of the old priory in the manor-house adjoining. Here they were met by the Rev. D. JONES, incumbent of Leonard Stanley, who most obligingly gave all the information in his power.

The church, which is dedicated to St. Swithin, is a fine specimen of Middle Norman, probably about 1120. Certain alterations in the chancel appear to have been made about 1310. It is cruciform; and the tower, which is very massive, contains four bells and a clock. A small monastery, dedicated to Saint Leonard, was established here at a very early date; it had a prior and canons, one of whom, Dr. Crosse, is buried in the south aisle of the church, probably about 1190. The inscription on the tomb appears to have been as follows:—

"Qui jacet hoc tumulo Doctor John Crosse nominatur
Ille Prior Stanly Sancti fuerat Leonardi
Hunc sancto rotulo scribat Deus et tueatur."

This Priory was dissolved with the Abbey of Gloucester in the reign of Henry VIII. A very ancient stone coffin in the south transept of the church attracted much attention. A very general opinion was expressed by the members present, in favour of a complete restoration of this ancient and venerable church, to be carried out, not for the benefit of Stanley only, but for the credit of the County at large.

The members of the Club, including the party from Doverow Hill, proceeded to Stanley House, where they were most hospitably entertained at luncheon by Mr. and Mrs. W. H. Marling.

From Stanley House the party followed the course of the Stonehouse and Nailsworth Railway, to the Light Pill cutting, from whence, leaving the line, they made their way to the Gas Works, to examine a fine section in the upper beds of the Lower Lias, there exposed to a depth of 20 feet, in the excavation for the new gasometer.

The sewage works, under the direction of Dr. Bird, in the field adjoining, were shown to the Club by that gentleman, who demonstrated to all the perfectly innocuous character of his deodorising process, and its complete success in abstracting all trace of sewage matter from the overflow in the tail-water channel.

From this point the Club proceeded to Stroud, and dined at the George Hotel in that town.

After dinner Mr. LUCY, who, in the absence of the President, occupied the chair, called the attention of the Club to a communication he had recently received from Mr. JOHN JONES, in reference to some comments made by Mr. J. GWYNNE JEFFREYS on a statement contained in Mr. WITCHELL's Paper on the Stroud Hill deposits. Mr. JEFFREYS had written to Mr. JONES as follows:—

"I observe, in the last number of the *Geological Journal*, that Mr. EDWIN WITCHELL, of Stroud, states on your authority that *Helix lamellata* is not found south of Scarborough. He accordingly draws certain conclusions from this statement, in his account of a deposit at Stroud which contained this species in a fossil state. You will find in the first volume of my work on British Conchology, p. 175, a more southern range recorded, viz. Anglesea (McAndrew) and nearly every part of Ireland. I have myself taken it in the most southern extremity of Ireland. I also noticed it as one of the Copford fossils. As I do not know Mr. WITCHELL's address, you may communicate this to him. *Helix fulva* is a species of *Zonites;* and *Zua* is now discarded by Continental Naturalists."

The following is the reply of Mr. JONES:—

"Bruxelles, April, 1865.

"The enclosed note reached me some time ago from Mr. JEFFREYS, but I was at the time too busy to notice it. It is well for the Club to know that some exception has been taken to my statements, although I cannot see in what way my argument is controverted. I give certain recorded English localities in which a given mollusk occurs in the living state, at present; and I particularly describe a locality in which I found it dead and sub-fossil, and where no one pretends to have found it living. From all the information to be obtained from continental works, as well as from those of our own country, the only conclusion to be arrived at is that it once occupied a more extensive area than at present, and is now dying out, *e.g.* it is no more found living at Grey's, in Essex, than at Stroud Hill, although found abundantly at both places in the fossil or sub-fossil state. Unless we accept these facts as they come before us, we have the alternative of believing that the isolated spots mentioned by my friend Mr. Jeffreys are so many centres of creation of one insignificant species.

"If there should be any doubt at all about the existence of *Helix lamellata* as one of the living mollusks of Gloucestershire, it would be well if the Cotteswold Club would give its mind to it. Mr. Witchell's collection will prove in the most satisfactory manner that it once existed at Stroud Hill. I sent specimens to the President, and have his receipt in full for them, and there cannot be a more unmistakable species."

The Rev. F. Smithe, at the request of the Chairman, gave a short account of the proceedings of the Geological section during the day. He said that the cutting on the Stonehouse and Nailsworth Railway had proved to be interesting, not only on account of its fossil contents, but from the fact that the excavation affords an opportunity of examining a zone of the Middle Lias in a series of beds which are never worked for their intrinsic value, for the workings into the Marlstone for the sake of road-metal always stop short of the peculiar underlying beds which had been on that day visited. Wallets might soon have been filled with the characteristic fossils of the section. The zones included, comprise those from the *Spinatus* to the *Jamesoni*, and well deserve close working. They constitute the "Micaceous Sandstone" of Murchison. A few of the leading fossils met with were as follows:—*Ammonites maculosus*, common; *Belemnites brevis; Myacites*, sp., abundant; a large *Pinna*, not unfrequent; *Monotis inæquivalvis; Arca*, not unlike *A. Buckmanni; Rhynchonella concinna;* large *Pecten; Modiola scalprum; Pholodomya ambigua;* and Crinoidal remains. Mr. Smithe thought it would be very desirable to look for the *Leptæna* bed, which he had found on Churchdown Hill, in a similar Geological position. Mr. Witchell stated that he had found the *Leptæna-bed* in some cellar excavations near the railway station at Stroud, where it was of about the same thickness as at Churchdown—from one to two inches—and he had no doubt that it would be found at the Light Pill cutting. Mr. Witchell then called attention to the gravel-beds at Stonehouse, and at the Gas

Works section, and inferred from their condition that considerable changes had occurred during the period in which the bottoms of the Stroud Valleys had been excavated, and the deposition of the gravel, and afterwards of the peat, had taken place. All these gravels rest upon excavated hollows in the Middle and Lower Lias, and there is no trace of any transition period between the excavating and depositing processes. The subject was suggested as one for further investigation and discussion by the Club, and of importance in its bearing on the great question of our valley formations.

Wednesday, 21st June. The Second Field Meeting of the Club was held at the New Passage, distant about two and a half miles from Aust Cliff, by a most delightful walk along the banks of the Severn. The state of the tide was very favourable for a complete examination of the base of the cliff, and the Geologists were thus enabled to make a careful survey of the section, and to obtain a good series of characteristic fossils. The escarpment at Aust Cliff is well known as presenting a fine section of those remarkable alternations of shales and marls, now known as the Rhætic or "Pennarth Beds," with their accompanying Bone bed, of which the section at Garden Cliff, Westbury, so well described by Mr. Etheridge, is another and typical example.

I am indebted to Mr. Etheridge for a short account of the Aust section, which, with the beautiful diagram annexed, is well worthy of study and reference.

Notes upon the Rhætic Beds at Aust Cliff, with relation to those at Westbury-on-Severn.

The Valley of the Severn, in many localities, is famous for its exposed sections of the newly discovered and interesting deposits termed "Rhætic," the beds of which at Westbury, Aust, Coombe Hill, Wainlode Cliff, Patchway, &c., have successively received some direct or incidental notice at the hands of investigators. The two former, however, have become classical in the annals of Geological investigation, having received *the earliest and most marked* attention, arising doubtless from the favourable nature of the exposed sections, and the difficulty also of clearly understanding them, as well as the remarkable assemblage of organic remains which occur in the black, grey, and brown Marls and Shales, &c., which make up the mass of strata above the Red Marls at the base of both sections. All these conditions of late we have been able more fully to understand, and also to correlate with a similar order of things in many parts of the continent; and thus our own Severn Valley sections—those of Gloucester and Somerset—stand unrivalled, both on physical and palæontological grounds. I need only instance the truly grand sections of Pennarth and Watchett, Uphill and Purton, which, with those above mentioned, are unequalled in Great Britain and elsewhere, save on the flanks of the Rhætian Alps and parts of Lombardy. A memoir may be written on either of the sections named, and a slight one has been attempted, descriptive of the Garden Cliff or Westbury section,* in which the chief facts were successively detailed, and their relation to other sections in the County alluded to.

I now attempt to compare the Aust section with that of Westbury; and although they are similar in many respects, yet in others they differ.

Aust.—The first authentic notice of Aust Cliff occurs in the *Trans. of the Geological Society, Vol.* 1, *(see Series p., pl.* 37,*) in* Messrs. BUCKLAND *and* CONYBEARE'S *Observations on the South Western Coal District of England;* and afterwards by SIR HENRY DE LA BECHE and Mr. W. SANDERS, in *Mem. Geo. Surv. Great Britain, Vol.* 1, 1846, *p.* 253. It has been incidentally mentioned and partly described by many since, when treating of the distribution of the Lower Lias, *Avicula contorta* zone, or Rhætic beds, of which we now know its chief mass to be composed.

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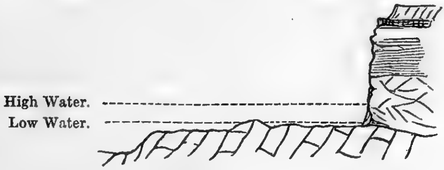
* Read at Gloucester, March 29th, 1865.

Mountain or Carboniferous Limestone.—The *bed* of the Severn, from the most projecting point of Aust Cliff, is composed of the lower beds of the Mountain Limestone, which at low water are exposed, and covered with Fuci. The Gypseous Marls of the



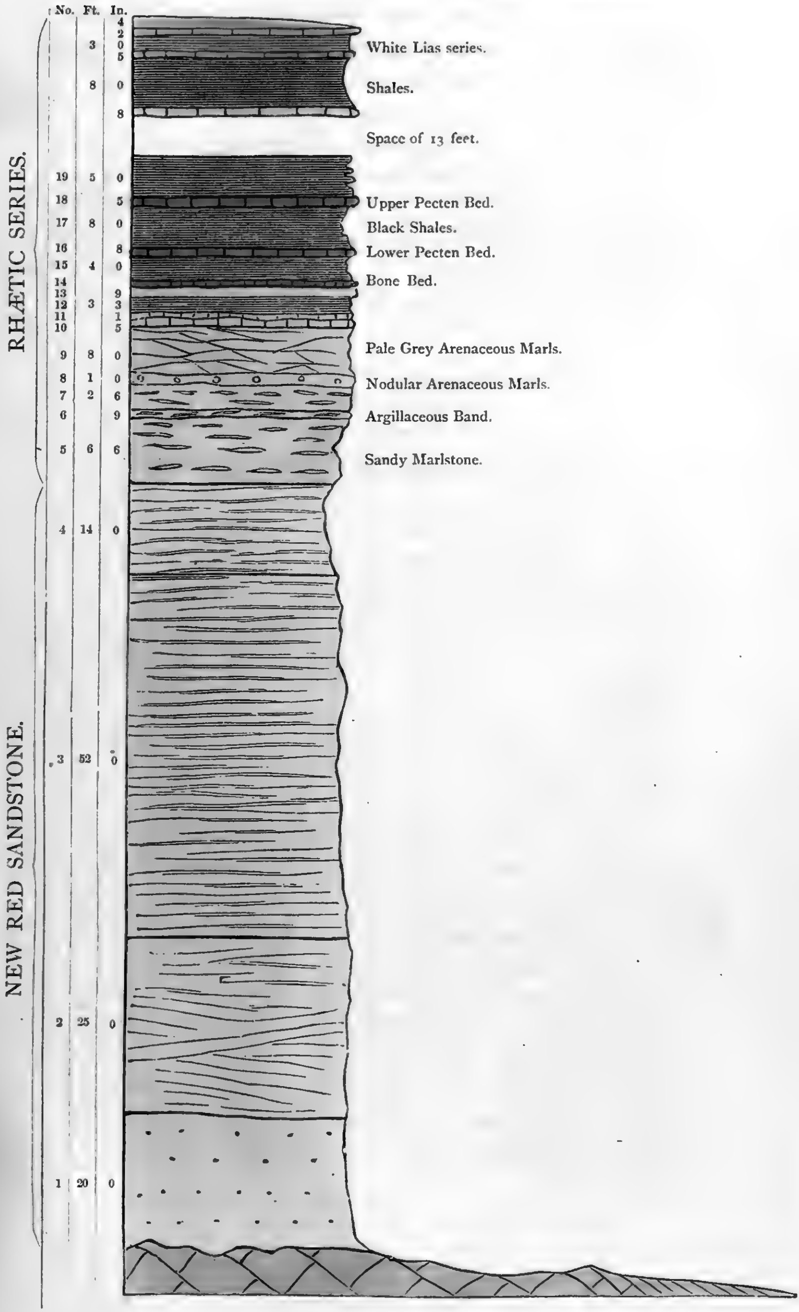
New Red rest upon them, the entire series of the *New Red Sandstone* being absent—indeed, were never deposited—a somewhat remarkable feature in this district, and clearly indicates that the overlie of New Red upon the Mountain or Carboniferous Limestone of the western side of the Bristol Coal Field (north) is exceedingly thin and occurs in patches. The points marked "Ulverstone," in the Severn at Aust and Upper Beach, are both on these Limestones, and also St. Tecla's Chapel. I mention this as a point not known to all, though visible at low water; and as another instance of the variability of level of these Limestone masses, I may bring again to your notice the fact of the Rhætic beds being also upon them in the Earl of Ducie's Park.

New Red Marls.—These beds, the upper member of the New Red series, constitute the base of the Cliff at Aust. They are Gypsiferous—the Gypsum being of the fibrous variety—though not sufficiently pure to be used as Plaster of Paris. At the base of the section the beds are somewhat sandy, and rest upon the upturned Carboniferous Limestones. The following measurements may be relied upon, being numbered from the base upwards; but which in *my* section I will reverse, and give their true order.

Carboniferous Limestone at the Base.

		ft.	in.
New Red Sandstone.	1 Red Sandy Marls, sandy at the base especially .	20	0
	2 Gypsiferous series, (fibrous Gypsum,) occurs in string-like lines and thin beds at all angles . .	25	6
	3 Series of Marls, having conchoidal fractures .	52	0
	4 Thick bedded, red striped, and nodular greenish Marls	14	0
Rhætic.	5 Sandy Marls, in nodular masses, blue, gray, and green in colour	6	6
	6 Thin band of Argillaceous or Sandy Marlstone, containing Lime	0	8 to 10
	7 Marls having a green hue, breaking up into small nodules (nodular fracture,) and sandy or argillo-arenaceous Shales at the base . . .	2	6
	8 Pale grey arenaceous Marls, with Sandstone nodules, and a calcareous matrix; becomes indurated in places. Passing into the Marls and dark Shales, or Bone Bed series	1	0
	9 Pale greenish grey, and yellow conchoidal Marls. Veined yellow. Hard and crumbling . .	8	0
	10 Pale brownish grey, Sandy Marl; indurated . .	0	4 to 6
	11 Ochreous band	0	1
	12 Pale greenish grey, Sandy Marls, weathering whitish, and crumbling with hard concretionary nodules	3	3
	13 Dark grey or black Shales, weathering into yellow or white efflorescence; hard thin bands .	0	9
	14 Bone Bed (Fish Bed.) *Dark grey Crystalline Siliceous Limestone or Grit,* in places containing nodules of grey Marl, or argillo-arenaceous masses, re-constructed from Marls below, and highly conglomeratic in places. Saurian and Fish Remains	0 0	4 to 6 or 1 to 6
	15 *Black Shales,* thinly laminated; here and there thin bands of calcareous or arenaceous matter. Fish Scales, &c.	4	0

SECTION.—AUST CLIFF, AUST PASSAGE.



	ft.	in.
16 *Lower Pecten Bed.* Blue, hard, grey, shelly Limestone, evenly bedded, and full of the ordinary Rhætic Fossils, *Av. contorta, Pecten Valoniensis, Cardium Rhæticum, Pullastra, Anatina, Axinus, Anomia, &c.*	0	8
17 *Black Shales, (Avicula* Shales,) with *Axinus, Cardium Rhæticum, Avicula contorta, Pullastra,* occurring in definite lines. *An indurated band* divides these Shales from some of those above, but its inconstancy makes it advisable not to separate the Shales. Together they measure	6	0
18 *Upper Pecten Bed.* Hard grey Limestone, containing Fish Scales, *Pecten Valoniensis, Placunopsis Alpina, Pleurophorus elongatus, &c.*	0	5
19 *Black Shales,* highly laminated	5	0

A space of some 13 or 14 feet occurs here, which, from the *nature of the cliff,* could neither be measured nor critically examined. They are grey and white Marls, with nodular Limestones, and I doubt not occupy the place of the White Lias, and are the equivalents of beds numbered *from* 14 *to* 19 *in my Westbury section,* as the Cotham Marble occurs at the top of these Marly beds, and immediately upon it occurs the Ostrea beds of the Lower Lias, as at Westbury.

There is one feature in Aust, with relation to its physical structure, which is of importance, and contra-distinguishes it from its neighbour Westbury, viz., that *the two Pecten beds* are thick hard grey crystalline bands, whereas at Westbury no Limestone whatever is found below the Estheria Zone or Monotis beds; in this respect Aust is allied to Pennarth, Patchway, Watchett, and the series south of Weston-super-Mare, where the *Valoniensis* bands are very thick.

The chief difference between the Aust section and Westbury consists also in the absence of the Pullastra beds at the base, and which are a most marked feature at the latter place; and again in the absence at Aust of the Estheria Zone, unless it be covered at the top of the section. Another remarkable circumstance is also observable in the fossil contents of the Bone bed, from the fact of the total absence of the remains of *Ceratodi* at

Westbury; whereas at Aust *some hundreds of forms, palates* of this singular genus have been found, always occurring in the Bone bed. What peculiar barrier under any condition, whether geographical or otherwise, could have existed at so short a distance, to so completely prevent the migratory habit of a genus of fishes, is a singular and remarkable problem.

I append a vertical section of the Aust beds, where you will, by comparison with my section in the Club transactions, see at once the main differences, which are clearly defined in the descriptive section at page 16.

The Third Field Meeting was fixed for Bradford Abbas, at the special invitation of our friend and colleague, Professor Buckman, to whose hospitable summons a more numerous attendance of his old associates might well have been looked for.

The following account of the day's proceedings is drawn up from notes kindly furnished by Professor Buckman.

Having been put down at the Sparkford Station, our small party was guided to a point about a quarter of a mile to the west of the station, where both sides of the cutting on the Great Western Railway, afford magnificent sections of the Lower Lias Limestones, resting upon the Rhætic beds.

Mr. Charles Moore produced a carefully measured diagram of these beds, which it is hoped will furnish subject matter for a paper from his pen at a future time.

From Sparkford our course was shaped in a southern direction for Bradford Abbas, passing through Marston Magna and Mudford, the latter significant of "wet clays," which cling to the feet like some of the stiffest parts of the vale of Gloucester, with the Lower Lias Clays of which, this part of Somerset is perfectly identical.

Passing from Compton to Bradford Abbas, (which we may do by way of the celebrated "Half-way House,") we surmount nearly two hundred feet, consisting of alternations of Siliceous Limestones and Sands, the former sometimes nodular, sometimes imbedded. The Siliceous Limestones are very hard and have contained fossils, but the lime of these has all been dissolved out, leaving only indistinct impressions which are difficult to distinguish.

On these beds rest the Inferior Oolite Limestones, altogether about 20 feet; which for its lower 10 feet is so rich in fossils, both as regards species and individuals, that in the words of Professor Buckman, he "knows of no bed equal to it." In its upper part, however, fossils are very few, and it becomes a white rubbly limestone, with the external appearance of the Great Oolite.

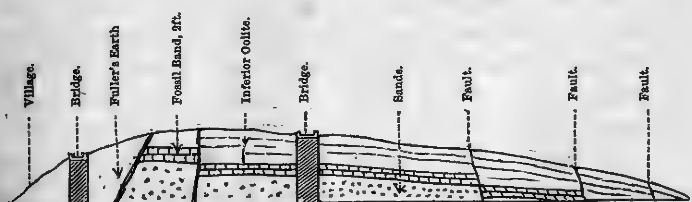
"All these lower 10 feet—nay, sometimes even 3 feet—contain all the characteristic fossils of the whole of the Inferior Oolite of Leckhampton and Cleeve Clouds.

"The following list is taken from these beds at Bradford:—

Ammonites Parkinsoni
———— *Sowerbyi*
———— *Moorei*
———— *Martinsii*
———— *variabilis*, and many others
Nautilus lineatus
———— *latidorsatus*, and others
Belemnites canaliculatus, and others

Gryphæa Buckmanni
Trigonia costata, and others
Modiola plicata
Terebratula Phillipsii
———— *perovalis*
———— *var. ampla*
———— *Sphæroidalis*
———— *Buckmanni*, and others
Rhynchonella spinosa, and others"

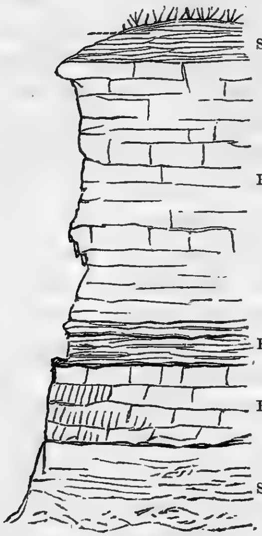
The sections at "Half-way House" and on the South Western Railway, at Bradford, are very fine, and afford instructive instances of "faults."



Section on South-Western Railway, Bradford Abbas.

The length gone over in the Railway section is a little better than a quarter of a mile. The *A. Humphresianus* is common in the fossil band, and *A. Murchisonæ* occurs.

Professor Buckman says: "I don't think any one will identify this band with the 'Cephalopoda bed,' indeed Dr. Holl, from the fossils, considers this to be the equivalent of the upper part of the Inferior Oolite, but its fossil evidences are about equally balanced, *i.e.*, it is a most extraordinary and rich admixture of the fossils of 200 feet of the Cotteswold Hills."



"Half-way House" Section.

After the conclusion of the day's work, the Club partook of the hospitality of their former Secretary. After dinner a paper was read by Professor Buckman, on "*Datura Tatula* as a variety of *Datura Stramonium*." This, which was illustrated by living specimens, gave rise to an interesting discussion on the nature of species.

The business portion of the meeting was concluded by a paper on *Ancyloceras annulatum*, discovered at Bradford Abbas by Lockhart Kennedy, Esq., an intelligent pupil of the Professor.

This paper was further illustrated by a fine series of fossils, obtained by the author at Bradford, the list of which, with an account of the beds in which they occur, furnished subject for a lively debate.

Next day, the Naturalists and Antiquaries, after examining the section at Bradford, the "Half-way House," &c., terminated a most agreeable visit with an excursion to the venerable Abbey Church of Sherborne, the interesting features of which remarkable structure cannot fail to make a lasting impression on the mind of every intelligent visitor.

Wednesday, 16th August. The Club met at Tortworth Court, the seat of the Earl of Ducie, where, in the absence of the noble proprietor, the boat-house on the lake was prepared for the reception of the party. From hence they proceeded to examine a locality on the Vineyard Hill, where Roman coins and pottery had been occasionally turned up. The Vineyard Hill at Tortworth occupies a warm and sheltered slope, in a valley facing the south. The old vineyards, with their terraces of dry masonry, are still well preserved and clearly traceable, and demonstrate unmistakeably the fact that at no distant period of time the out-door culture of the vine was well understood, and practised on a large scale in this country. The quality of the wine yielded by these grapes may be matter for discussion; but in those days, when the wines of France, Italy, and the Rhine were with difficulty attainable, even by the most wealthy, it may well have been that the thin liquor fermented from native-grown grapes was deemed no ill substitute.

A body of labourers with pickaxes were employed in excavating on the spot which had yielded Roman relics, and were successful in finding a quantity of coins, for the most part undecipherable, but amongst them some were recognised as belonging to the period of the second Constantine, in the fourth century. With these were found portions of pottery of unquestionable Roman origin, together with some pieces of pure-grained hæmatitic Iron ore.

The attention of members was especially directed to the well marked lines of circumvallation which occupy the summit of the adjoining eminence of Camp Hill, including within their area a considerable space known as "the bloody acre." A question arose as to the date of these fortifications—a question, the solution of which would be greatly facilitated by the use of the pickaxe, but it would be a work requiring time and care to ensure any satisfactory results. That the site was occupied by the Romans is certain; but whether in this, as in many other instances, they adapted to their purposes a fortress which had been garrisoned in times preceding their occupancy, cannot now be ascertained. The date of the coins found on the adjoining slopes of Vineyard Hill points to the later period of the Roman occupation.

A triple line of rampart and fosse defends the fort on its northern face; the precipitous slope of the hill, with the addition doubtless of palisades, having been deemed a sufficient protection on the southern exposure. There are evident symptoms of the fosse having been deepened at a subsequent period; but whether this be due to the weathering of the stone, or to military occupation of the site at a later period, is open to discussion.

The church, with its beautiful tower, and the celebrated chestnut tree adjoining, were objects of great interest to the visitors. The monuments of the Throgmortons in the chancel, quartering the arms of the Whittingtons, together with the portrait of Edward IV., in stained glass, occupied the attention of the party, and were regarded with much interest by the antiquaries.

From hence the party proceeded, under the guidance of Mr. Etheridge to investigate the physical structure and history of the district, especially that area north of the Court known as Michaelwood Chase, where remarkable and decisive evidence is exhibited, shewing the manner in which the eruptive amygdaloidal "traps" have thrust themselves through the rocks of the Upper Llandovery series, which here occupy an extensive tract, and constitute a prominent feature in the district, extending from the old Tortworth Court on the south, to Stone and Malford Common on the north. Abundant proof was obtained of the intrusive character of the porphyritic Greenstones, and of their metamorphic action when in contact with surrounding Silurian strata, which is especially observable at Avening Green, where the Shales and Sandstones are remarkably altered. The New Red Marls near Huntingford Mill, with their capping of Rhætic beds, were examined, and their position with respect to the palæozoic strata of the west discussed.

The remarkable absence of all the beds between the "Caradoc" or "May Hill" series, and the "New Red" or "Keuper" Marls, clearly indicate the deposition of these latter upon the old coast line of the Silurian deposits.

The stone heaps by the wayside, brought for road-metal, yielded many a specimen of the Ammonite, characteristic of the lowest beds of the Lias, *Ammonites planorbis*—a fact sufficient of itself to demonstrate the range of this zone from Tewkesbury, and all through the Valley of the Severn. From the same source was obtained *Modiola minima* and *Ostrea liassica*, both typical of the lowest Lias.

These and numerous other questions bearing on Geology and Archæology were discussed during the extended walk, which at the close of the day brought the party back to the "Boat-house," where a well-spread table, furnished with fruits from his Lordship's gardens, and wines from his cellar, formed no inappropriate or unwelcome termination to the day's ramble.

A paper was read by Mr. Witchell on the "Stroud Gravels;" and Mr. Etheridge, of the Geological Survey, gave an outline of a paper in course of preparation, briefly describing the physical structure of the northern part of the Bristol Coal-basin, having reference chiefly to the Iron ores of the Tortworth area.

Mr. Etheridge, after alluding to the importance and value of the ores of Iron to man, and their abundance in Great Britain, as also the intimate association of these ores with other minerals, such as Coal, Limestone, &c., then drew the attention of members of the Club to the more intimate structure of the area, and, as appropriate to the occasion and circumstances under which they met, of the country traversed on that day.

Mr. Etheridge's address bore almost exclusively upon the relation of the "faulted rocks" surrounding Tortworth,—or from

Frampton Cotterell to Michaelwood Chase,—and their mineral contents; especially the ores of Iron, the mode of their occurence, and the date of their filling-in. Mr. Etheridge noticed and described the chief faults which traversed the country from north to south, viz., the May Hill, Ram Hill, Rangeworthy, and Frampton Cotterell faults; which he believed terminated in the lake near Tortworth Court. In these "faults" are situated the rich ores of brown hæmatitic Iron, or the brown hydrous peroxides, which are so well known in other parts of the county. The main deposit at Frampton Cotterell, and the workings upon it, were described, and the course of the lode and fault traced through the apex of the Coal-basin and through the Limestones, &c., to Tortworth; so also the two other parallel and iron-bearing faults (lodes); the Iron in them being determined by its presence along the depressed ground, and by the dislocation of the country. The chief feature, however, in Mr. Etheridge's paper was the age and mode of filling-in or accumulation of the Iron ores in these "faults" and "veins," which he believed mainly to have taken place during the denudation of the Bristol Coal-basin by the seas that deposited the New Red Sandstone, and again were much influenced and modified upon the removal of the mesozoic rocks afterwards down to their present condition, and the re-exposure of the palæozoic land-area again.

Mr. Etheridge bases his views upon the existence of the "faults" and "fissures," which were present during the palæozoic epoch, after their disturbed and folded conditions; their subsequent filling in under the agencies of denudation, and the deposition of new material; the oxidation of these materials upon exposure; and chemical action under various conditions.

Mr. Etheridge also endeavoured to shew the relation the Dolomitic Conglomerate holds to the lodes; especially as determined upon the higher levels of the Carboniferous, Limestone, Millstone Grit, &c., everywhere surrounding the basin. The chief rock, however, in which the Ironstones run and are now deposited is the Pennant, in which it is that the mining operations at Frampton are carried on. This great Micaceous Sandstone zone divides the upper from the lower Coal-measures over the whole of the Bristol Coal Field, and in the northern part is a marked feature and broadly exposed. The "faults" named traverse this, and its jointed structure added to its porous condition facilitates the passage of water and the decomposition of oxidizable materials; thus also it may be the means of *still increasing* the deposit of Iron ore, which is believed to be now rapidly accumulating through the agency of great volumes of water highly charged with the oxides of Iron in solution, which is being deposited on the sides of the fissures and walls of the lodes.

These several conditions and theoretical views upon the whole question of the modes, age, or time of infilling, &c., are discussed at considerable length in Mr. ETHERIDGE's paper, which contains diagrammatic illustrations of the "faults" and position of the "Pennant."

In conclusion, Mr. ETHERIDGE seemed to have no doubt but that these deposits of Iron are due to phenomena acting mainly from without through infiltration and percolation, or are "exoteric" in their origin, not being connected with any deeply seated action from within, or "esoteric." Both these and other phenomena relative to the filling-in or accummulation of the ores of Iron are gone into at length in the important paper which forms so striking a feature in our published transactions for the past season.

The last meeting of the Club for the season was held on Wednesday, 27th September, at Beckford. The railway cuttings in that neighbourhood afford good sections of the "lower level gravels," which have at various times yeilded bones of the Mammoth, shells of boreal type, and other evidences of the latest geological changes, to which the valley of the Severn has been subjected. These gravels are for the most part made up of "detritus" from the Cotteswold range, as shewn by the numerous fragments of oolitic fossils and material mixed with liassic forms which constitute the staple of these drift-beds. Many of these fossils are found in a remarkable state of preservation, shewing that they have undergone but little alteration from rolling. A very fine example of *Ammonites radians* was picked up on the present occasion scarcely at all altered by friction.

After some time spent amongst the gravels, the party listened to a short lecture by Dr. Wright, given with his usual clearness and felicity of expression, on the formation of the Beckford gravels, which the Doctor referred to a period when the Cotteswold outliers were emerging as islands from the waters of the sea, and Bredon formed a sort of breakwater across the strait, controlling the violence of the currents, and thereby permitting the gravel to be deposited in the regular and almost stratified manner which it exhibits in the Beckford sections.

The party was hospitable entertained at luncheon by Mr. and Mrs. Holland, at Dumbleton House, after which, advantage was taken of the opportunity to inspect the fine collection of fossils formed by Miss Holland, (now Mrs. Hutton,) which has been so well described in our transactions by Dr. Wright.

The party returned to Cheltenham and dined at the Queen's Hotel. After dinner a paper was read by Dr. Wright, entitled "Some additional Notes on the Geology of Cleeve Hill," which clears up satisfactorily and sets at rest the points in dispute between him and Dr. Holl, which were raised at our Cheltenham meeting in August, 1863.

I cannot terminate this paper better than by annexing a specimen of philosophy in sport made science in earnest, being a rhyme by Professor Buckman, which puts the matter of weed growth and its prevention in a form which conveys under its homely verse instruction of much practical value.

Farmers grow Charlock, vulgarly called "Kerlock," because they allow it to seed; and when we are assured that a single plant of the *Sinapis arvensis* has been found to ripen 6000 seeds, it is easy to conceive the effect of permitting the seeding of a few of these weeds.

"A GLOSTERZHUR ZONG ON THE KERLOCK."

"The Kerlock plant 's a zite to zee,
As a zhines in the vields like gowld ;
But all yent gowld as glitters vree,
I wur' once by my veather towld.

"Zo I'll teke a heow* an' cut un all up,
All out o' tha' Barley ground;
An' arter that I'd like to kneow
Whur' a bit o' nast† can be vound?

"But a zays, zays he, as 't 'yunt no use
Vor to gwoo to a girt expense ;
Vor t'wull come ageun, whatever thee doos,
In a yur or two vrom yence.

"But Pa'sson zays as every weed,
Like the Turmuts and Whaet we seows,
Mus' all come up vrom a zort o' zeed,
Zo I wun't let 'un zeed if I kneows :

"But I'll teke a heow an' heow un all clane,
Right out o' tha' Barley ground;
Vor if I doant let un zeed, 'tis plane
Nat a bit o' nast can be vound."

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* Anglice, *Hoe*. The root is the Saxon *Heawan*, to cut.

† *Nast*, a generic term for dirt, applied more particularly to weeds. Picking nast, or burning nast, will mean picking couch, burning weeds, &c. The root of this word, though difficult to trace, is not entirely lost. Its primary meaning is that of *filth* or *dirt* : a sense preserved in the adjective *nasty*. It has no substantive form in English. The Swedish has *nesa*, dishonour, shame ; and the Old Norse, *neiss*, shameful ; secondary derivatives from the same root.

On the Physical Structure of the Northern part of the Bristol Coal Basin, chiefly having reference to the Iron Ores of the Tortworth area. By ROBERT ETHERIDGE, F.R.S.E[d.] F.G.S., *Honorary Member of the Cotteswold Club.*

READ AT THE TORTWORTH MEETING.

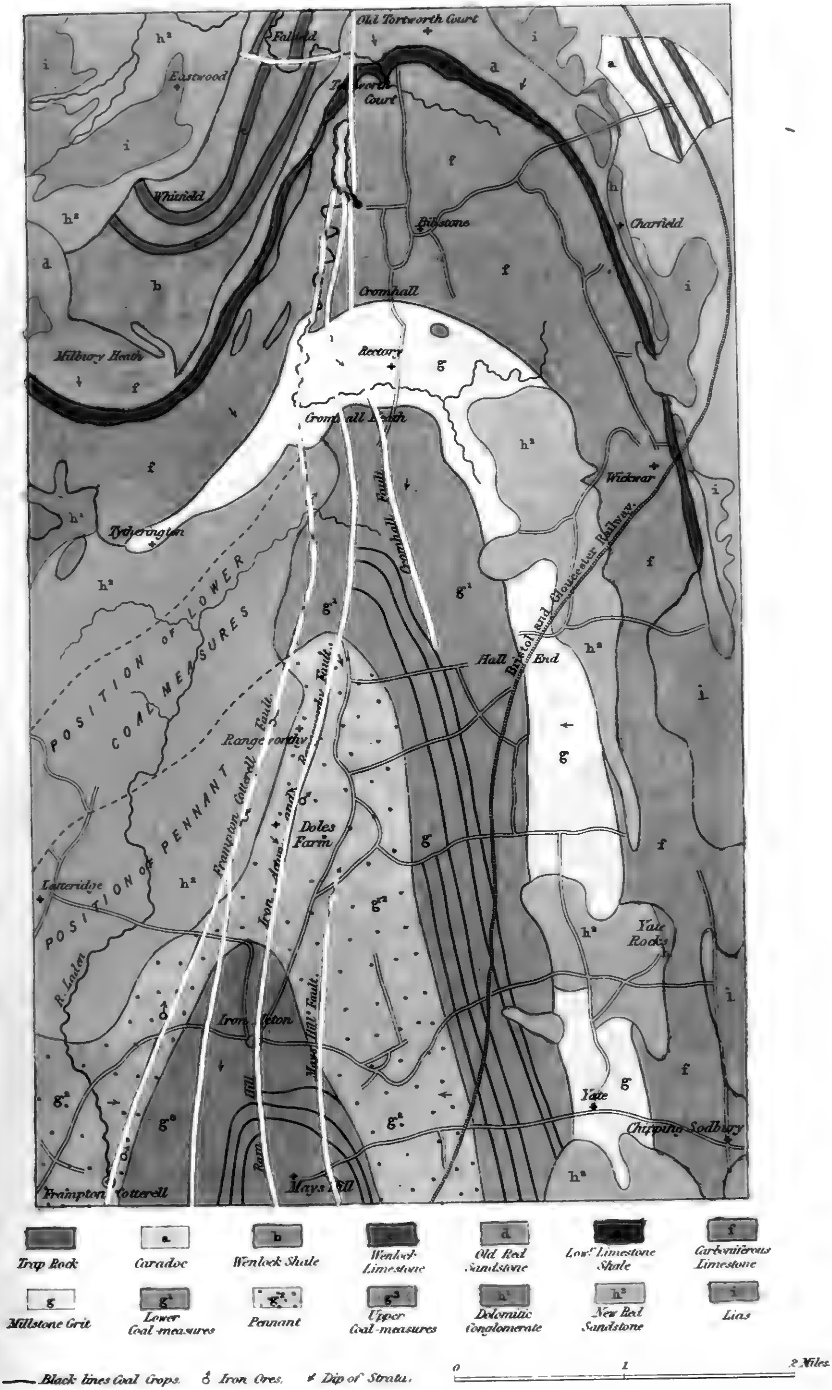
M. FOURNET has well remarked, that "Metals having become objects of the first necessity to man, he would, during all times and in all places, attach great importance to their receptacles; and that it is to the study of their mode of occurrence, their connexion with adjoining substances, and their relation to the phenomena observable in the neighbouring country, that Geology owes its birth."*

There is no branch of British commerce and industry which has of late years advanced so rapidly or so successfully, or has grown to such gigantic proportions, as that which is comprehended under the important mineral products Coal and Iron; of the former we now rise in Great Britain alone for home consumption and foreign shipment 92,787,873 tons, the value of which at the pit's mouth is £23,197,968; of the latter, 10,064,890 tons, having a recognised value of £3,367,144 in the raw state, or as mineral ore; but when converted into pig-iron, 4,767,951 tons, and at the value of £11,919,877.† The magnitude of these items alone testifies to the resources contained in the physical structure of the British Islands, and their application in the arts and manufactures, as well as to the amount of wealth, support, comfort, and happiness enjoyed by large masses of the people engaged in those pursuits which are classed under the head of

* Etudes sur les Depôts Métalliféres. Dâubuisson's Traité de Géognosie, 2nd, tome 3, p. 383.

† Mineral Statistics of the United Kingdom of Great Britain and Ireland, 1864. By ROBERT HUNT, Keeper of Mining Records.

Map of the Northern part of the Bristol Coal-field, shewing place of Pennant & associated Iron veins.



mining operations; and last, but not the least, as one of the elements affording us such pre-eminent position amongst the civilized and progressive nations of the world.

I have long felt that the subject of the present communication would be acceptable to the Cotteswold Club, although perhaps at first sight there may not be much to recommend it, but believing that it is one of the duties of the Society to examine, unravel, and chronicle the entire natural history, physical structure, and features of their County in all its phases and under all conditions, it appears to me that a communication like the present, at this time and in this locality, would enable us to discuss the important question of the Geological position and condition of the ores of Iron in the northern portion of the Bristol Coalfield, and that of the districts of Frampton Cotterell, Iron Acton, and Tortworth in particular.

It is singular, though nevertheless true, and seems almost to be due to some great law, especially as regards the association and deposition of the ores of Iron, that the ore, the fuel, and the fluxes are generally, if not always, intimately associated mineral products; and doubtless it is to this circumstance and fact, that the prosperity of the Iron trade in Great Britain owes its great success, this proximity and association tending to concentrate and centralize capital and labour.

These conditions are remarkably exemplified in the Coal Basins of Bristol, Forest of Dean, and South Wales, but in no one area is the succession of rocks and associated mineral deposits more clearly ascertained or determinable than the one now under consideration, and scarcely any area until lately has been so little examined or understood on economical grounds.

Sketch of the History of Iron Workings, &c., in the County.— The working or mining for, and the manufacture of Iron, has evidently been carried on in this immediate district from a remote period, for in many places in the neighbourhood of Iron Acton, Frampton, and Rangeworthy we meet with the remains of smelting-heaths, forges, or old blomaries, which occur in the form of scoriæ mounds, slag heaps, &c. And from the circumstance that the masses of slag, scoriæ, cinders, &c. are charged with charcoal, intimately mixed and partly consumed, it is clear from these accumulations that the operation or process of smelting was carried on prior to the use of coal, and that wood was used as fuel for the reduction or conversion of the raw ore to the metallic state.

The early process of smelting was accomplished by wind furnaces, termed air blomaries, or low conical furnaces, in which the ore was placed in layers, alternating with charcoal and limestone, somewhat resembling the method adopted in India and Africa at the present day. These heaps or mounds are now found occupying elevated positions or sites, thus originally being favorably situated and exposed to the influence of the wind. On the country becoming deforested, and the woods becoming exhausted for the supply of charcoal required for the purposes of smelting, resort must then have been had to the coal, which in early times was worked only at the outcrop, along the strike of the coal seams, thus easily obtained, but of inferior quality; and although little more than a century has elapsed since pit coal was used, we have no historical notice or evidence as to smelting works having been erected, or the manufacture of Iron being carried on in this immediate district. We are therefore obliged to refer these metallic Iron-slag heaps to an early date: either during the time the Danes occupied this area, (hence the term "Danes' cinders,") or they may be as old as the period of the Roman occupation.* In none of the early histories of Gloucestershire do we find mention made of coal having been used as fuel until the year 1740, when the general adoption of Dudley's patent for smelting Iron with pit coal was carried out. Prior to that date and event, the Forest of Dean and its air blomaries stood unrivalled as regards the manufacture of Iron. The invention of the bellows set aside air blomaries, and introduced small blast furnaces, termed "blast blomaries," into which the air was artificially introduced; thus these latter formed the first attempt towards the art of smelting and casting, now carried on with such success, and attended with results

* In ancient slag heaps in the Forest of Dean, Roman coins have been found, and embedded remains of a sacrificial altar.

which my subject does not touch upon. I am only anxious to state, that under whatever conditions Iron ore was mined for, (or won,) and smelted or reduced to the metallic state, it is evident that in this part of Gloucestershire, as well as in the Forest of Dean, it was carried on successfully.* In the year 1720, a date prior to the manufacture of pig-iron with pit coal, it is stated that in Gloucestershire and Herefordshire, and on the borders of the Dean Forest, there were ten furnaces, being then the only iron-making locality that (at that time) could vie with the famous manufactories and the charcoal-made Iron of Sussex and Kent,† where fourteen furnaces were in blast; but they, with the Wolds, "wooded fields of Kent and Sussex," have long since passed away, and the hidden fields of carbon that so long lay unknown to the eye of science and the demands of industry and commerce, have succeeded in their turn to be again perhaps at some future day, through research and the application of Chemistry, still further superseded.

General Physical Features of the District.—The area, though limited in extent, nevertheless contains a finely-developed series of the Upper Palœozoic rocks, especially the upper members of the Old Red Sandstone, the Carboniferous Limestones, Millstone Grit, Lower Coal Measures, Pennant Sandstone, and Upper Coal Measures. The whole of these, with their chief physical features, may be studied and examined in the Tortworth area, or at the apex of the Bristol Coal Basin. A section constructed from Tortworth to Coalpit Heath will give the following, viz.:—From the Rectory through Tortworth Green (which is situated on the Old Red Sandstone,) the Court and Park (on the Lower Limestone shales,) on to Ley Hill and Cromhall (on the Carboniferous Limestone,) Cromhall to the edge of Cromhall Heath (on Millstone Grit,) thence to Sweethouse (on the Lower Coal shales,) where the Pennant and its *stores of Iron* first come into position, and which occupies a surface area of considerable

* 63,830 tons are now annually raised in Gloucestershire.

† In Evelyn's time, 1620-1680, in Sussex alone, owing to the devastation caused by the manufacture of iron and glass alone, little or no sign remains of the famous Andradswald, originally one entire wood 120 miles long by 30 broad.

extent, viz., from Sweethouse, its north outcrop, to Robins' Wood House, where its southern boundary is covered by the overlying Upper Coal Measures of the Coalpit Heath Basin.

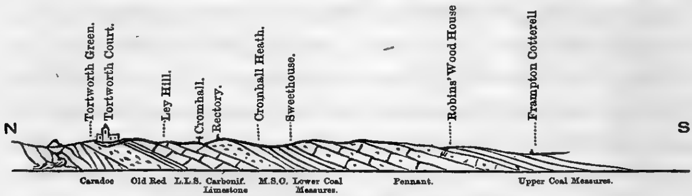


Fig. 1.—Section from Tortworth to Coalpit Heath.

The Bristol Coal Field, extending as it does from Tortworth on the north, to Vobster at the north foot of the Mendip Hills on the south, may be conveniently divided into two sections, or a northern and southern area, *or the north and south coal basins*, the natural or physical boundary separating the two occurring in the neighbourhood of Kingswood, immediately north of Bristol. I say *physical* division, because there is evidently a deeply-seated east and west anticlinal axis of disturbance along a line projected from Bristol on the west, to the Wick Rocks and Drayton on the east; it may be slightly north of this line, and through Kingswood from Siston on the east, to Stapleton and Redland on the west, and is probably a continuation of the axis of disturbance along the line of great fracture from Clevedon, Clapton-in-Gordano, the Observatory Down, Clifton, and on to Kingswood and Siston: but be this line where it may, as far as its *exact position* is concerned, it is evident that between these points, and deeply seated, there does exist, either by fault or roll, *(anticlinal,)* a disturbed line of sufficient magnitude to determine and give good reasons for believing that the once continuous coal field may now be divided physically and economically into two sections or areas, viz.—a northern and southern. It is to the northern half only that my remarks upon the Iron of the district will apply, as the special localities under consideration are within the area termed the "Northern Coal Field." This coal tract north of Bristol is elliptical in form, and about eleven miles in its longest axis from north to south, and the *exposed portion* from east to west, or its transverse axis, is not more than four miles, though I believe that nearly *double this latter area* is occupied by the coal measures, which, on the western side of the basin, are covered up by the New Red Sandstone and Lias series, which overlie the deeper seated Palæozoic rocks; so that a line extending from Tytherington and Cromhall Heath on the north and west, to Earthcott, Patchway, Filton, and Bristol on the south, would indicate the probable extension of the coal measures beyond its now assigned limits; and the overlie on the eastern side, from Golden Valley to Yate Station, covers also a considerable and important area of valuable coal. Again: it is the lower series of coals, the "Lower Coal Measures," that are thus covered up along the western borders by these newer rocks, and it must be through them that all attempts to find and win the coal must take place and be carried on, if ever attempted, and which ere long I hope to see done. This lower series of coals, &c., as they occur at Kingswood, St. Georges, &c., are a marked and grand feature in the structure and economical value of the district, there being no less than 18 seams of coal, possessing a united thickness of 42 feet of workable coal; and several of these seams are associated with argillaceous ores of (siderite) Iron of great value, and which are now for the first time being systematically worked *(and will be smelted)* in the Bristol district. Applying this fact therefore to the *northern end* and *western side* of the basin, where there is every reason to believe they exist also, it is not improbable that in time both the lower coals and their associated argillaceous iron ores may be successfully worked.

Pennant.—Resting upon the Lower Coal Measures, and dividing them from the upper series, there occurs over the whole area of the Bristol Basin (north and south) a series of coarse-grained Micaceous Grits and Sandstones, red, grey, and brown in colour, about 1000 feet in thickness, and apparently highly charged with the oxides of Iron disseminated homogeneously through the mass. This persistent rock is termed the Pennant Sandstone, and is magnificently developed in the gorge of the Avon at Hanham and Brislington, and also at Mangotsfield; it is evidently the matrix and storehouse for the ores of Iron in the

Frampton, Iron Acton, and Tortworth districts, and those that concern us in this paper. There are three or four seams of workable coal in the lower portion of this Pennant Sandstone, besides much carbonaceous matter distributed through its general structure; but hitherto its chief economical value has consisted in certain beds which are extensively worked for paving, building, and sepulchral purposes. We have now to consider it under another phase and condition, having to recognise it as associated with, and as the important matrix and storehouse for, the Hydrated Oxides of Iron that occur at Frampton, Iron Acton, Rangeworthy, &c., and *on towards* Tortworth. This Pennant occupies a most definite zone and position all around the north coal basin, being of nearly one uniform thickness, and indicating a mass of country devoid of coal. It is much to be regretted, both on economical as well as physical grounds, that this broad tract was not laid down either upon the Geological Survey Maps, or the later Geological Map of the Bristol Coalfields, on a scale of four inches to the mile, prepared by W. Sanders, Esq., F.R.S., where this important band of Iron-bearing Sandstone might have been fully expressed. I will, however, in the absence of such lines, or of these maps, endeavour to delineate its chief features, as it is of importance to understand its position. I have stated that its Geological position is between the Lower and Upper true Coal Measures, and that it is 1000 feet and upwards in thickness. Its most northerly outcrop is at Sweethouse, its most southerly at Rodway Hill, Mangotsfield; its most westerly outcrop is at Winterbourne, and its easterly at Yate. Its *western* boundary *beneath the New Red,* I believe may be defined by a line drawn from Sweethouse to Kite's Hill, thence to Winterbourne, Hambrook, and Stapleton; its *southern* boundary extends from Stapleton to Mangotsfield and Siston; its eastern strike and extension is under the New Red Sandstone and Lias, to Pucklechurch, Westerleigh Hill, and on to Yate Station, and thence to Sweethouse again, its northern apex, where it bends somewhat sharply round. This contour I believe to be its outward limit; the inner line, or boundary, is governed by the overlie of the Upper Coals and Shales, and is easily understood.

It will thus be seen that the Lower series of Coals, or those occurring beneath the Pennant, can only be, and are only worked along and around the basin at their outcrops, as in the following wood-cut, (Fig. 2,) the dotted oval indicating the

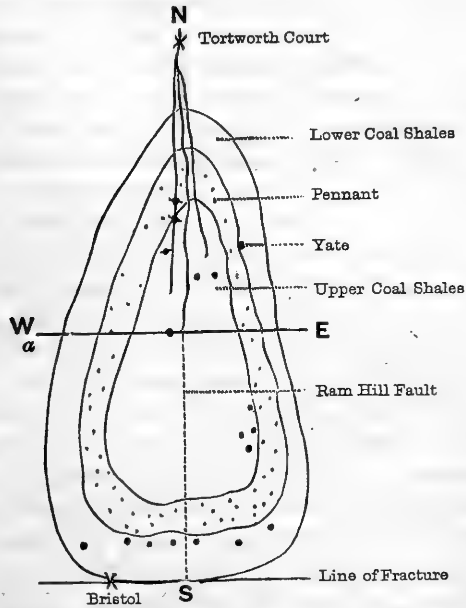


Fig. 2.—Section showing the Pennant Zone; places of rich Iron ×; position of Pits, &c., •; to show their relation to the Pennant, which in the Transverse Section shows its place, &c.

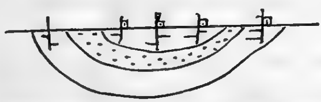


Fig. 3.—Section across the Basin at *a*, showing Pennant dividing Upper and Lower Coal Measures.

intermediate position of the Pennant. The upper series of coals, on the contrary, are worked within the zone and down to the Pennant, though never through it, as no shaft has ever penetrated through the Upper Coal Measures and Pennant down to the Lower Coals in one continuous sinking, this Pennant Sandstone forming an effectual barrier, both physically and economically, to such an undertaking, (see Figs. 3 and 4) this widely-spread surface rock thus fully accounting for the absence of coal-shafts in a definitely determined zone along and around the northern portion of the Bristol Coal Basin. Nevertheless it must not be supposed that the coals and coal measures do not exist in all their integrity below this belt of Pennant; but perhaps until a scarcity of coal is felt in this region, it is questionable if ever any adventurer will be bold enough to win the coal below, by piercing or sinking through this Sandstone barrier.

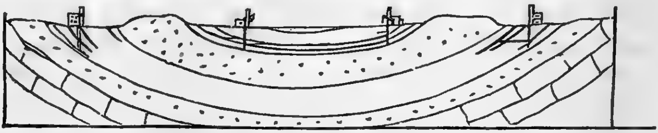


Fig. 4.—Section showing why Pits are worked below the Pennant, or above it, as the case may be, and also the area now unworked beneath the Pennant.

Having thus generally, yet definitely, fixed or defined the position and extent of the district traversed by this Pennant, and which Rock, as I believe, determines the chief Iron-producing ground, I will now enter upon the more immediate subject of my paper, dividing it under its chief heads, viz.—

POSITION OF THE IRON, and
MODE OF OCCURRENCE, &c.

Geological Position and Mode of Occurrence of the Iron Ores.—There are numerous localities in Gloucestershire where Iron Ores occur under various conditions, and are largely developed and worked, and which in a popular sense may be designated according to the Geological formations in which they occur. Indeed most of the Palæozoic sub-formations of the counties of Gloucester and Somerset possess ores of Iron which may be recognized or associated with the rocks from whence they come, such as Göthite or Hydrous Oxide; Brown Hæmatite, (*Hydrous Oxide of Iron*) from the Carboniferous Limestone, Millstone Grit, and Pennant; also Limonite, another variety of brown Hydrated Peroxide, occurring in the Limestones and Sandstones; and the massive Argillaceous or Clay Ironstones (Siderite)* occurring in

* The most valuable of our Iron ores, being easily smelted, as the clay and lime which is associated with it acts readily as a flux. This ore is the Blackband when charged with Carbonaceous matter, and occurs in almost unlimited quantities with our Coal seams. The amount of Protoxide of Iron varies from 20 to 40 per cent. Four-fifths of the Iron of this country is produced from this variety (Siderite.)

masses, either in the form of nodular or lenticular concretions, or bands, in both of which conditions it is intimately associated with the Coal seams of the Lower Coal Measures, especially those worked in the Kingswood district, at Ashton, near Bristol, and the Pitcot area immediately north of the Mendip Hills. This massive Siderite, or Clay Iron-stone, occurs also in the Argillaceous group of rocks termed Lias, Oxford, Kimmeridge, and London Clays; and hence the common practice of recognizing and naming these ores according to the formations in which they occur. No enquiry is so wide and interesting as the relation which mineral veins hold to the rocks which enclose them, or with which they are intimately associated. With veins filled with other ores than those of Iron, the origin of the metallic accumulations may generally be referred to causes acting from within, *(esoteric,)* or distant centres in the interior, assisted by those subterranean changes which are the universal result of those calorific and sublimitic agents that are always at work in the earth's crust. The origin of these various ores, in their different matrices, and under so many conditions, is yet a problem for solution, and is a difficult one to determine; but I have in this communication endeavoured to account for the mode of occurrence, position, and condition of the Hydrous Oxides of Iron so abundantly distributed in the faults and veins of the North Bristol Coal Basin. I now come to the Geological position, place, or age of these Minerals in question; and from careful observation and examination, both in this area and others in the district, have no hesitation in referring the *origin* of these extensive lode accumulations or deposits of Hydrated Peroxides, or Brown Hæmatite Iron Ores, to the age of the New Red Sandstone: that is to say, the fissures, faults, &c., which occurred in the older rocks *(prior to the deposition of the New Red)* were filled up, in a manner I hope to make clear, during the period of the accumulation of the Trias group of rocks, either through chemical changes, or mechanical suspension or infiltration. It is well known and understood that the whole of the Palæozoic rocks of this area, like all others, were placed in their present disturbed position, after having gone through the process of consolidation and other changes of condition due to induration, metamorphism, and mechanical changes, &c., prior to that epoch of grand denudation, which was ushered in with the commencement of the Permian and succeeded by the Trias epochs. It was also during the vast period of time which succeeded, that the denudation, removal, and destruction of the bolder masses and tilted edges of the older or Palæozoic rocks took place; and this also during their depression to profound depths in *the then New Red Ocean*, thus giving rise to the accumulation of the deposited Sandstones and Marls upon them, and added to these the superimposed Lias and Oolites. This depression and consequent accumulation of matter having gone on to the depth of some 4000 or 5000 feet. The process of time and physical cosmical changes again brought to the surface the old Palæozoic land under new modifications; and during its slow and gradual emergence, the accumulated Permian, Trias, Lias, and Oolitic rocks were in their turn swept away, leaving the general features of the Severn Valley somewhat like its present aspect. Thus we have to do with two distinct epochs of denudation; the first, that of the Palæozoic rocks, through the ushering in of the Mesozoic period, and by the agency of the Permian and Triassic Seas, which cut back and denuded the bold coast lines that must have been exposed to their influence, and depositing in the quieter regions of their depths the spoils of the older continent. The second epoch was upon the re-elevation—or re-emergence of these accumulated or newly formed secondary masses, and their removal consequent upon the forces exercised by the sea, as the land rose and came under the successive action of the unceasing and destroying influence of the waves, until the old surfaces, *if not still deeper ones*, were again exposed—a question depending upon the amount of oscillation the land then underwent, with relation to the stability of the ocean's level. Thus may the fissures and faults in the Palæozoic rocks have been twice exposed and influenced, and through great periods of time, by these denuding forces. No one can witness the remnants of the Permian and Trias rocks, which rest upon the higher lands occupied by the Carboniferous Limestone and

Millstone Grit of the district, or examine the fissures and faults or joints filled-in by them, and with the ores of Iron, without being impressed (other circumstances being considered) with the facts and conditions I wish to bring before you. I believe it to be not at all improbable that a lower member of the Permian Group of Rocks than is now generally recognized around the Bristol Coalfields, once existed, and has since been removed by denudation. For we have evidence of Magnesian rocks, having all the characters of the Permian of the North of England, at many parts of the Basin, especially at Yate Rocks, where the pale yellow hard finely laminated Limestones repose upon the highly inclined beds of Carboniferous Limestone, which have been planed away as smoothly as if done artificially. See Fig. 5.

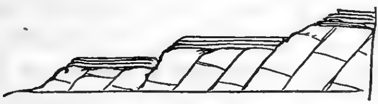


Fig. 5.—Section at Yate Rocks, showing Yellow Magnesian Beds resting upon Beds of Carb. Limestone, which have been planed away in terraces.

I believe these laminated yellow Magnesian beds are lower and older than the remarkable patches of the anomalous Dolomitic Conglomerate, which everywhere fringes and rests upon the older rocks of the district, and which so fully testifies to a once widely spread rock, whose Geological place in the series is still here uncertain, and which the miners call the *overlie*, when sinking to the Lower or Upper Coals through the Lias and New Red: its place invariably being at the base of the New Red Sandstone series that cover the surrounding edges of the north and south basins, but which has been swept away in the centre of both, thus clearly shewing us that this intensely hard Conglomerate is now the mere remnant of a once widely-spread and continuous sheet, patches of which are now left us. The waves of that age cut back the perhaps rapidly depressing land or coast line, composed as it was of Old Red Sandstone, Carboniferous Limestone, Millstone Grit, Pennant, &c., alike exposed at once and in succession; for all these rocks are found abundantly constituting the mass of the Conglomerate now left to us. No one can examine this northern portion of the Bristol Coalfield without profound conviction of the enormous lapse of time which must have taken place, or the forces employed during the New Red Sandstone period, whether we consider it under its powerful denuding agency, or the chemical and mechanical deposits it has left behind it. Again, if we wish to examine typical sections of the entire series of this New Red group, we must look to the Valley of the Severn at Tewkesbury, Newent, &c., for examples to aid our research, where they occur 1400 feet thick.

I believe, then, that it was during the process of the denudation of the Palæozoic Rocks by the seas of this New Red epoch, that the faults and fissures, which had their prior existence, were filled-in, either chemically or mechanically, or both combined. It is evident, from the colour and nature of the New Red Marls and Sandstones, that a vast abundance of the Peroxide and Protoxide of Iron must have been present under some condition at the time of deposition* perhaps through the rapid oxidation of the denuded masses of Old Red Sandstone, Carboniferous Limestone, and Coal Measures, &c. It is not improbable, either, but that the chemical condition of the Saline waters, or waters at higher temperature, may have tended more readily to deposit the Iron in the faults, &c., &c.

* In order to shew that some value may be attached to this view, I append an analysis of both the Grey and Red Marls of the New Red series, when it will be seen that in both cases a large per centage of Iron occurs either in the form of Protoxide or Peroxide, both of them being found in the Red Marls, and only the Protoxide in the Grey or Blue.

	Red Marl	Grey or Blue Marl
Silica	48.69	48.62
Protoxide of Iron	4.79	13.09
Peroxide	9.09	0.00
Alumina	8.77	9.01
Lime	8.69	8.39
Magnesia	0.94	1.00
Soda	0.53	0.58
Potash	3.15	3.30
Sulphuric Acid	0.27	0.14
Carbonic Acid	8.56	10.18
Organic matter	1.18	1.90
Water and loss	4.25	3.79

Now the *Metallic Iron* contained in these Marls is considerable: they yield the following results:—

Red Marl	9.99
Blue Marl	10.47

There are numerous localities in the Bristol Basin where full and complete evidence can be obtained as to the age of the filling-in of these dislocations, as well as in the joints both of the Limestones and Pennant; and which I have no hesitation in stating must have taken place during the entire period of the destruction of the older rocks of the district by the New Red, &c. At Broadfield Down, between Bristol and the Mendip Hills, at many places on the Mendips, such as Eber Rocks, &c., Providence Place,* near Ashton (Bristol,) and numerous other localities where these Hydrous Oxides of Iron are worked, the broad and exposed surface of the Carboniferous Limestones are smoothed and planed away, having been laid bare through the denuding influence of the New Red, as in the section Fig. 6. Here and there in the depressions, occur the remains or remnant

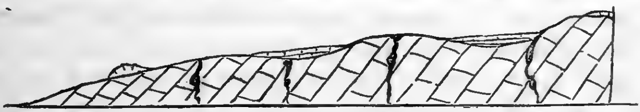


Fig. 6.—Section showing modes of occurrence of Fissures and Faults in the Carboniferous Limestone, with patches of Dol. Conglomerate and New Red lying in hollows, &c.

of the Dolomitic Conglomerata *(lower member of the Trias, if not older,)* and the fissures and faults *(almost always productive of Iron)* are associated with the Conglomerate, which frequently fills them, the cementing matrix in some cases being the Brown Hæmatite as well as the Dolomite. This phenomena occurs both in the Carboniferous Limestone, Millstone Grit, and Pennant, the qualities of the ore differing with the matrix or rock in which it occurs. I may mention also that at Llantrissant and Llanharry, in Glamorganshire, the same conditions occur in and on the Mountain Limestone.

Faults.—We now come, however, to the deposits at Frampton Cotterell, and the disturbed area north of that and on towards Tortworth, where we find occurring three, if not four parallel faults, all of which determine the presence of Iron at their "backs" or "outcrop." These faults I have respectively named the Cromhall or Mays Hill, Ram Hill, Rangeworthy, and

* The Iron Lode in a fissure is here worked up the entire face of the hill.

Frampton Cotterell faults, in the order of their succession from east to west. The first named, or Cromhall, cannot be traced southwards from Tortworth beyond Sweethouse, but its northern bearing seems continuous from this spot to the Carboniferous Limestones of Cromhall and Tortworth, through the picturesque lake at the Court, the Old Red Sandstone north of the lake, the Caradoc series of Micklewood Chase, and on to Purton Passage, bringing in its course the Old Red Sandstone against the Wenlock Shales, along a line of country from Malford Common, through Berkeley, to the Passage.

From compass bearings, &c., and the physical structure of the county, I believe that three of the Iron-bearing faults mentioned, which traverse the Coal measures at Serridge and Ram Hill, in the middle of the basin, are continuous, and the same that I have mentioned above, and also that they all unite in the course of the stream and gorge of the Tortworth lake, and so onwards as one to the shattered and disturbed area of Micklewood Chase.

It is also remarkable that with all the research made in the northern portion of the Bristol Coal Field, it has failed to reveal or determine any transverse, or east and west faults, although the northern attenuation of the area under examination would lead us to expect such, all that are known being north and south parallel (or nearly so) dislocations, and downthrows to the east, all uniting at the northern apex, and in the lake as one.

Now each of the following lines of faulted ground give evidence and proof of extensive stores of these Brown Hæmatite or Hydrated Peroxides of Iron. The third, or Frampton Cotterell, Iron Acton, and Rangeworthy fault, is of great magnitude, is also the most westerly, and is now producing vast quantities of ore,* which is situated in the fault under the ordinary conditions of a lode, and occurs in the Pennant Sandstone. Extensive works are established at Frampton Cotterell to develop this ore, and along the course of the lode (fault) levels and other mining operations are being constructed and carried on. Much trouble is, however, experienced from the volume of water carried into the fault, and which the county here influences, lying at a

* 11,000 risen in the year 1864.

generally lower level than the surrounding rock masses. All along the back or strike of this disturbed line north of Frampton, the influence of the fault is distinctly traceable by depressed ground, deeply stained red, from the quantity of oxidized ore that occurs along its course, and the occurrence of fresh pieces which the plough and agricultural pursuits constantly bring to the surface. And again, it has been determined at several places north of Frampton, by the process of costeening, or transverse cuttings, made east and west, to intersect its north and south bearing. At Mudge Down, Doles Farm, Rangeworthy, and Bagstone Farm, this extensive line of fracture clearly continues as a productive lode, and is situated in the Pennant all along its course to Sweethouse. (See sect. Fig. 1.) It is traceable also, though apparently not so productive, on the western side of Wickwar Heath, to Ashworthy, and on to the Millstone Grit at Tapwell Bridge, where I should expect it would be richer than in the Coal measures. At some places along its course (at Doles Farm and Rangeworthy) it is covered by the New Red Sandstone, though still distinctly traceable by the depression of the land and highly ferruginous line of country.

The system of deep drainage tends towards Iron Acton and Frampton from the west, north, and east, and apparently along the courses of the faults, and hence the volume of water concentrated at the Iron mines of Frampton Cotterell. This doubtless has also been one of the causes of the quantity, richness, and concentration of the ores in this more immediate region for ages—even since the removal of the great mass of the *overlie*, or superincumbent mass of New Red Sandstone, by denudation. And I doubt not but that now large deposits of the Oxides of Iron in suspension are taking place through infiltration, and deposited along the sides of the fissures, &c., through the highly charged or saturated condition of the waters which take their rise in the Carboniferous Limestone, Millstone Grit, Coal Measures, and New Red Sandstone, to the north, and all around that area of the basin.

The second named fault (the continuation of the "Ram Hill,") lies to the east of the Rangeworthy line, and parallel to it; and from the presence of Iron all along its course, and the disturbed nature of the surface, reversed dips, &c., it is evident that productive places may be determined along its bearing.

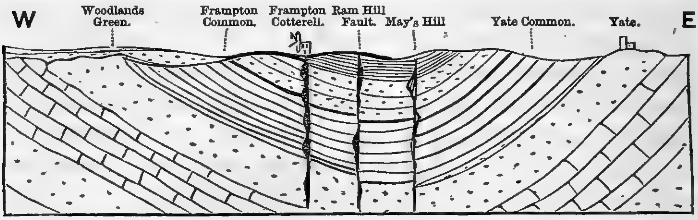


Fig. 7.—Section shewing the three faults, May's Hill, Ram Hill, and Frampton, with the plan of the Upper Coal Series, Pennant, Lower Coal Series, Millstone Grit, Carboniferous Limestone, and Old Red, covered by the New Red Sandstone and Lias on the west.

I have before stated that I believe these faults were filled during the period of the denudation of the Palæozoic series, when undergoing deep depression, and the consequent deposition and accumulation of the Permian and New Red Sandstone and Marls upon them; and again much modified, influenced and added to at the subsequent destruction and re-denudation of the New Red and higher Secondary rocks, consequent upon their re-elevation to the present land area, all these non-conformable series above the Old Red Sandstone, Carboniferous Limestone, and Coal Measures from Tortworth, at the northern apex of the basin to the Mendips on the south, having been swept away; and wherever in the Bristol area, whether in the Carboniferous Limestone, Millstone Grit, or Pennant, lodes and fissures are filled with these hydrated peroxides, I believe the age of that infilling to be due to the changes which took place during the long period of time that must have elapsed in modifying and reconstructing the physical conditions of the area we are describing.

It cannot be doubted but that the percolation of water through porous rocks highly charged with the Oxides of Iron, as is the case with the New Red series* and Pennant, and then deposited almost in the form of Scinter or Tufa, has also been a mode of accumulation in these fissures and joints, and is a process now going on in the Pennant, wherever the influences of

* See Analysis page 40.

the atmosphere and water are brought into play: for in every quarry where the planes of joints and smaller fissures are exposed, it will be found that the faces or sides of these planes are coated and filled with rich Hæmatite Iron Ore. Examination underground at Frampton Cotterell and other places, testifies to the accumulation of Iron in the same manner, though in this latter case due to the action of large quantities of water, carrying with it Iron in suspension, taken up by percolation through a porous sandy matrix charged with the mineral in question.

I have remarkable and fine specimens shewing these conditions from joints and fissures, taken both from underground and from numerous quarries worked in the district. Again, the walls of the Great Fault and main lode at Frampton Cotterell are festooned with bunches of "Brush Ore," which hang from solid irregular walls of Iron, which line the vertical sides of the great fissure, this being only a more extended condition of the same phenomena under more favourable conditions for accumulation.

Fig. 8.—Section showing Fault and Iron Lode.

I cannot satisfy myself that these lodes are the result of causes acting directly from within, or are entirely *esoteric* in their origin, or due to subterranean calorific agency or sublimation, many of which we know to be at work in the earth's crust. We have no evidence of water at high temperature having had any important office in their accumulation, though it is not improbable these ores may have been accumulated by means of the solvent powers of water, saturated with Carbonic Acid, and holding Proto-carbonate of Iron in solution, and then, by the escape of the Carbonic Acid, deposited the ores of Iron in the same way as Calcareous Sinter, when, by the contact or under the influence of Oxygen, it may become Peroxidized. Indeed, the more we examine these veins *in situ*, and under all phases of their conditions, the more am I inclined to believe them to have had their origin, so far as filling-in is concerned, during the period of the destruction of the Palæozoic Rocks and the deposition of the New Red Sandstone, and again at its subsequent re-elevation and re-denudation in later times. To account for these views in still more concise reasoning, I may state that the Brown Iron Ore found in the veins or Faults at Frampton Cotterell, and the Tortworth area, have very probably been derived in great measure from the Iron which must have been present in the variegated Sandstones and Marls of the New Red Sandstone series, which formerly covered the Palæozoic series of the Basin,* but which have been entirely removed by denudation from a considerable area in the centre of the Coalfield, and also extensively on its eastern and western borders. In the New Red Sandstone the Iron occurs *partly* in the state of a Silicate of the Protoxide, but *chiefly* as a Hydrated Peroxide; of these compounds the Silicates would be decomposed by water containing Carbonic Acid in solution, whilst the latter (the *Hydrated Peroxide*) could not be acted upon until reduced to the condition of Protoxide, a change which might, however, be readily effected in various ways; such change, for example, may be effected by the reducing agency of organic matter. Once brought into the condition of Protoxide, it would then be readily acted upon by meteoric or atmospheric waters, charged, as they always are, to a greater or less extent with Carbonic Acid, thus giving rise to the formation of Carbonate of Protoxide of Iron, a compound easily soluble in water containing Carbonic Acid in solution, and, therefore, capable of being readily introduced into any fissures to which the waters might gain access. This Carbonate of Iron being exceedingly unstable, is decomposed with great facility, merely by exposure to atmospheric influences, its Carbonic Acid being evolved whilst Oxygen is absorbed from the air, thus

* See Analysis, page 40.

converting the Carbonate into a Peroxide of Iron; which, being insoluble, is deposited in the state of Hydrate as a reddish-brown precipitate, the reactions being indeed indentical with those which are occurring daily in every Chalybeate spring, or where Tufas and Sinters are similarly deposited. The Hydrous Peroxide of Iron thus formed might either be precipitated on the walls of the Fissure or Lode in successive deposits and layers, as may be well seen in certain regularly banded specimens from the Frampton Mines, and the openings near Mudgedown Farm to the north: or it may be more slowly deposited in stalactitic forms, of which the Frampton Cotterell workings present beautiful examples, consisting in many cases of fine pendant masses of compact brown ore, surrounded by coatings of the crystalline or fibrous variety termed Göthite, and resembling in their general characters the well-known specimens from the Restormel Iron Lode, near Lostwithiel, in Cornwall. Now when we reflect upon the vast mass of these Iron-charged Red Sandstones and Marls* that once rested upon the Coal Measure Rocks of this area, and admit the theory that long-continued percolation and infiltration, both during the period of deposition, and after by the slow agency of water through long periods of time into fissures and joints, it would, I believe, fully account for the origin of the Hydrated Oxides now stored in the fissures and faulted recesses of the Carboniferous Limestone, Millstone Grit, and Pennant Rocks below.

We must not fail also to recognize and consider the great influence that the subsequent removal of these Red rocks must have had upon the exposed land surfaces, probably after the Oolitic period, when the waters were again charged with the Silicates and Carbonates of Iron. Remnants of these Lower Red Sandstones (if not Permian) are now familiar to us in the patches of Dolomitic Conglomerate which fringe the edges of the Basin, and in places, the remaining masses of the New Red Sandstone, which still cover up large subterranean tracts of Palæozoic rocks.

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* See Analysis, page 40.

Numerous indeed are the theories relative to the formation and filling of veins, &c.; but this question, as a whole, does not concern us, it being only the ores of Iron that engage our attention, and the general theories relative to Copper, Tin, Lead, and other mineral veins and lodes, do not at all help us; for whilst most if not all of these ores are esoterically derived, the opposite, or exoteric condition, I believe to be the origin of most, if not all, our Iron lodes and deposits. No question is perhaps more difficult to grapple with, and few subjects have been, or are, more fruitful in hypotheses: for where the metallic minerals are derived from is still a question—whether directly from repositories below, or esoteric,—or indirectly by segregation or solution in minute particles from the adjacent rocks, or infiltration. It may be that at the time our various minerals were deposited in veins, those veins might have been beneath the sea, and also that they were covered with considerable rock masses, which have since been removed by denudation; and the veins that are now exposed and worked may have been, therefore, much deeper in the earth at the time the minerals were deposited in them, and both the rocks and the water have had a much higher temperature through deeply seated pressure, as well as chemical and internal heat, than they now possess, or since the denudation of the rocks from above them. Again, the waters may have been in a state of heated vapour, and have acted upon materials just as the frequent occurrence of pure and uncombined Silica, *either in the state of crystalline or amorphous Quartz*, seems to require the presence of water, probably at high temperature, which, traversing the adjacent rocks, might dissolve some of the Silicates, and deposit the Silica in an uncombined state.

The investigations of SORBY, DOBRÈ, and others, have long led us to believe and understand that many of the Crystalline rocks are *hydato-pyrogene*, rather than purely *pyrogene*, an hypothesis which has for its basis that many of them (Granite, Gneiss, &c.) were formed at high temperatures, but in connection with water. This remarkable discovery, and the results arising from it, is of the highest importance relative to the theory of mineral veins, for in them, and to a large extent, we constantly find conditions which can only be accounted for by the action of waters highly charged with mineral matters (in solution,) being, indeed, the medium or carrier from the metallic sources, where atom by atom it was taken up in solution, and subsequently deposited or precipitated in the vein.

As regards Ironstone veins, many doubtless may be filled by the process of sublimation (esoteric,) either from great depths or through igneous agencies not deeply seated (as some of the specular ores of Iron;) or partly, if not entirely, through the action of, or by means of infiltration (exoteric,) as in the Hydrated Oxides in question: and it may be said that these are the only ore veins whose origin we may perhaps ever determine. For when we take a general view of the filling-in of the dislocations in a district, whether termed faults, lodes, or cross courses, we distinctly see that it has depended upon conditions among which the mineral character of the adjacent rocks holds a prominent place, and upon this character seems to have greatly depended the nature of the chief mineral substances in them. Among the Limestones we find Carbonate of Lime;—the sandstones or Silicious Rocks, Quartz, &c. We may therefore rightly infer that either water charged with mineral matters in suspension, derived from the adjacent rocks, has infiltered into the fissures, or that the liquid contents have acted on the adjoining rocks, and dissolved and deposited a portion of them. And upon the mineral characters of the adjacent rocks seems also to me to have greatly depended the accumulation of the ores of the useful metals.

Or, if we may sum up the different theories, or those generally received, they may be divided into—first, the *contemporaneous* formation of mineral veins, with the rocks which enclose them: secondly, the filling-in of fissures formed in rocks by the *sublimation* of substances driven by heat from beneath upwards: and, thirdly, the filling of fissures in rocks by chemical deposits from substances held in solution in the fissures, and by infiltration, such accumulations and deposits being, perhaps, greatly due to electro-chemical agency. It is to this latter in the main, and at the age I have mentioned, that I believe the Iron lodes and ores of the Tortworth district were accumulated.

On the Datura Tatula (Torr.) *as a variety of D. Stramonium* (Linn.)
By Professor James Buckman, F.G.S., F.L.S., F.S.A., &c.

Read at Bradford Abbas, July 19th, 1865.

Having engaged in a series of experiments on these plants when at Cirencester, which I have followed out in Dorsetshire, I have thought that some few remarks upon the two forms, *Datura Stramonium* and *Datura Tatula,* might be interesting to the Cotteswold Club, and more especially as I have now such a fine plantation of *D. Tatula* to illustrate the subject. Most of our members will be acquainted with the white flowered *D. Stramonium,* called American Thorn Apple. The peculiarities of the *D. Tatula* consist in purple flowers, and indeed a more or less dark purple pervades the whole of the plant, which is, too, sometimes as much as three or four times the size of the *D. Stramonium.* However, in the details of form I have failed to detect any difference, a fact which at once induced me to suspect that the plants in question were only varieties; and therefore I procured some seeds in 1857, and commenced the experiments and observations about to be detailed. In the reports to the British Association for 1857 will be found the following:—

"A plot each of *D. Stramonium* and *D. Tatula,* was sown side by side (at Cirencester,) the former from seed grown in the district, the latter from seed kindly communicated by Mr. Savory, of New Bond-street. Of the former not one seed came up, whilst of the latter several plants are in great perfection. The *flowers of my specimens* are but very slightly tinctured with purple."

Then follows the remark:—

"These plants are very abundant in the United States, the tinctured variety being much more common towards the South than in the Northern States; and it is not at all improbable that the want of colour in my specimens is the result of the cold exposed climate* of my garden, and the poor soil† in which I have planted them."

In 1859 I reported to the Association as follows:—

"The *D. Tatula,* Purple Thorn Apple.—The crop of this season is from seed supplied by Butler, of Covent Garden. It is at least twice the size of that which was previously reported upon, and the flowers and whole plant appear to be unusually dark in colour, in which it contrasts finely with the following."

"*Datura Stramonium,* American Thorn Apple."

"Only three plants have this year arrived at maturity, but its extreme whiteness is quite remarkable when placed beside the *D. Tatula,* a crop which, it will be remembered, was formerly reported upon as being almost destitute of colour."

In 1859 the summer was remarkably dry and hot, and so, doubtless, favoured the full development of the *D. Tatula.*

During the last year, 1864, I grew a quantity of this plant at Bradford; and here, not only the season, but I think the climate favoured its growth, as here the plants were not only larger than any I had heretofore grown, but the colour was considerably darker; and in this latter respect it contrasted curiously with examples grown in the neighbourhood of London, which were considerably less coloured.

My crop of this year promises equally well, both for size and colour; indeed, I appear to have got into a strain of this plant, which perhaps may be considered as perfect.

I am thus led experimentally to consider that the *Datura Stramonium* and *Datura Tatula* are not distinct species; a notion, indeed, in which I am not singular. Beck, in his "United States Botany," considers the *D. Tatula* a variety of *D. Stramonium,* and I have myself seen them growing together in Virginia, with only the distinction in colour, but apparently none in size. It was doubtless introduced into the States, being an Eastern plant.

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* The climate was that of the Cotteswolds.

† The soil that of Forest Marble Clay.

It is worthy of remark that the purple form has the common name of Indian; the white, of American Thorn Apple; and *Tatorah* is the Arabic name from which our generic term of *Datura* has been derived.

The cogency of these remarks will be seen in the fact that the *D. Stramonium* is a medicinal plant, having been much used for asthma. Some few years since, a medical friend from India introduced the *D. Tatula* to Mr. Savory as being more powerful than the *D. Stramonium.* Since then he has had it cultivated, and it is now extensively employed in the shape of cigars and cut tobacco, and smoked by the asthmatic; so much so, indeed, that though I was only one of the growers, and sent up a few truck loads to London, yet it is not sufficient, and I am now growing as much as half an acre for medicinal use alone.

If, then, we are to view the *D. Stramonium* as the form adapted to colder atmospheres, and the *D. Tatula* as a warmer or more Eastern variety, and to view the heightening of colour as an evidence of a further elaboration of juices, it would follow that in growing plants for medicine they should be placed in as warm and open a situation as possible, in order to the full perfecting of colour, which may be considered as equivalent to tone or power.

Some confirmation of this view may be derived from the cultivation of garden esculents; thus celery, a native, poisonous plant, is quite innocuous *when blanched*; and lettuce, *Lactuca virosa,* a dark plant in its native state, with an extremely bitter and narcotic sap, in cultivation is sweet and wholesome in proportion to its negation of colour.

Again, the subject assumes importance when we consider that varieties should be externally so different, and also so different in power. No one seeing the two forms as I have grown them side by side, for the first time, but would conclude them to be specifically distinct. This view, however, on seeing the two colours in the States, would, as it is by American botanists, be modified. Still, I feel sure that the experimenter from these two wild strains would surely get our two cultivated forms very quickly; but, on the other hand, if we start with one form with the view of producing the two varieties therefrom, the difficulty would be greater, and the time longer. I believe, then, that in most species of plants there will be found to be forms capable, under the required conditions, of producing individuals to which some may be induced to attach the value of distinct species; and so where a large list of species occurs, it is in cases where these variable forms, or rather capabilities for variation, are most common; and it is in cases where we have a large list of reputed species, that experiment is capable of demonstrating the fact, that several so-called species can be produced from a simple form.

Bradford Abbas, Dorset, July 17th, 1865.

On the occurrence of Ancyloceras Annulatus in Dorsetshire. By LOCKHART KENNEDY, ESQ. *Communicated by* PROFESSOR BUCKMAN, F.A.S., &c.

As the occurrence of this form of *Cephalopoda* in so old a rock as the Inferior Oolite is a matter of some geological interest, it is to be hoped that a few remarks upon some specimens found at Bradford Abbas will be of interest to the Cotteswold Club.

The genus *Ancyloceras,* though nearly allied to the Ammonite in many important particulars, is yet separated from it by the fact that whilst in the Ammonite the whorls are in contact, and even generally overlapping, the *Ancyloceras* has, as it were, the whorls uncoiled.

The greater number of species of this group belong to the chalk series. In the Oolites we have, in the Inferior Oolite, the specimens under review; also, in the Lower Oxford Clay are two species mentioned by d'ORBIGNY as

1. Ancyloceras Calloviensis, *Morris*
2. Ancyloceras distans

Of these the first was formerly called *Crioceras,* to which genus all of them have been referred.

Our Dorsetshire specimen is well figured by D'ORBIGNY under the name of *Ancyloceras annulatus,* the specific character depending upon some prominent annular ribs. The author refers to the following synonyms:—

Hamites annulatus, *Deschayes*
Toxoceras obliquus, *Baugier and Jauzé*
Ancyloceras costatus, *Morris*
——————— Waltoni, *Morris*

It occurs sparingly in this district, in a thin band of coarse rubbly Oolite, which we may perhaps say is made so by the quantity of fossils which it contains. The bed itself is about two feet thick, and yet from one quarry, of which we give the section, it has yielded the following list of Ammonites and other shells, as at present determined :—

Ammonites concavus
———— Murchisoni
———— Parkinsoni
———— subradiatus
———— Sowerbii }
———— Browni }
———— Humphresianus
Astarte elegans
———— excavata, var.
———— crassitesta
Melania Heddingtoniensis

Modiola plicata
Pleurotomaria convidea
———— granulata
———— intermedia
———— armata
Rostellaria subpunctata
Trigonia clavellata
———— costata
Turbo Dunkein
———— pustulus

Added to these are several Ammonites and other shells at present undetermined, and perhaps some of them as yet unnamed.

We can also add to the list the following Ammonites, found in the same bed in the neighbourhood, chiefly at Half-way House :—

Ammonites Truellii
———— discus
———— polymorphus
———— Moorii
———— Martinsii

Now if we bring all together the fossils that we have found in different sections, it will not be difficult to show that the list would contain typical fossils of somewhere about 200 feet of the so-called "different zones," as we have met with them in Gloucestershire; and the interest of this thin band is heightened when we consider that in it are to be found a greater number of individuals of each species than are scattered about in the zones to which they are in Gloucestershire locally peculiar.

We have not as yet completed our list and sections so as to enable us to compare the Oolites of Dorsetshire with those of Gloucestershire, but we hope hereafter to be able to do so; and in the meantime it has not been thought out of place to give this slight history of a fossil as yet undiscovered in the Inferior Oolites of the latter County.

On a Section of the Lias and Recent Deposits in the Valley of the River Frome, at Stroud. By E. W. Witchell, F.G.S.

Read at Tortworth, August 19th, 1865.

Section.

	ft.	in.
a Surface mould, passing into buff-coloured clay or brick-earth. Varies from 2 to 5 feet thick	2	0
b Peat, formed of leaves, roots, water-plants, and river mud. Contains shells of nuts, &c.	2	0
c Gravel, resting upon Lias Marl *(d.)* The surface of this Marl is undulating, so that the thickness of the Gravel varies considerably	3 to 6	0 0
d Blue Lias Marl, in which are three layers of brown concretionary nodules, about 3 feet apart, composed chiefly of casts of fossils	9	0
e Lias Shale and Limestone, irregularly bedded, and of variable degrees of hardness, containing layers of shells in the partings; the whole very fossiliferous	4	0
f Lias Shale	2	0
g Oyster bed, composed of valves of G. Cymbium	0	2
h Lias Shale. Plesiosaurus remains at a depth of 3 feet.		

There is now in progress on the bank of the river Frome, about half-a-mile below the town of Stroud, an excavation in the river gravel, and in the more recent drift and overlying clay, which is of considerable interest. The excavation, which is circular, is 136 feet in diameter, and nearly 30 feet in depth, of which about one-third is in the recent deposits, and the remainder is in the upper beds of the Lower Lias.

A section from an excavation in an adjoining meadow is given in the Transactions of the year 1860, but, as that excavation was comparatively small in extent, the opportunity for observation was less favourable than in the present case. I have therefore made a more complete section of the beds. It may also be mentioned that the beds *d. e. f.*, and which are referred to in the former section as blue Marlstone, are in the zone of *Ammonites Henleyi*, the young forms of *A. maculatus (A capricornus* Schloth,*)* being abundant. A few aged examples *of the same species*, which there is reason to suppose are identical with *A. Henleyi*, Sow., were likewise obtained.

The springs which the excavation opened in the rock bed were highly charged with proto-Carbonate of Iron, no doubt produced by the decomposition of Iron pyrites.

It is not, however, so much the Liassic formation which gives an interest to the section as the recent deposits of gravel and peat, disclosing as they do, the results of the operation of natural laws in the river valleys of the district.

The gravel deposit is distinct from, and more recent than, the more extensive beds, which, commencing at Stroud and continuing through Cainscross and Stonehouse, run far into the vale in the direction of the Severn. It is, in fact, the ancient bed of the Frome, while the older beds are at a higher level, and were once the drifts and shores of a lake, which nearly, if not quite, covered the surface of the vale of the Severn. This may, perhaps, be considered a rather large assumption, but it is probable there was a time when such a lake existed, and the streams of the Stroud valleys formed one or more inlets of it for the following reasons:—1st. The height of the older gravels above the sea—namely, 160 feet, clearly proves the existence of a body of water at that elevation. 2nd. The appearance of the cliffs and the bed of the Severn at Aust, indicate the probable existence, at some former period, of high land across the present bed of the Severn sufficient to retain the waters, and so form an extensive lake, covering the vale to the height of the gravel beds at Stroud and other localities, of which the gravel beds were the beaches; and, 3rd., because all the organic remains hitherto found in these gravels pertain either to the land or fresh water.

If such a lake existed, the high land at Aust would, by the action of the outfall current passing over it, be gradually denuded, a channel would be formed, and gradually deepened, until, eventually, the lake would be drained. The streams from the hills would then, on their way to the Severn, commence the excavation of new and deeper channels, the smaller valleys which now intersect the district would be formed, and new gravel beds, such as the one under consideration, would be deposited, the gravel being probably derived from the washings of the slopes of the more ancient deposits.

The recent deposits, which at Stroud are about 40 feet below those at the higher level, are generally found not far below the present beds of the streams. They occur in the Nailsworth Valley; in the valley of the Frome below Stroud, where the bed is about 100 yards in breadth, and they probably extend several miles further down the river. In the excavation at Stroud the gravel rests upon an undulated surface of Lias cleanly excavated, as if the process of excavation had suddenly terminated, and the deposit of gravel had immediately commenced. There is an appearance of stratification in the finer portions of the gravel, but from its discoloured and dirty condition, it is manifest that the volume of water acting upon it was small, as compared with that by which the older gravels were formed, the latter being perfectly clean.

The close of the period during which these deposits were made would seem to approach near to, if it be not actually, within that of man; and although no human remains have hitherto been found in them, yet it is not improbable that the formation of the peaty deposit by which the gravel beds are covered up, is owing to the damming of the river by human agency and for human purposes. Still a long period of time would be required to produce the present state of the surface of the ground. The deposit of peat has been formed and compressed into a bed two feet thick, and upon this a bed of clay has been deposited, varying in thickness, at different parts of the locality, from two to five feet, and as this clay bed must be attributed to the overflowing of the river in times of flood, assisted by the washings of the adjoining land, its formation must have been at a slow rate, tending to carry back the deposit of the gravel to a remote period.

The formation of the gravel drifts of the valley of the Severn generally, is a large subject, and worthy of systematic investigation. I do not assume, in this brief paper, to deal with it further than is necessary to account for the more recent deposits of gravel in the beds of the present streams of the district as illustrated by the section at Stroud, and I have altogether referred to the subject in a general way, rather for the purpose of introducing it as a proper subject for discussion by the Club, than to attempt an elucidation of the various questions connected with it.

The terms "older" and "recent" gravels are used relatively to each other, and not to the still more ancient marine drifts at much higher levels, which are found in the northern parts of the vale of the Severn.

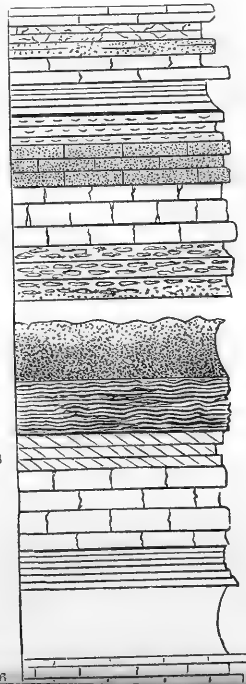
Additional Notes on Cleeve Hill Section.

By Thomas Wright, M.D., F.R.S.E., F.G.S.

The prominence given to the sections at Cleeve Hill, in the learned Presidential Address of Sir William Guise, Bart., in March, 1864, and published in the last part of our Proceedings, induced me to visit Cleeve Hill again, in September, 1865, for the purpose of studying the relative position of the different beds developed and exposed at that locality. The object I had in view was to ascertain whether more recent workings in the Upper Beds had brought any new facts to light relative to the correlation of the strata comprising the Rolling-bank Quarry, and described by me in a former paper communicated to the Club. The partial filling up of the old Quarry, by the soil that had rolled over the glacis of the hill, induced the men to tunnel at a higher level for the roadstone—the best road material of the Rolling-bank Quarry. From this underground quarry a large quantity of good rock had been obtained, and was stacked at the time of my visit. I found a considerable number of the species of shells, characteristic of this bed, so that there could be no mistake as to its identity with the beds previously worked on the western slope of the hill.

In order to place before the Club the facts upon which I had formed my previous conclusions, relative to the correlation of the beds comprising the Rolling-bank Quarry, I have thought it best to give a general section of the beds developed and exposed at Cleeve Hill, because it forms the highest elevation of the Cotteswolds, and exhibits very fine sections of all the subordinate beds composing the Inferior Oolite in the district which we claim as our own. This generalised section, (of which

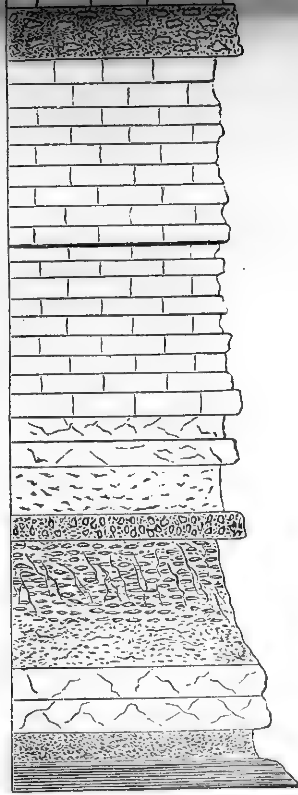
SECTION OF THE INFERIOR OOLITE AT CLEEVE HILL.



	No.	ft	in.	
Summit	1	6		TRIGONIA-GRIT. Ammonites Parkinsoni, and Corals. Thecosmilia gregaria, Thamnastræa Isastræa, &c. Gryphæa sublobata, Lima proboscidea, Trigonia costata.
	2	1	6	CHEMNITZIA-GRIT. Chemnitzia procera.
Rolling-bank	3	2		Rubbly Oolite.
	4	2	6	BRACHIOPODA-BED. Terebratula Phillipsii, in clusters.
	5	10		ROAD-STONE. Ammonites Humphriesianus, Chemnitzia Sœmanni.
	6	3		OYSTER-BED. Ostrea flabelloides, Lima Etheridgii.
				Not known.
North Quarry	7	5		Yellow and Brown Sands, with lenticular nodules of Sandstone.
	8	3		Hard wavy Sandstone. Serpula socialis, abundant.
	9		8	Marly Oolite.
	10	12		UPPER FREESTONE, with old Terebratula fimbria
	11	4		Thin flaggy Oolite.
	12	8		OOLITE MARL. Lucina Wrightii, Terebratula fimbria.
...rry	13	1	6	Thin hard bands of Limestone.

OOLITE.

INFERIOR



Upper Freestone	15	5		Hard rubbly Oolitic Marl, in broken masses.
	16	26		LOWER FREESTONE, the Upper Terrace.
Western Slope of the Hill	17	40	2	LOWER FREESTONE, the Lower Terrace
	18	2		Hard beds of pisolitic Oolite.
	19	4		Buff-coloured pisolitic Limestone.
	20	1	6	ROE - STONE. Pseudodiadema depressum, Acrosaleniæ, Trochotoma carinata.
	21	30?		PEA-GRIT. Pygaster semisulcatus, Ammonites Murchisonæ, Patella rugosa, Hinnites velatus, Avicula complicata, Terebratula simplex, Terebratula plicata.
	22	5		Coarse ferruginous Oolite.
	23	2		LIASSIC SANDS. Highly ferruginous.
				UPPER LIAS. Ammonites bifrons.

the annexed wood engraving is a reduced copy,) gives us the relative position of these various beds, and the different quarries in which they are exposed. I shall describe the beds in descending order, commencing with those exposed at the summit of the hill.

I divide the Inferior Oolite of our district into three zones:—

1st, the Zone of *Ammonites Parkinsoni.*
2nd, the Zone of *Ammonites Humphriesianus.*
3rd, the Zone of *Ammonites Murchisonæ.*

As these are all well developed in Cleeve Hill section, I purpose prefacing the description of the beds belonging to the three groups with a few general remarks on the typical character of each zone.

1. The Zone of *Ammonites Parkinsoni.*

Synonyms.—Trigonia-grit and Gryphite-grit, Murchison, Geology of Cheltenham, 1845; Strickland, Quarterly Journal Geological Society, vol. vi., 1850. Ragstone and Clypeus-grit, Hull, Memoir of the Geological Survey, 1857. Zone of *Ammonites Parkinsoni,* Wright, Monograph of Oolitic Echinoderms, 1856. Spinosa-stage, Lycett, Cotteswold Hills Handbook, 1858.

Description.—The series of beds included in this zone exhibit various degrees of development in Gloucestershire. In the Northern Cotteswolds, where the best types are seen, the thin beds of this stage rest on the *Brachiopoda* bed of the middle division, as at Cleeve Hill; and when these are absent, on the Upper Freestone, above the Oolite Marl, as at Leckhampton. When the Upper Freestone is absent, as at Turkdean, they rest on the Oolite Marl; at Sherborne, on the Lower Freestone; and at Burford, on the Upper Lias. They are overlain by the Fullers-earth, sometimes containing shelly bands, with *Ostrea acuminata.*

This zone is the most persistent of the three sub-divisions of the Inferior Oolite, and is the only representative of that formation in the south-eastern parts of the County of Gloucester. At Leckhampton Hill, the whole formation attains a thickness of 264 feet, whilst at Burford, 20 miles to the eastward, it has thinned down to less than 20 feet, and is there represented by the *Parkinsoni* beds, the middle and lower divisions being absent.

In one or two sections in the Northern Cotteswolds the following beds belonging to this zone may be distinguished:—

FULLERS-EARTH WITH *Ostrea acuminata.*

A.—*Upper Trigonia Grit.*—Consisting of thin-bedded brown Oolitic Ragstones, containing many fossils, chiefly as moulds. The following are the most characteristic:—*Trigonia costata, T. formosa, T. signata, Rhynchonella spinosa, Terebratula globata, Ammonites Parkinsoni, A. Martinsii, Clypeus Plotii.*

B.—*Gryphite Grit.*—Almost entirely composed of the valves of *Gryphæa sublobata,* imbedded in a fine hard calcareo-siliceous matrix. It is an oyster-bed of greater or less thickness, and is exposed in many sections in the Northern Cotteswolds; it is absent south of Rodborough Hill. Besides *Gryphææ,* it contains many species of Mollusca.

C.—*Lower Trigonia-grit.*—Light coloured, or brownish, Oolitic Ragstone, often iron-shot; containing, in some places, numerous fossils in fine preservation. *Echinobrissus clunicularis, Pedina rotata, Holectypus depressus, Lima gibbosa, Tancredia donaciformis, Gervillia Hartmanni,* and *Perna rugosa,* appear first in this bed.

D.—*Chemnitzia-grit.*—Consists of a hard bed of Ragstone above, and bands of Marls and Clays below. The Marls contain *Chemnitzia procera,* Fishes' teeth, and Crustacean remains. The Marls rest upon a thick bedded Oolitic Limestone, often bored by *Annelida.*

The Upper division of the Inferior Oolite has been much denuded from Cleeve Hill, and there is now but a feeble representation of the beds of this group in that locality. Those that remain remind me of the section of the same at Ravensgate Hill, both as regards the lithological character of the rocks, and the suite of fossils they contain. This zone is seen in a small exposure which faces the east, and overlooks the valley leading to Postlip Mills. The strata are composed of beds of brown rubbly iron-shot Oolite, from five to six feet in thickness. This small quarry has yielded some good Corals, and it was here that the fine *Thecosmilia gregarea,* figured in Edwards and Haime's Corals, was obtained.

No. 1 consists of α, rubbly Oolite above, hard slabs of Ragstone in the middle, and a clayey bed below, passing into β, a sandy Oolite of a rich brownish colour, freely speckled with ferruginous grains of the Silicate of Iron. I have obtained the following fossils therefrom:—

CEPHALOPODA.

Ammonites Parkinsoni, *Sow.*
——— Martinsii, *d'Orbig.*
Nautilus lineatus, *Sow.*
Belemnites canaliculatus, *Schloth.*

GASTEROPODA.

Pleurotomaria fasciata, *Sow.*
Trochotoma carinata, *Lyc.*
Natica adducta, *Phil.*
Monodonta lævigata, *Sow.*

CONCHIFERA.

Trigonia costata, *Sow.*
Pholadomya ovulum, *Agass.*
——— fidicula, *Sow.*
——— Heraulti, *Agass.*
Myopsis dilatata, *Phil.*
Goniomya angulifera, *Sow.*
Lima proboscidea, *Sow.*
—— gibbosa, *Sow.*
Lima compressa, *Wright.*
Gryphæa sublobata, *Desh.*
Trichites undulatus, *Lyc.*
Gervillia Hartmanni, *Golds.*
Opis cordiformis, *Lyc.*
Modiola Sowerbii, *d'Orbig.*
——— bipartita, *Sow.*
——— imbricata, *Sow.*

ZOANTHARIA.

Thecosmilia gregaria, *Edw. and Haime.*
Isastræa tenuistriata, *Edw. and Haime.*
Thamnastræa Defranciana, *Michelin.*
Latomeandra Davidsonii, *Edw. and Haime.*
Montlivaltia Wrightii, *Edw. and Haime.*
——— Delabechii, *Edw. and Haime.*

No. 2.—*Chemnitzia-grit* is a thin band of brownish Marl and Clay, in which are sometimes found specimens of *Chemnitzia procera,* DESLONG, and moulds of *Nerinæa.* Fishes' teeth are occasionally collected in this band.

No. 3.—*Rubbly Oolite.*—Consisting of Oolitic Ragstones, in a fragmentary state, with few fossils. This bed caps the next division.

2. The Zone of *Ammonites Humphriesianus.*

Synonyms.—Inferior Oolite of Dundry Hill, Conybeare, and Phillips, Outlines, p. 236. Grey Limestone, or Bath Oolite, Phillips, Geology of York, 1829, p. 149. Zone of *Ammonites Humphriesianus*, Wright, Jour. Geol. Soc. vol. xvi., p. 17.

Description.—This zone forms a well-marked division characterised by a fauna containing species of *Gasteropoda* and *Conchifera* not found in the others. The best type of this zone is the Ferruginous Oolite of Dundry, Yeovil, and Burton-Bradstock; and the only complete series I have found in the Northern Cotteswolds is in the exposure at Cleeve Hill, now to be described.

The original section in the Rolling-bank has been in a great measure covered up by the fall of the soil, and the thinning out of the rock beds. This quarry consisted of strata that had rolled from a higher level over the western slope of the hill, so that they appeared to occupy a much lower level than they in reality did. The recent workings near the summit, where the roadstone is now excavated by a subterranean cutting, shows the true position of these beds; I refer Nos. 4, 5, and 6 to this zone.

No. 4. The *Brachiopoda* bed is a compact crystalline buff-coloured Limestone; many blocks of great hardness are almost entirely composed of the shells of *Terebratula Phillipsii.* It measures two feet six inches, and contains, besides this species, the following:—

Lima proboscidea, *Sow.*	Terebratula Buckmani, *Davids.*
Terebratula Phillipsii, *Mor.*	Rhynchonella spinosa, *Schloth.*
———— perovalis, *Sow.*	———— subtetrahedra, *Davids.*
———— carinata, *Lamk.*	———— angulata, *Sow.*

On one occasion, by digging into the floor of the quarry, I found a bed of Marly Oolite, or Mudstone; it contained many fossils, the shells of which were in such a perished condition that I could not determine all the species. I noted, however, the following:—

Chemnitzia
Nerinæa
Modiola plicata, *Sow.*
Pecten lens, *Sow.*
Cypricardia cordiformis, *Desh.*
Terebratula Etheridgii, *Davids.*
Montlivaltia, species.

3. The Zone of *Ammonites Murchisonæ.*

Synonyms.—Dogger, (pars.) Young and Bird, Geology of the Yorkshire Coast, 1822. Phillips, Geology of Yorkshire, 1829. Central and lower division of the Inferior Oolite, Murchison, Geology of Cheltenham, 1834. *Fimbria* stage of the Inferior Oolitè, Lycett, Cotteswold Hills Handbook, 1857. Zone of *Ammonites Murchisonæ,* Wright, Monograph of Oolitic Echinoderms, 1856.

Description.—This division attains a considerable thickness in the western escarpment of the Northern Cotteswolds, where it consists of thick bedded Oolitic Freestones, frequently overlain by cream-coloured Marls, or thin bedded Limestones, and resting on calcareo-siliceous Ragstones, largely charged with the Peroxide of Iron, having inter-stratified therewith remarkable beds of Pisolite and Pea-grit, strongly impregnated with the same mineral.

In the neighbourhood of Cheltenham, as at Cleeve, Dowdeswell, Leckhampton, Crickley, and Birdlip, this zone is well exposed and attains its greatest development, measuring in some places upwards of 200 feet in thickness.

In the Southern Cotteswolds, the beds become thinner, in proportion as they are traced southwards; and at Dundry Hill, Somerset, they almost entirely disappear.

In the Eastern parts of the chain the same result obtains; at Turkdean, near Northleach, the zone is 50 feet thick; at Sherborne, only 5 feet; and near Burford it has entirely thinned out, the Inferior Oolite being there represented by the Ragstone beds of the *Parkinsoni* zone. At Leckhampton Hill, which may be taken as the most complete section of this division, the Upper Freestone is 34 feet, the Oolite Marl 7 feet, the Lower Freestone 147 feet, the Pea-grit and Ferruginous Ragstone 40 feet in thickness; the latter resting on the *Cephalopoda* bed and sands of the Upper Lias.

The upper portion of this zone is well exposed in the North Quarry, half a mile distant from the Rolling-bank. The sandy subsoil feels boggy to the tread, and is thrown up into numerous elevations by the burrowing of rabbits. There is a gap in my section between the base of the Oyster-bed No. 6 and the next stratum No. 7, which I have not been able to fill up, as in none of the exposures do we find the consecutive beds in super-position. The missing stratum may be represented by the Marly Oolite found beneath the Oyster-bed in the Rolling-bank Quarry; but of this I have no evidence.

No. 5.—The *Road-stone* consists of a coarse, brown, ferruginous, Oolitic Limestone, hard and crystalline in some parts, and in others traversed by sandy layers, containing concretionary masses of calcareo-siliceous rock, having an unequal fracture, and crystalline structure. It contains a small assemblage of Mollusca, many of which are specifically distinct from those of the upper beds, as *Chemnitzia Sœmanni*, Oppel., nearly identical with the Coralline Oolite species, *C. striata*, Sow., gigantic forms of *Pholadomya Heraulti*, Ag., and very large shells of *Trichites undulatus*, Lyc. This bed varies in thickness from ten to fifteen feet.

CEPHALOPODA.

Ammonites Orbignianus, *Wright.*	Ammonites Brocchi, *Sow.*
———— Humphriesianus, *Sow.*	———— Braikenridgii, *Sow.*
———— Sowerbii, *Mill.*	Nautilus lineatus, *Sow.*

GASTEROPODA.

Chemnitzia Sœmanni, *Oppel,*	Pleurotomaria fasciata, *Sow.*
———— lineata, *Sow.*	————elongata, *Sow.*
Turbo lævigata, *Sow.*	————constricta, *Deslong.*

CONCHIFERA.

Ostrea flabelloides, *Lamk.*
———large flat, new species
Hinnites tuberculosus, *Goldf.*
Lima proboscidea, *Sow.*
—— Etheridgii, *Wright*
—— duplicata, *Sow.*
Trichites undulatus, *Lyc.*
Astarte excavata, *Sow.*
Cyprina, (mould)
Cypricardia cordiformis, *Desh.*
Myacites calceiformis, *Sow.*
Gervillia consobrina, *d Orbig.*
Mytilus explanatus, *Mor.*
Pholadomya Heraulti, *Agass.*
Homomya crassiuscula, *Lyc.*
Myoconcha crassa, *Sow.*
Pteroperna plana, *Lyc.*
Trigonia costata, *Sow.*
——— striata, *Sow.*
——— decorata, *Agass.*
Modiola imbricata, *Sow.*
Pinna fissa, *Phil.*

No. 6.—*The Oyster-bed* consists of a coarse brown, ferruginous, sandy Marl, with inconstant layers of hard rock, which breaks up unequally. It is chiefly in the sandy seams that the fossils are found. The bed is about a yard in thickness. The bottom was seldom exposed, as it was mainly for the Roadstone that the working was carried on. It contains:—

CONCHIFERA.

Ostrea flabelloides, *Lamk.*, and several well-marked varieties of the species
Ostrea pyxiformis, *Wright*
Pecten demissus, *Goldf.*
Lima proboscidea, *Sow.*
—— Etheridgii, *Wright*
Monotis tenuicostata, *Wright*
Gresslya abducta, *Phil.*
Pleuromya tenuistriata, *Agass.*
Pholadomya Heraulti, *Agass.*
———— ovulum, *Agass.*
———— media, *Agass.*
———— Dewalquei, *Lyc.*

ANNULOSA.

Serpula grandis, *Goldf.*
Serpula limax, *Goldf.*

ECHINODERMATA.

Clypeus Michelini, *Wright*
Stomechinus germinans, *Phil.*
Pseudodiadema depressum, *Agass.*
Acrosalenia Lycetti, *Wright*

No. 7.—*Calcareo-siliceous Sand.*—Of a brown, grey, or yellow colour. It forms the uppermost bed in the North Quarry, and constitutes the subsoil over a considerable area of this part of the hill. It has been denuded much in parts; measures in some places five feet in thickness, and is unfossiliferous. I know of no other bed in our district which presents similar lithological characters to this sandy stratum.

No. 8.—*Wavy Sandstone.*—This is a hard, brown, thin bedded rock, with a wavy stratification; it is siliceous in some parts, and calcareous in others. The siliceous portions are unfossiliferous; the calcareous are represented by slabs of thin Ragstones, containing many fossils. On some of these I found *Serpula socialis*, Goldf., in great abundance. This bed has a thickness of three feet, and rests on

No. 9.—*Marly Oolite.*—Broken up into fragmentary portions. It appears to be the upper portion of the Upper Freestone.

No. 10.—*Upper Freestone.*—A thick bedded, coarse grained Oolitic Limestone, used for rough work. This rock was long thought to be unfossiliferous; and considerable doubts were entertained as to the precise position of these beds in the series. During my last visit, however, I succeeded in obtaining from the lower and middle beds a few specimens of large old deformed *Terebratula fimbria*, Sow., which enabled me to determine its position as superior to the Oolite Marl; and identified the rock as the Upper Freestone, which here has a thickness of twelve feet.

No. 11.—*Thin flaggy Oolite.*—This rock splits into thin layers. Numerous shelly fragments are found in some slabs, but fossils are rare; thickness, four feet.

No. 12.—*Fimbria-bed, or Oolite Marl.*—This bed is well exposed on the western side of the hill, and consists of a cream-coloured Marl, like indurated Chalk, interstratified between two beds of Oolitic Limestone, resting upon the uppermost bed of the Lower, and overlain by the thin flaggy beds of the Upper Freestone. It forms a very persistent stratum in the Northern and Middle Cotteswolds, extending across this portion of the *plateau*, from the vales of Morton and Bourton on the east, to the mural escarpments of the Inferior Oolite on the west; but thinning out and disappearing in the southern part of the range. In some localities, as at Leckhampton, Sheepscombe, and Swift's Hill, near Stroud, it contains masses of Corals, of the genera *Thamnastræa* and *Isastræa;* in others, as near Nailsworth, it abounds with numerous shells of the genus *Nerinæa,* forming there a "Nerinæan Limestone;" in others, as at Cleeve and Cubberley, the Marl is charged with *Brachiopoda,* chiefly *Terebratula fimbria,* Sow., associated with a few *Terebratula carinata, T. submaxillata,* and *Rhynchonella Lycetti.* The fauna of the Oolite Marl induced me, in a former paper thereon, to consider this bed as the product of an ancient Coral-bank. "The direct evidence of the existence of Zoantharia in considerable numbers, added to the abundance of long spiral univalves belonging to the genera *Chemnitzia* and *Nerinæa,* which are known to nestle in Coral formations, together with the indirect evidence of a super-abundance of *Brachiopoda,* added to the lithological character of the Marl itself, which appears to be the product of Coral-mud and other *dèbris,* leads to the conclusion that the *Fimbria-bed* was a portion of a Jurassic Coral-bank* in the Oolitic Sea."

MOLLUSCA.

Chemnitzia procera, *Deslong.*
Nerinæa gracilis, *Lyc.*
Natica adducta, *Phil.*
Trochotomia calyx, *Lyc.*
Trochus monilitectus, *Phil.*
Monodonta lævigata, *Sow.*
Natica macrostoma, *Röem.*
Mytilus imbricatus, *Sow.*
Lima punctata, *Phil.*
—— Pontonis, *Lyc.*
Arca cancellata, *Phil.*
Lucina Wrightii, *Oppel.*
Myopsis punctata, *Buck.*
Ceromya concentrica, *Sow.*

BRACHIOPODA.

Terebratula submaxillata, *Davids.*
—— fimbria, *Sow.*
—— carinata, *Lamk.*
Rhynchonella Lycetti, *Davids.*
—— concinna, *Sow.*
—— angulata, *Sow.*

ECHINODERMATA.

Stomechinus germinans, *Phil.*
Pedina Smithii, *Forb.*
Pseudodiadema depressum, *Agass.*
Acrosalenia Lycetti, *Wright*

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* WRIGHT on the Sub-divisions of the Inferior Oolite. Quart. Jour. of the Geol. Soc. Vol. xvi., p. 13, 1860.

No. 13.—*Thin hard bands* of Oolitic Limestone, without fossils, eighteen inches.

No. 14.—*Thin beds of fine-grained* Oolitic Limestone, four feet six inches.

No. 15.—*Hard Rubbly Oolite Marl.*—This occurs in broken masses five feet thick.

These three beds are well exposed in a small escarpment on the western slope of the hill, near the large Freestone Quarry. They contain few fossils, and the rock is much shaken.

No. 16. — *The Lower Freestone.* — Attains a considerable thickness in Cleeve Hill, and has long been extensively raised there for building purposes. It is divisible into two terraces, the Upper of which contains the best beds of stone. The rock is a fine-grained thick-bedded Oolitic Limestone, remarkably free from organic remains and ferruginous stains. The Upper terrace is 26 feet in thickness.

No. 17.—*The Lower Freestone.*—The Lower terrace is exposed on the western escarpment of the hill. The rock is not equal in quality to the beds in the Upper terrace, and it is therefore not now worked for building-stone. Its exact thickness I have not ascertained. I estimate it at 40 feet.

No. 18.—*Hard Beds of Pisolitic Oolite,* and

No. 19.—*Buff-coloured Pisolitic Limestone,* forming a kind of transition lithological condition from the Oolitic Limestones of the Freestone to the beds of Roestone and Pea-grit.

No. 20.—*The Roestone* forms the base of the Freestone series. It consists of a whitish Limestone, composed of large Oolitic grains, containing a great variety of small Shells, Corals, and Echinoderms, in very fine preservation. In some respects the general *facies* of the fauna of the Roestone resembles that of the Great Oolite of Minchinhampton. Many of the Mollusca are specifically distinct, and others are identical with those of that formation. The shells are nearly all small, and well preserved. In some, the colouring is present, and there are many undescribed species in the series. My friend the late W. H. Gomonde, Esq., obtained many beautiful *Alaria,* with their long spines, from this bed at Leckhampton; and my old fellow-workers and valued friends, the Rev. P. B. Brodie and Dr. Lycett, collected, determined, and published, in 1850, a full list of these remains. I have not worked with much attention this bed at Cleeve Hill, but I collected in a short time many of the species of my friends' list.

Zoantharia.

Caryophillia. Thecosmilia. Montlivaltia. Isastræa.

Echinodermata.

Pseudodiadema depressum, *Ag.*
Acrosalenia Lycetti, *Wright.*
Stomechinus germinans, *Phil.*
Polycyphus Deslongchampsii, *Wr.*

Conchifera.

Astarte orbicularis, *Sow.*
——— depressa, *Münst.*
Arca pulchra, *Sow.*
Avicula complicata, *Buck.*
Cardium cognatum, *Phil.*
Cucullæa elongata, *Sow.*
———— oblonga, *Phil.*
Corbula curtansata, *Phil.*
Hinnites velatus, *Goldf.*
Psammobia lævigata, *Phil.*
Gervillia costatula, *Deslong.*
Cypricardia cordiformis, *Desh.*
Limea duplicata, *Sow.*
Lucina despecta, *Phil.*
Mytilus asper, *Sow.*
Nucula variabilis, *Sow.*
Ostrea costata, *Sow.*
Pecten lens, *Sow.*
——— Dewalquei, *Oppel.*
Trigonia striata, *Sow.*

Brachiopoda.

Terebratula simplex, *Buck.*
Terebratula plicata, *Buck.*

Gasteropoda.

Patella rugosa, *Sow.*
——— nitida, *Deslong.*
Pileolus lævis, *Sow.*
Natica adducta, *Phil.*
Nerita costata, *Sow.*
Alaria—(three new species.)
Rimula clathrata, *Sow.*
Solarium—(two new species.)
Emarginula tricarinata. *Sow.*
Fissurella acuta, *Deslong.*

No. 21.—*The Pea-grit* is one of the most remarkable beds of the Inferior Oolite in our district. It invariably claims the most marked attention from all the continental Oolitic Geologists to whom I have shown our local sections, as it is unlike any bed they are acquainted with in France or Germany. Its upper part consists of: α—a hard coarse brown rubbly Oolite, full of flattened concretions, cemented together by a calcareous matrix. When the blocks weather, the concretions resemble flattened peas, and form an uneven surface. In the cavities of the Pisolite beautiful Echinidæ are often found in great perfection, and many other fossils are very well preserved therein. β—A hard cream-coloured pisolitic rock, made up of compressed flattened concretions like those of α; the bed is more compact in parts. γ—A coarse brown ferruginous Ragstone, full of large Oolitic grains, and much Peroxide of Iron; it is readily disintegrated by frost. The three beds measure from 30 to 40 feet in thickness. The Pea-grit varies considerably in development in different localities. Crickley, Leckhampton, and Cleeve Hills afford good types of this bed.

Cephalopoda.

Ammonities Murchisonæ, *Sow.*
Nautilus truncatus, *Sow.*
Belemnites spinatus, *Quenst.*

Gasteropoda.

Patella rugosa, *Sow.*
——— inornata, *Lyc.*
Pileolus lævis, *Sow.*
Nerita costata, *Sow.*
Natica adducta, *Phil.*
Cirrus nodosus, *Sow.*
Turbo capitaneus, *Goldf.*
Trochotoma carinata, *Lyc.*

Conchifera.

Ostrea gregaria, *Sow.*
Placunopsis, *Sp.*
Hinnites abjectus, *Phil.*
Mytilus imbricatus, *Sow.*
Lima sulcata, *Münst.*
—— pecteniformis, *Schoth.*
—— duplicata, *Goldf.*
—— lyrata, *Münst.*
—— Lycetti, *Wright*
Astarte excavata, var., *Sow.*
Myopsis rotundata, *Buck.*
Goniomya angulifera, *Sow.*
Avicula complicata, *Buck.*
Ceromya Bajociana, *d'Orb.*
Cardium striatulum, *Phil.*
——— lævigatum, *Lyc.*
Pinna cuneata, *Bean.*

BRACHIOPODA.

Terebratula simplex, *Buck.*
——— plicata, *Buck.*
Rhynchonella Lycetti, *David.*
———subtetrahedra, *David.*

ECHINODERMATA.

Pseudodiadema depressum, *Agass.*
Cidaris Fowleri, *Wright*
——— Bouchardii, *Wright*
——— Wrightii, *Desor.*
Diplocidaris Desori, *Wright*
——— Wrightii, *Desor.*
Stomechinus germinans, *Phillips*
Acrosalenia Lycetti, *Wright*
Pentacrinus Austenii, *Wright*
Hemipedina Bakeriæ, *Wright*
——— perforata, *Wright*
——— tetragramma, *Wright*
——— Waterhousei, *Wright*
Polycyphus Deslongchampsii, *Wr.*
Pygaster semisulcatus, *Phillips*
Hyboclypus agariciformis, *Forbes*
Goniaster obtusus, *Wright*

ZOANTHARIA.

Latomeandra Flemingii, *Ed. and Haime*
——— Davidsonii, *Ed. and Haime*
Axosmilia Wrightii, *Ed. and Haime*
Thamnastræa Terquemi, *Ed. and Haime*
——— Mettensis, *Ed. and Haime*
——— Defranciana, *Ed. and Haime*
Isastræa tenuistriata, *Ed. and Haime*

No. 22.—*The Coarse Ferruginous Oolite* is composed of large Oolitic grains of Carbonate of Lime, having incorporated there-with a considerable per centage of the Peroxide of Iron. This rock has a fine rich brown colour, and where exposed in the escarpment, when lit by the sun's rays, it imparts a warm colouring to the surrounding landscape, varying in its tones from one hour to another. I know of no part of the Cotteswolds which exhibits more picturesque effects of colour than the bold naked escarpment of Cleeve Hill, and to which the beds forming this portion of the section so largely contribute by their deep rich tints. It is of little value as a road-stone, because it is readily disintegrated by rain and frost; it might have some economic value for the Iron it contains, if the per centage was sufficiently large to be remunerative, but no quantitative analysis has yet been made, that I am aware of, to ascertain its actual proportions. I have found few fossils in this bed at Cleeve. Belemnites and Pholodomyæ are occasionally met with.

No. 23.—*The Upper Liassic Sands,* which attain a considerable development at Cooper's Hill, Haresfield Beacon, Nailsworth, the Long Wood near Frocester, Uley Bury, Stinchcombe, the hills around Dursley, and at Nibley, Wotton-under-Edge, Ozleworth, and all along the chain of the southern Cotteswolds as far as Bath, are only feebly represented at Cleeve. These Sands afford an example of that thinning-out process which is seen to a greater or less extent in all the other beds in our section, if traced in certain directions from the point where they attain their maximum development. As a general rule it may be stated that all the Inferior Oolitic rocks thin out from their western escarpment in the Cotteswolds when traced eastwards, and that the Upper Liassic Sands gradually thicken when traced from the northern to the southern part of the chain. I have found no traces of the *Cephalopoda bed* at Cleeve, which contains such a large assemblage of Ammonites, Nautili, and Belemnites at Nailsworth, the Long Wood near Frocester, and other localities. The Liassic Sands rest conformably on the Clays of the Upper Lias, which are occasionally exposed in the escarpment, and contain small dwarfed specimens of *Ammonites bifrons,* Brug. The line of junction between the Sands and Clays is indicated by the outburst of springs, as it is the Upper Lias Clay which throws out the drainage of the Inferior Oolite. This is well shewn at Noverton Head, near Prestbury, Thrift Wood, Queen's Wood, and at the small valley leading down to Woodmancote; in all these localities the origin of the spring indicates the line of junction of the Upper Liassic Sands with the Clays on which they repose.

Annual Address to the Cotteswold Naturalists' Field Club. Read by the President, Sir W. V. Guise, Bart., F.L.S., F.G.S., *on Wednesday, March* 27, 1867.

Gentlemen,—

In observance of our annual custom, I have the honour to submit to you a report upon the proceedings of the Club during the past season.

It is again satisfactory to observe that in respect of numbers the Club suffers no diminution. It is not necessary now to insist upon the reputation of a society which has secured to itself so eminent a position among similar bodies, as by universal consent attaches to the Cotteswold Club; the greater cause therefore is there that we should not suffer that reputation to decay. It is in this sense that I notice with regret the falling off this year in our published papers. Dr. Wright's instructive paper on the "Coral beds of the Inferior Oolite" being, in truth, the only one of a character to take a place in our published transactions. A joint paper, by the Rev. Mr. Symonds and myself, on the "Belgian Bone-caves," I reluctantly permitted to appear; though, as being merely a record of our personal experiences, it lays but little claim to originality. The work so well done by Dr. Edouard Dupont in his explorations of the Lesse-valley caves, has received at his hands the fullest elucidation; and all the facts connected with those important discoveries have been embodied in a series of memoirs read before the Académie Royale de Belgique, since published by their illustrious author. Dr. Wright's Monograph on the

Ammonites has been temporarily suspended for lack of funds to meet the heavy outlay for maps, sections, woodcuts, &c. I should hope, however, that that impediment being now removed, we may look to see that important work continued and carried steadily forward to completion. I trust that the present season will produce a larger quantity of original work. For though I will not call a season wasted which does not bring large accessions to our printed papers, still the public—and by that I mean the scientific public—will necessarily measure our progress by some such standard; and I desire, above all things, that the standard to which we have of late years aspired should be maintained. In the meantime it is satisfactory to note that there is no falling-off in the interest of members, as shown by the usually full attendance at the "meets." I say *usually*, as I have again to notice, with regret, that the "foreign meeting," as I style the one which assembles outside the boundary of our own county, was again very scantily attended; indeed, had it not been for the full gathering of Bath Naturalists who came to greet us, the failure would have been very mortifying. This makes me hesitate respecting the appointment this year of a similar meeting. It has been tried now for several years, without securing that support which I have so anxiously looked for. I have in former addresses referred at length to this subject, and urged all the reasons which in my opinion could have weight, to induce members to support me in carrying out this object—but hitherto almost in vain. I will not re-state these reasons, but leave it to the Club to decide whether to repeat the experiment or not; only pressing upon members the obligation, in case they agree to do so, to support their President in becoming force.

Before concluding these preliminary remarks, I must take occasion to call to the notice of the Club the present condition of the Museum at Gloucester—a Museum containing the only local collection illustrative of the Natural History of our county, of which the fossils collected by our colleague, Mr. John Jones, of remarkable value and admirably arranged, were secured for the benefit of the county some three years ago. A considerable sum of money was then subscribed towards defraying the expense of fitly displaying the collection, though unfortunately the sum subscribed fell far short of the requirements of the case. The ordinary cost has been, since then, met by annual subscriptions; but from the first a debt was incurred, beyond what was covered by donations, to the extent of £60. This debt still remains uncancelled; and it seems to me not out of place, in an annual address to the Cotteswold Club, to bring prominently under their notice the financial condition of the Museum, and to urge its claims for support. Some £20 are already promised, and if every member of the Cotteswold Club would give a small donation it would greatly aid the exertions now making, to place the collection in a position of permanent security—a collection which is an honour to our city and county, the maintenance whereof in its integrity is, in my opinion, an object well worthy the best exertions of the Cotteswold Club.

First Meeting. The Club met for their First Field Meeting at the Haresfield Station, on the Midland Railway, and walked from thence over the Cotteswolds to Stroud. The Haresfield section was first examined stage by stage up to the Gryphite bed on Broadbarrow Green, whence the party proceeded to White's Hill, where good sections of the Trigonia beds and Oolite Marl are exposed. A further section of the Oolite Marl was examined at Scots' Quar, at which point the kindly forethought of Captain DICKENSON had provided an abundant luncheon, which was very welcome to the hungry wayfarers.

The Inferior Oolite Marl, as is well known to Cotteswold Geologists, occupies a position between the two Freestone beds, where, by its lithological aspect and characteristic fossils, it is easily recognisable; it has been traced over a considerable area, and is believed to represent an ancient Coral reef in the Oolitic sea. But besides the "Oolitic Marl," properly so-called, two other Coral beds have been recognised in the Inferior Oolite, the true position of which it was the special object of the day to examine and determine—or rather the position of the lowest of the three; as respects the two uppermost there was little or no difference of opinion. The lowest Coral bed, which belongs to the Pea-grit, at the base of the Inferior Oolite, is a white efflorescent rock, full of Corals, *Thamnastrea*, &c., branched and single in habit. It has always been difficult to find *in situ*, in consequence of its argillaceous nature, causing it to slip and slide over the Pea-grits, and thus to become one of the numerous tumbled Oolite masses that so commonly occur on the flanks of the Cotteswold range. This Coral bed was satisfactorily recognised in the situation above indicated, at a Roadstone quarry, and again by the turnpike-road leading to Stroud. Crossing the Painswick valley, the same Coral bed was seen at Juniper Hill, or Brown's Hill, where it occurs in a section twenty feet thick, charged with characteristic Corals, a full description of which will be found in Dr. WRIGHT's paper. Ascending the hill to Capel's quarry, overlooking the Slad or Slade valley, the upper Coral bed is well shown, from two to three feet thick, forming part of the Upper Trigonia Grit.

The Club dined at the Imperial Hotel, Stroud. After dinner, a good specimen of the Dartford Warbler *(Melizophilus provincialis)* was exhibited by Mr. JENNER FUST, who procured it in Kent. Some relics of a Roman villa, which had been found on the site of a house in process of erection by Dr. WETHERED, at Stroud, were exhibited by the Hon. Secretary, Dr. PAINE. Dr. WRIGHT then gave an interesting address on the palæontological evidence presented by the Supra-Liassic Sands of the Haresfield and other Cotteswold sections, urging, with his accustomed eloquence, the claim of the Sands in question to be ranged with the Upper Lias,—a claim founded on palæontological evidence, which he proceeded to illustrate by the exhibition of a fine suite of typical fossils; amongst these, *Ammonites opalinus*, of Reinecke, was, he said, "riveted to the Sands," in which he had been found it at Haresfield, more than twenty years ago; the form which replaces it in the Inferior Oolite, *Ammonites Murchisonæ*, being quite distinct. Dr. WRIGHT remarked that this form of Ammonite is not confined to the Sands, ranging into the Lias; but so persistent is this form, that it marks the zone of deposits between the

Lias and Inferior Oolite at Braun Jura, at Gmünd, and at Gündershofen, on the Lower Rhine. "The Sands," urged the Doctor, "possess a fauna entirely different from that of the Inferior Oolite, and should be ranged with the Upper Lias, to which they palæontologically belong."

Mr. Symonds, of Pendock, drew attention to a subject of great interest to the public in general, and one especially fitted for examination by Cotteswold Geologists, viz., the "weathering" qualities of the so-called Bath Stone. It is well known that under this name are comprised building-stones of very different qualities, much of which, when used for external purposes, are utterly valueless, splitting and shivering with the first winter's frost. Mr. Symonds urged upon the Club the desirability of instituting careful experiments, with a view to testing the qualities of different beds of Oolite, and thus signalising those which could be relied upon as *weather*-stones. Dr. Wright observed that the whole education of builders ought to be re-cast; it being most painful to see how good money is frequently thrown away in consequence of the use of improper materials. It is still an open question, which are the best qualities of building materials? The committee appointed to decide on the best to employ on the Houses of Parliament, failed. The building-stone of Bath, which is Great Oolite, has advantages in some respects over the Inferior Oolite. It would seem difficult, however, to lay down any fixed rule on the subject, beds varying in the same quarry. It is asserted, moreover, that the best beds of stone, if used in a green state, will pulverise rapidly; while the same beds, if allowed to season, will bear any amount of exposure. This subject is one which in former years much engaged the attention of one of the oldest members of the Cotteswold Club, Mr. W. H. Hyett, F.R.S., of Painswick, who instituted a series of experiments on the qualities of the Inferior Oolite building-stones, bearing more particularly on the weather stone qualities of the quarries of Bisley and Minchinhampton, as compared with the more perishable material of Painswick and Leckhampton, from whose communication to me on the subject I quote as follows:—

"The object of these experiments is this: Seeing that the natural moisture of a quarry, which masons call the 'sap' of the stone, or its tendency to absorb wet, seems to be the chief cause of its tearing and wearing away in frost, what I do is this:—I get samples fresh from different quarries, have them gauged to six-inch cubes, weigh them accurately, dry them artificially and by exposure to sun and air, and continue weighing them every morning and evening, till they come to a fixed weight; I then immerse some in water, and expose some to wind, rain, &c., and go on weighing.

"Of the Painswick stone, which alone I have tried lately, one sample which weighed 18lb. 4oz., gained only 2oz. by soaking in rain-water for five days; while another, which weighed 18lb. 8oz. on coming out of the quarry, sank to 17lb. in ten days' exposure to sun and wind, with ten nights on the hot-plate in the kitchen; and what was curious, was, that one day, after a night on the hot-plate, during a hot sun and wind, it gained 2oz. from the air, showing that it absorbed moisture very readily, although there was not a drop of rain. This experiment shows also that Painswick stone in its natural state is nearly saturated with moisture. This was the general result I obtained before, but of comparative details I remember *nil*. I acted upon it when I made additions to my house. I had the stone quarried and worked-up ready to go in the building the year before, keeping it in a covered shed open on the sides. That stone I used in any dangerous positions for stone not considered weather-stone. It has now been exposed since 1827, with scarcely an imperfection —I may, indeed, say none, except in the horizontal surface of the coping on the parapet, which has required restoration. But I used none within reach of the absorption from the ground, and laid it all on its natural bed; and this may account for the giving of the coping, which, I am told, masons within a few years past, used to lay with the *edge* of the natural bed as the top surface.

"Another precaution which, I am told, is put in practice now, is to use the saw, in preference to a heavy axe or broad chisel; everything which jars the fibre, as it were, gives it a tendency to suck up moisture, and to disintegrate with frost.

"I hope to get you to stir up some of our colleagues in the Cotteswold Club to work out, and confirm or negative my crude notions. If any one does, the trial should be made with stone fresh from the quarries of Bisley, Minchinhampton, Leckhampton, and Painswick; and of the two very different stones, both of which are 'Bath stones,'—one hard and durable, the other soft and perishable,—yet both are sold as the same; the softer more often, because the contractor works it more easily."

These points should be cleared up and made public, and Mr. Hyett offers to co-operate with any member of the Cotteswold Club who is disposed to follow up the enquiry. I consider the foregoing notes by Mr. Hyett of great interest, and calculated to form the basis of a series of experiments, which, if carefully carried out, may be made productive of most useful results.

The Second Field Meeting took place on Wednesday, 13th of May, the fixture being May Hill. This was a joint meeting of the Cotteswold and Malvern Field Clubs. The party proceeded from Gloucester on wheels, visiting by the way the Pinetum at Highnam, and the New Church at Huntley—the former affording a rare treat to the lover of the beautiful in nature—the latter not less interesting to the admirers of ecclesiastical art and decoration.

At Huntley the party was hospitably entertained at luncheon by Major Probyn; after which they proceeded to the summit of May Hill, from which commanding elevation the Rev. W. S. Symonds, President of the Malvern Club, delivered an instructive address on the Geology of the complicated district which, in a panorama of unequalled beauty and extent, lay spread around the observers. Commencing with the primæval history of the Malverns, he shewed how their plutonic masses have been thrust through the overlying Silurian strata; how the prolongation of their axis of disturbance has brought the Llandovery Rock to the summit of May Hill, while throwing off the overlying Silurians and Old Red on the flanks like the coats of an onion; how the prolongation of this line of up-thrust, passing under Tortworth and the Bristol Coal-field, is traceable over an extensive area, giving rise to a series of dislocations and up-heavals, most important in an economical point of view, as bearing upon the practicable working of many of our beds of coal and iron. It were long to follow all the speaker's points as his eye glanced from the Oolitic escarpment of the Cotteswolds over the broad vales of Worcester and Gloucester. He described the action of ice and water, which, in the course of illimitable ages, have ground down and worn away superincumbent strata, leaving only a gravel-bed here and there to tell of what once has been: and he wound up by an eloquent description of the appearance of Man upon the scene, in company with Mammals of huge growth —the Mammoth and Hairy Rhinoceros—now no longer living on the face of the earth, but whose bones, entombed with the works and remains of man, have of late years been found associated under circumstances which render their contemporaneity no longer doubtful.

Scarcely was the address concluded before rain began to fall, which caused a speedy retreat in the direction of Dursley Cross, where the carriages were in waiting, which conveyed the party back to Gloucester.

Dinner was served at the Bell Hotel.

After dinner Dr. Wright gave a lucid and instructive account of the Coral beds of the Oolites, shewing in what respect they differ from those of our present oceans and seas; pointing out the remarkable fact that, except as dwarfed and isolated individuals, these Polyps appears to have been absent from the close of the Oolitic period until, in the seas of the present epoch, they have reached their climax of greatest development.

On Wednesday, 18th July, the Club was summoned to meet at Bath. This was the occasion already referred to, which has rendered necessary the remarks in the opening portion of this address, on the very indifferent response made by the Club to that summons—not more than six or seven members appearing at the place of rendezvous to represent their associates and support the President. They were, however, joined by several members of the Bath Field Club, and under the guidance of Mr. Charles Moore, the party proceeded by train to Freshford, to examine the drifts and beds of the Avon valley, returning to Bath by way of Hampton Down.

At Freshford there is a good section of the Lower Level Gravels resting on Lias Sands, which Gravels have yielded *Bos moschatus*, *Elephas primigenius*, &c. Attention was drawn to the mixed character of the Gravels, with which, together with a preponderance of Oolitic detritus, is associated much Carboniferous Limestone, Old Red, and Chalk Flints, together with a very appreciable admixture of hæmatitic Iron Ore. The mixed character of these accumulations is due to denudation from the Chalk of Wiltshire in one direction, and from the Mendips in another, occurring as they do at the point of junction of the Frome valley with that of the Avon, whose divergent channels command the respective sources of supply.

The party crossed the Avon, and followed the line of the Canal, which exhibits a good section of the *Parkinsoni* beds of the Inferior Oolite, about thirty feet thick, resting on the Lias Sands. These beds are overlaid by a great thickness of Fullers Earth, capped by Great Oolite, a sequence which is characteristic of all the hills around Bath.

The following local plants were observed in bloom in or near the Canal:—

Carex vulpina	*Sagittaria sagittalis*
Butomus umbellatus	*Nuphar lutea*
Origanum vulgare	*Scutellaria vulgaris*
Chlora perfoliata	

At Dundas aqueduct a quarry was examined exhibiting sections of Upper and Middle Lias, (Marlstone,) the former not exceeding three feet in thickness, containing *Am. communis* and *serpentinus*. The Marlstone, which is rarely exposed in the neighbourhood of Bath, was characterised by *Lingula Beanii* in great abundance.

Passing by "The Brass Knocker" the party reached the Great Oolite on Hampton Down, from whence they returned to Bath, and dined at the Royal Hotel.

After dinner Mr. Charles Moore, at the request of the President, gave an outline of his views respecting the beds at Sutton and Southerndown, near Bridgend, which have long been a *crux* to Geologists. But the more immediate interest of the question arose from a paper lately published in the Quarterly Journal of the Geological Society for May, 1866, by Mr. Tawney, of "The Survey," who finds in these beds an extension into this country of the Upper Rhætic series of the Continent of Europe. Mr. Moore, however, was of opinion that the beds in question are an abnormal extension of the true Lima beds of the Lower Lias, and contain Fossils identically the same. According to Mr. Moore, *Lima subduplicata* (*Tawney*) = *Lima duplicata*, *Ostrea lævis*=*O. liassica*, and *Pecten suttonensis*, are found associated with Lower Lias forms at Shepton Mallett, Saltford, and elsewhere. Mr. Moore, in noticing the range of species, referred to the finding of *Ostrea intusstriata* in Lias, near Bridgend, which formed the subject of a correspondence with our colleague, Mr. John Jones, three or four years ago. Mr. Moore now further stated that at Weston, near Bath, he had since found a specimen of *Ammonites angulatus*, with not less than 100 examples of *O. intusstriata* attached to it, shewing conclusively, if further proof were needed, that *O. intusstriata* can no longer be deemed reliable evidence of the presence of Rhætic beds. Mr. Moore exhibited an object of great interest and importance, in a block of Rhætic limestone, which had fallen on the line of railway near Shepton Mallett, containing a metacarpal bone belonging either to a Mammal or to a land reptile, probably the latter, but if so, undoubtedly representing the most ancient in that class of animal life yet discovered.

It may not be out of place here to draw attention to a paper in the Quarterly Journal of the Geological Society for February in the present year, by P. M. Duncan, M.B., on "The Madreporaria of the Infra-Lias," having reference especially to the intricate question of the age of the Sutton and Southerndown beds.

In this paper Mr. Duncan mentions, in terms of well-merited eulogy, the assistance afforded him by Mr. Charles Moore in his investigation of these beds, though he adds, "there is a difference in our opinion about their Geological age." Mr. Duncan's conclusions, drawn from an elaborate survey, and comparison of a vast array of facts, may be summed up as follows:—"The great bulk of the Brocastle, Sutton, and

Southerndown Mollusca are peculiar to a definite horizon, and but a few species pass upwards" into the *Ammonites Bucklandi* zone. "The Sutton stone, with its superimposed Southerndown beds," he regards as "forming one palæontological series," and as "the representatives and equivalents, lithologically and palæontologically, and in a positive as well as in a differential sense, of the beds included in the zones of *Ammonites angulatus* and *Ammonites Moreanus*—the Hettangian." Finally he includes under the term Infra-Lias all the beds between the *Ammonites Bucklandi* zone, or the true Lias, and the Keuper. He further divides the Infra-Lias into three zones—an upper, middle, and lower. In the upper, he places the Sutton and Southerndown group. In the middle, the *Ammonites planorbis zone* of Wright, and part of the White Lias. In the lower bed, he places the remainder of the White Lias, the *Avicula contorta* beds, and the Keuper; this last zone corresponding with the Rhætic of Moore.

Since the publication of the paper by Mr. Duncan above referred to, a very long and elaborate notice of these beds has been read by Mr. Moore before the Geological Society of London, in which he strenuously adheres to his view of the Liassic character of the beds in question, and maintains his argument with all the force which a long and intimate acquaintance with their contained organisms enables him to bring to bear upon the subject. He takes the whole line of country from Frome, in Somersetshire, to Sutton, Southerndown, &c., in Glamorgan. He first alludes to the Mendip up-lift, its basaltic dykes, &c., and describes the physical changes produced. He then points out the normal condition of the secondary deposits south of the Mendips, and shews that everything within the coal-basin is either in a great degree uncomformable or abnormal. He takes the Camel Section as the typical one, which he divides as follows:—

1. Keuper
2. Rhætic
3. Insect and Crustacea beds
4. *Ostrea* bed
5. *Am. planorbis* bed;

nearly, if not all the upper beds, belonging to the latter. He goes on to shew that the secondary beds, where they come in contact with the old Carboniferous Limestone coast line, are metamorphosed, and that we may have a *Sutton shore condition*, with beds of different ages in different localities. He gives sections where there are Liassic infillings, and at Charter House and other places shews that hundreds of feet down the veins possess a Liassic fauna. A dry-land area is inferred from the presence of several genera of land shells, the *Microlestes*, and the bones of a large land reptile. Passing into Wales he shews that the Sutton shore is only a local condition of beds, that are deposited either on ledges or in basins of the Carboniferous Limestone, and that as they retreat from thence, they pass into the usual stratified conditions those beds usually assume. He argues that only one or two of Tawney's species will stand, all the others being Liassic—Liassic Shells and *Gryphæa incurva* being found not only in the Sutton Stone, but in the very lowest beds round the shore at low water.

At Brocastle, from whence Mr. Moore obtained the Corals described by Mr. Duncan, he gives a list of about 180 species new to England, and altogether notices about 400 species, most of which are new to the English Lias, though many of them are found in the Infra-Lias of the Continent.

Mr. Moore enters a hearty protest against the adoption of the term of Infra-Lias for beds below the *Bucklandi* zone, arguing that our classifications should be based, not upon beds under such abnormal conditions as are the Infra-Lias beds of the Continent, where often they are but a few feet thick, but upon such sections as at Camel, where we have the beds in their full development.

The French authors, it appears, commence their *Lower Lias* with the *Gryphæa incurva* and *Am. Bucklandi* beds, including all below to the Keuper as Infra-Lias, to which they ascribe a special fauna. Mr. Moore shews, as he considers conclusively, that we have the fauna of their so-called Infra-Liassic beds in actual association with that of beds higher in the series, in proof of which he produces an *Am. Bucklandi*, and other Ammonites, with their Infra-Liassic fauna in great numbers actually in their chambers!

Moreover, in the Coral bed at Brocastle, which Mr. Duncan would make Infra-Lias, Mr. Moore has taken *Gryphœa incurva* in abundance. He finally urges that by the adoption of such a classification as that proposed by Mr. Duncan nine-tenths of the English Lias would have to be obliterated from the Geological Map of England.

On Wednesday, 15th August, the Club met at Evesham, to which place a branch railway from Ashchurch gives ready access. The points selected for a visit were the fine tower—all that now remains of the once important Abbey—and the two Churches close by, of All Saints and St. Laurence.

The Rev. W. S. Symonds read a short notice of the history of the Abbey, to which the President added a few notes upon the armorial glass formerly existing in the windows of the two parish churches—now alas! wholly obliterated. In the Vicarage adjoining the Church of St. Laurence, the party was kindly permitted to inspect a most curious ancient wall-painting, concealed behind a wainscot, a portion of which was removed in order to afford a view of it.

From Evesham the party proceeded to view the site of the famous battle, in which Symon de Montfort, the great Earl of Leicester, was slain in the month of August, A.D. 1265. An important portion of the field lies within the domain of — Rudge, Esq., whose family has been long seated there. Permission having been obtained to enter the grounds, the least military eye was able to appreciate the disastrous consequences to a large army, of being driven pell-mell down those heights into the river Avon, which, here describing a wide bend, completely bounds the rear of the position. The spot where the stout Earl fell, resolutely refusing to surrender to "dogs and perjurers, but to God alone," is still traditionally preserved, and is marked by a modern tower, which, from its summit, commands a noble prospect over the rich and diversified valley of the Avon. Hard by, a spring of water, now a watering-place for cattle, is pointed out as "The Earl's Well," and is probably the same to which miraculous powers were attributed in monkish chronicles, when its waters were duly applied by believers, in the name of God and St. Simon.

In the gardens attached to the mansion, which are extensive and well kept, are many relics of the ancient Abbey of Evesham, in gargoyles, finials, crockets, encaustic tiles, &c.; but many of these being preserved in a locked building, to which access could not be obtained, were not examined.

Before quitting the grounds, the President and the Rev. W. S. Symonds read notices of the battle; that by the former being mainly compiled from the latin chronicle of Rishanger, Monk of St. Albans, who flourished fifty or sixty years after the events of which he wrote; while Mr. Symonds drew his facts principally from the careful account of May, the historian of Evesham.

From hence the party, under the guidance of Mr. Symonds, crossed the Avon by a ferry to Offenham, a small village at which King Offa had a residence, the position of which is still pointed out, though no traces are now apparent to the eye, of the site of the ancient palace of the kings of Mercia.

The valley of the Avon hereabouts exhibits well-defined examples of those terraces, called "Low-Level Drifts," which mark the boundary of a more ancient Avon; while the rich meadows through which the river now flows are due to the contraction of the stream, and its gradual silting-up through long spaces of time.

The party dined at the Crown Inn, at Evesham. After dinner Mr. Symonds read a paper on the "Belgian Bone-caves," from the joint notes of himself and the President, who had lately in company visited the district referred to. The authors described the three now celebrated caves of the *Trou du Frontal*, the *Trou des Nutons*, and the *Trou de la Naulette*, and explained the relations of the stratified deposits (called by Dr. Dupont, *Lehm* and *Loess*) to the rolled drifts which underlie them. They showed that the phenomena exhibited in these caves are in all respects analogous to those in the English and Welsh Bone caverns in Gower, at St. Asaph, Tenby, Banwell, &c., and concluded by drawing attention to the remarkable human jaw found by Dr. Dupont in the cave of *La Naulette*, and taken out thence by his own hands from beneath seven feet of stratified *Loess* Sand, hermetically sealed by three distinct layers of Stalagmite. This jaw, which has been recognised by the first anatomists of Paris and Belgium as human, is certainly the the most ape-like that has ever yet been attributed to man. Its analogy is with the Australian or Lapp type, but notably with the former. It is small and round, the chin-bone is wholly wanting, and the orifices of the canines, which are absent, are of such dimensions as to show that they must have been almost tusk-like in character.

The Rev. Mr. Smythe exhibited portions of two human crania, which he had found at the isle of Portland, under four feet of superficial rubble, associated with a deer's antler and some coarse black pottery. These relics were found mixed with black carbonaceous matter; and a round stone which was found with them bore upon it evident marks of fire. The crania were of elongated form, the frontal bone much depressed, and were altogether of a very low type.

On Wednesday, 12th September, the Club held their last meeting for the season at Malvern, where they were joined by the Woolhope, Worcestershire, and Malvern Field Clubs. The day, for the most part raining, was ill-adapted for field excursions; nevertheless, a party, under Dr. Holl, scaled the Hills, and were rewarded by an interval of fine weather, which enabled them to enjoy the prospect, and to listen with advantage to a short lecture on the Geology of the surrounding district, by the Rev. W. S. Symonds. Malvern is, however, no uninteresting place of detention for weather-bound visitors. A large number congregated at the Abbey, and listened to a discourse on the stained glass, and other features of interest, of that noble structure, carefully prepared by the Rev. Mr. Munn. In the meantime, the Geological section of the associated Field Clubs met at the residence of Dr. Grindrod, whose extensive and choice Museum was liberally thrown open for their inspection. Here a paper was read by Dr. Holl, on the

Rocks of Malvern, which gave rise to an animated discussion, in which Dr. WRIGHT and Professor MORRIS were especially distinguished. It would seem as if the intellectual resources of the readers had been stimulated by the adverse circumstances of the weather; but however that may be, it is certain that rarely has a greater treat been enjoyed than by those who were present on this occasion. Tea and refreshments were liberally supplied by Dr. GRINDROD. Mr. EDWIN LEES produced a sensation by exhibiting a rude, earthen cup, lately disentombed from a tumulus on the Malvern Hills, which, filled with wine, was handed round to the assembled guests, when a libation was poured—the first which had flowed from the ancient crock since the time when it was deposited (some 2000 years ago mayhap) in the grave of the old Silurian chief.

Dinner was provided by the landlord of the Beauchamp Arms, which was served in the public concert-room, there being no apartment in the Hotel of sufficient capacity wherein to entertain so large a company. Some 84 sat down to dinner; your President, who occupied the chair, being supported by Dr. BULL, President of the Woolhope Club, and the Rev. W. S. SYMONDS, President of the Malvern Club. The vice-chair was filled by EDWIN LEES, Esq., Vice-President of the Worcestershire Club. The bill of fare was extensive and various, but owing to a lack of waiters, the service was tedious. It is but justice, however, to the landlord, who had done his best to cater for his guests, to add, that his difficulties were much increased by the fact, that nearly all the available staff of waiters had been drafted off to the Musical Festival at Worcester.

I believe, however, that all who were grumblers upon that occasion will be content to forgive the irregularities of the service, in consideration of the following humorous lines, by a well-known Cotteswoldian pen, in which the leading features of the day's proceedings are facetiously embodied in a letter to a friend, from one "MARY BROWN:"—

"O! Betsy, here is troubles as ever I have had,
There's Brown have been and kill'd hisself, or what's almost as bad,
A-moaning and a-groaning as he's lying in his bed,
With the cramps a-flying round him, and a swooming in his head;
Which I tells him 'tis a judgment, and he merits what he's got,
A-going a philandering with that botheration lot,
A-dining with the *Cotsulls** and the *Wallops** as they call 'em;
Drat all that lot, I'd wallop 'em if I could overhaul 'em.
He would go off to Malvern, to somebody's museum,
To look at stones and things, as does no good to them as see 'em:
For my part I could never tell what is the satisfaction
Them Cotsulls takes in looking at a ugly petrifaction.
But its my belief as 'tisn't only stones they goes to see,
And there's some of their acquaintance no better than they should be:
For there they sat a-talking about their nasty fossils,
A-drinking tea and biscuits and buttered toast in mossels;
And Dr. Wright a-telling 'em about one *Sally Urans,*†
And other brazen hussies, as passed off for demure 'uns;
A lot of *Trollopites*‡ he'd met a-walking on the beaches,
A pretty thing for married men a-larking with such leeches:
As I tells Brown, if I'd been there, and met him with that thingamy,
I'd let him and that hussey know I wouldn't stand no bigamy;
And if that's how they carries on a-going of these excursions,
'Tis time these Cotsulls had a stopper put on their diversions.
Well, when they'd drunk their tea and heard all Dr. Wright could teach 'em,
They took their leave and went away to dinner at the Beechem.
Brown's got a printed paper with the dinner all set down,
A dinner fit to set before a King as wears a crown;
But when they come to eat it, if Brown don't tell no fable,
The dinner was upon the bill, but wasn't on the table,
For though they'd written down two soups, giblets, and Juliun,
As far as Brown could make it out there wasn't enough of one;
As for the other things set down they wasn't to be had,
And the Cotsulls and the Wollops a-taking on like mad,
And everyone a-crying out for something for to eat,
Brown he got currant jelly, but he couldn't get no meat;
And some a-speaking softly, some a-cussing at the waiters,
Who never brought 'em nothing but bottled beer and taturs—
The President a-sitting before a joint of beef,
Like patience at a moniment a-smiling at their grief:
And Mr. Symonds going round using of soothing means,
A-offering them the Reading Sauce and handing kidney beans;
But what's the good of kidney beans, and what's the good of sauce,

* Cotsulls and Wallops—probably Cotteswolds and Woolhopes.

† Sally Urans—*Quære* Silurians.

‡ Trollopites—*Quære* Trilobites.

When a man's half dead with hunger and feeling mortial cross?
And Brown he says he felt as though it would have eased his feelings,
To kick the landlord round the room for his unchristian dealings:
And why he didn't do it is more than I can tell 'ee,
But the best of men ain't good for much when he's dined on currant jelly.
And so as you may fancy when he come home at night,
His temper wasn't of the best, and nothing wasn't right:
And now his head's a-splitting, he can't take nothing more
But strong green tea and brandy, as I've often know'd afore.
But what I want's to know is this, if nothing was to be had,
No dinner nor no drink, what make his head so bad?
Brown says it is a mystery to him, as 'tis to me,
But the thing he put it down to, as he fancies, is the tea.
So I hopes t'will be a warning, and next time he's asked to roam
With the Cotsulls or the Wallops, he'll take his tea at home.
But mind you never says a word of what I've here set down,
Or I'll never hear the last of it.

Yours truly,

MARY BROWN."

On Stone Roof Tiles of Roman Date. *By* Professor JAMES BUCKMAN, F.G.S., F.L.S., &c.

DURING my excavations at ancient *Corinium*, I not unfrequently met with Stone Roof Tiles, in which the flat-headed clouted nails by which they were attached were occasionally found.

These stone tiles, as might have been expected, were made of materials found not far from the spot: thus, at Cirencester, those most commonly met with were made from the thinner slabs of the Forest Marble, which is a very heavy and coarse material for roofing, though it is employed for this purpose at the present time.

Another rock which furnished roof tiles is that of the fissile beds at the bottom of the Great Oolite, which, from having been used at Stonesfield, Oxon, for roofing, from time immemorial, is called Stonesfield Slate. The Forest Marble and Stonesfield Slate occur in the Cirencester district, so that it is easy to understand why these should have been used for roof tiles in that district, notwithstanding they were so heavy and coarse. The tiles made from these—as may be seen from specimens in the Corinium Museum—are usually lozenge-shaped, so that when placed in position they present a series of scallops, as seen in Figs. 1, 2, and 3, and of which Figs. 2 and 3 afford examples of a modern arrangement of stone roof tiles, in imitation of the antique method. During my residence at Bradford Abbas, I have been so fortunate as to mark down several Roman sites, and in one of these, on my own farm, an excavation exposed a couple of cart-loads [*Putt*-loads, Dorset] of stone tiles, of some of the most perfect of which I send you a paper cutting of their exact size and form. Before, however, I refer more particularly to these points, I would describe the nature of the material of the stone itself.

Bradford Abbas is situate on the Inferior Oolite and Fullers Earth, but the first of these rocks is—here especially—too uneven in its fracture to become fissile, and the Fullers Earth is not superimposed by the Stonesfield Slate, as both this latter and the Great Oolite are absent in Dorset, whilst the Forest Marble, which is not far off, is even rougher than that rock near Cirencester. In this position, then, the builders employed a fissile bed from the basement beds of the Lias of the adjoining county—Somerset; and from this source, probably at Sparkford, a material was obtained, which, though tolerably smooth on the surface, yet from its thickness, (1 inch,) is as heavy, if not more so, than the coarser tiles from the Forest Marble.

The length from the top to the point of the base of Fig. 1 is 16 inches; the breadth in the widest part, 10 inches; width at the top, 5 inches.

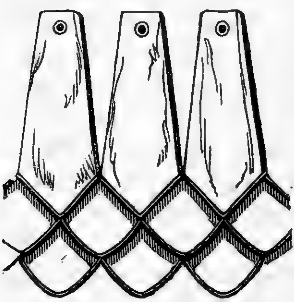

Fig. 1.—Roman Tiles.

Now the weight of a tile of this form and size (Fig. 1) is 11 lb.; but if square slabs are used, as as is done by the moderns, it would require to be nearly double that weight to effect the same purpose. See Fig. 2.

These, by being broader at the shoulder than at the top, and made lozenge-shaped at the bottom, are necessarily much lighter than though they had been slabs of parallelograms, arranged side by side, as is the modern custom.

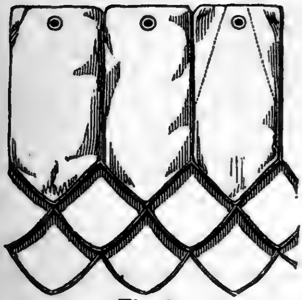

Fig. 2.

This Roman method of roofing is not unfrequently imitated in the present day, but when this is done it is supposed to be effected by merely making an escalloped or lozenge-shaped base, as Fig. 2; but this plan, it will be seen, does not render a roof so light as it would be, if the sides had been taken off, as marked in our figure by the dotted lines.

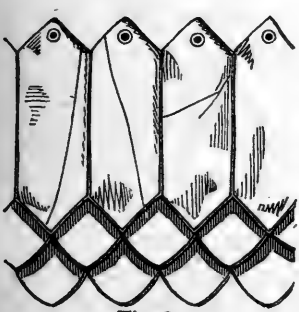

Fig. 3.

Fig. 3 would seem to show a further advance upon Fig. 2, and is the complete lozenge-shaped roofing tile, but in this the work at the upper portion is quite thrown away; as, if the tile were made shorter, the upper edge might be made flat, and then allow sufficient space for overlap.

Now if we arrange a series of tiles as seen in Fig. 1, we can form some idea of the ingenuity displayed in the manufacture of these *Liassic* tiles, as exhibited in the Bradford Abbas examples; and I cannot help thinking that, simple as this matter might appear, this ancient plan might be followed in the present day with considerable advantage.

It was, no doubt, the method of making the tiles lighter, by the clever calculations by which our tile No. 1 was formed, that enabled the ingenious people from whom they emanated to employ almost any stratum they might meet with within a convenient distance, for roofing purposes, notwithstanding the low pitch of roof in classic architecture. There is, then, no wonder that we should find the same materials too ponderous, even with a higher pitch, without those refinements by which not only weight was lessened, but heaviness of expression was got rid of by the lozenge bases, when contrasted with the flat ones.

I would now remark that the material of these tiles has been used for *tesseræ* for pavements, and it was, indeed, the finding of a number of these in the ploughed land, that induced the search which ended in the discovery upon which the foregoing remarks have been founded.

N.B.—The making of both tiles and tesseræ is favoured by the natural cleavage lines of the stone.

J. B.

Bradford Abbas, Dorset, Feb. 6, 1867.

On Coral Reefs Present and Past.

By Thomas Wright, M.D., F.R.S.E^{din.}, F.G.S.

Modern Coral Reefs.

Introduction.—The remarks made by our President, incident to the recent visit of the Cotteswold Club to the fine old Coral reef at Brown's Hill, near Stroud, suggested the following communication,* in which I shall endeavour to bring within the compass of a short paper the observations I have from time to time made to our members, by way of explanation, when the different Coral beds met with in our rambles over the Cotteswolds have formed the subject of conversation. In doing so, however, it will be necessary to introduce my remarks upon the Coral reefs of the past with a brief *resumé* of some of the leading facts connected with the natural history of the Coral formations of the present period, in order that the physical conditions under which such structures are produced, and the laws which appear to regulate the Polyp life of their builders, may be better understood.

That there are masses of rock many leagues in extent, founded in the recesses of the ocean, and built up into gigantic structures, from a hundred to two thousand feet in thickness, by the secretions of Polyps, is a fact of deep interest to the naturalist, and of great significance to the geologist, the study of which affords him important data for reasoning on the operations of these animals in former periods of the earth's history. It has

* The substance of this paper was communicated to the Members of the Club at the May-Hill Meeting, 13th June, 1866.

now been ascertained by the investigations of Quoy, Gaimard, Beechey, Fitzroy, Nelson, Darwin, Dana, Couthouy, Jukes, and Agassiz, that the vital operations of reef-building Polyps are limited within a certain Bathymetrical range; that beyond that depth they cannot live; and that the forms which reefs assume depend upon the elevation or subsidence of the ocean's bed on which their foundations are laid. When we compare the stupendous results obtained by the operations of a community of Polyps with the boasted monuments of man, the latter sink into insignificance. The great wall of China, or the pyramids on Egypt's plains, are as nothing when contrasted with the Atolls that stud the Coral Sea, and the Barrier reefs that stretch along the shore of New Caledonia to the length of four hundred, or those which extend along the north-east coast of Australia for upwards of twelve hundred miles. How marvellous the fact, that these masses of calcareous rock have been secreted, through successive ages, by generations of tiny architects, amidst the waters of the ocean, and in defiance of the violence of its ever-restless waves! The study of such phenomena prepares the mind of the geologist for the investigation of operations of a similar character, that have taken place in the seas of former periods of the earth's history; for many palæozoic and secondary rocks may be said to be ancient Coral reefs, which appear to have been formed under conditions analogous to those now in operation in the waters of the Pacific Ocean.

Coral reefs are masses of limestone accumulated through long periods of time, under certain physical conditions, by the living energies of reef-building Actinozoa: they assume various forms, in accordance with the outline of the coast, or the contour of the submarine rock or bottom on which they commence to build; such structures, however, are not entirely composed of dead and living Coral, for as these islands are the favourite abodes of many Mollusca, Crustacea, Echinodermata, and other Radiata, their skeletons after death largely contribute to augment the growth of the reef.

The principal reef-building Actinozoa belong to the groups *Poritidæ*, *Astræidæ*, and *Meandrinidæ;* these form the large solid masses of Coral Polyps which occupy the outer margin of the reef, and are there exposed to the wild fury of waves, rolling in an endless surge over their structures; whilst the branching Actinozoa, the *Madreporidæ*, and *Gorgonidæ*, and the cup-like *Explanariæ*, nestle in the still waters of the lagoon and channels within the reef, protected from the violence of the waves by the natural breakwater formed by their Astræan associates. It is only the external outer film of the Coral that contains in its myriads of cells the tiny living architects: the great mass of the structure is made up of the Coral masses, or of the branching forms of the skeletons growing on the reef; the intermediate spaces being filled in with fine light-coloured mud derived from the debris of other parts of the reef, or with triturated portions of the more delicate structure torn from the living margin, and embedded in the mud and sand accumulating in the still water of the lagoon; sometimes a true Oolitic or Pisolitic structure is produced by the motion given to the Coral grains; from these combined causes, and many others which may be unknown to us, we find the Coral rock consisting of a coarse grayish solid limestone, which is sometimes granular, or compact, earthy, or crystalline, according to the agencies that were in operation during the formation of the reef of which it formed a part.

Life Depth.—It was long supposed that the reef-building Polyps lived in very deep waters, as the remains of Coral structures were sometimes brought up by the sounding-line, or indicated by impressions made on its armed lead, at depths of many hundreds or even thousands of feet; and it was taken for granted that the Polyps lived and flourished in these profound recesses of the ocean. The careful observations, however, made by Ehrenberg, on the reef-building Actinozoa of the Red Sea, those of Darwin, Dana, and Jukes, in the Pacific, and of Agassiz, in the Gulf of Mexico, have proved that no reef-building Polyp can thrive at a depth of more than about fifteen fathoms, although other forms of Actinozoa live in much deeper water; the true reef-builders live and flourish only within this Bathymetrical position, many of them preferring much shallower water, but none of them working beyond one hundred feet of the surface. When reef structure is found beyond this depth, it has been caused by the subsidence of the ocean bottom on which such formations were originally laid. Should the reef region be slowly sinking, at a rate not faster than that at which the Polyps can make the reef rise, then almost any thickness may be obtained through long periods of operation. The observations made by Professor DANA about the Coral regions of the Pacific, have led to the conclusion "that some of the reefs have a thickness of two or three thousand feet, or more, and which has been acquired during such a slow subsidence." [1] DARWIN[2] says that thick beds of Coral are formed only at small depths beneath the surface of the sea, and that Captain MORESBY,—whose opportunities for observation during his survey of the Maldiva and Chagos Archipelagoes have been unrivalled,—informed him that the upper part or zone of the steep-sided reefs, on the inner and outer coasts of the Atolls in both groups, invariably consists of Coral, and the lower parts of sand. At seven or eight fathoms depth, the bottom is formed, as could be seen through the clear water, of great living masses of Coral, which at about ten fathoms generally stand some way apart from each other, with patches of white sand between them, and at a little greater depth these patches become united into a smooth steep slope without any Coral; and when we know that the reefs round these islands do not differ from other Coral formations in their form and structure, we may conclude that in ordinary cases reef-building Polypifers do not flourish at greater depths than between twenty and thirty fathoms. EHRENBERG[3] says of the Coral reefs of the Red Sea, which he carefully studied:—"The living Corals do not descend there into great depths. On the edges of islets and near reefs, where the depth was small, very many lived; but we found no more, even at six fathoms. The pearl-fishers at Yemen and Massaua asserted that there was no Coral near the pearl-banks at nine fathoms depth, but only sand."

[1] DANA, Text Book of Geology, p. 268.

[2] DARWIN, Structure and Distribution of Coral Reefs, pp. 82-83.

[3] EHRENBERG, Über die Natur und Bildung der Coralleninseln im Rothen-Meere, p. 56.

Distribution.—The influence of physical agents on living beings determines the geographical distribution of the species: thus light, heat, and temperature, latitude and longitude, atmospheric pressure and water pressure, individually and collectively, affect the life, growth, and development, as well as the decadence and destruction, of all organised bodies. The Actinozoa, it would appear, are remarkably sensitive to the influence of these agents; for although numerous genera of this class inhabit the waters of every region of the globe, still it has been ascertained that the true reef-building Polyps are limited to the seas of the tropics. Most of the high islands between the parallels of 28° north and south of the Equator, and also the borders of the continents within the same limits, are fringed with Coral reefs, provided the other conditions necessary to their development are present. Should the slope of the rocks below the water be steep, the Polyps cannot grow far from the shore; but if the slope is gentle, they make a wide fringing reef around the coast, the outer limit of which is determined by the depth of the water. Where the bottom is muddy, and rivers pour fresh water in any great abundance into the sea, there the reef-building Polyps are absent. According to Dana's observations, wherever cold oceanic currents invade tropical seas, and lower the mean temperature of the water in the coldest winter month below 68° Fahrenheit, there likewise reef-building Polyps cannot live. For this reason, and others perhaps not fully explained,—there are no Coral reefs on the West Coast of South America, or round the Galapagos Islands, in consequence of the cooling influence of that branch of the Great Antarctic or Humboldt's current, which sweeps along the western shores of that continent.

The Bermuda Islands, in 32° 15′ N., are the most northern limits of Coral reefs at present known; their distance from the Equator is, however, entirely compensated by the increased temperature of the ocean, derived from the Gulf-stream which flows around their western shores. In the Red Sea there are Coral reefs in lat. 30°. In the Pacific Ocean, the Loo-Choo Islands, in latitude 27° N., at the north-east of the Isle of Formosa, have reefs on their shores, and there is an Atoll at the north-west of the Archipelago of the Sandwich Islands, in 28° 30′.

In the Southern Hemisphere the reef-building Actinozoa do not extend so far from the Equator. In the Southern Pacific there are only a few reefs beyond the line of the tropic. Houtman's Abrolhos, on the western shores of Australia, in latitude 28° S., are of Coral formation.

In the middle of the Pacific Ocean the distribution of the reef-building Polyps extends over a zone of 56° of latitude in width, which on the western coast of America is reduced to 16°, and on that of Africa to 12°, whilst on the shores of Asia and Australia it extends over a diameter of 64°.

This irregularity in the width of the Coral zone in different parts of the ocean probably depends on the direction, force, and temperature of the extra-tropical currents, like those of the Galapagos Islands, which flow along the western shores of both continents at the north, and at the south of the Equator, and the inter-tropical currents found on their eastern shores; the Coral zone appears to be contracted on the west shore, and enlarged on the east. This irregular distribution of Coral reefs may at first sight appear to form an exception to the general law enunciated by Dana; but were all the physical conditions fully understood under which the exceptions occur, it would perhaps appear that the disposition of the warm and cold currents of the ocean is the real cause of their distribution, and that the exceptions, instead of breaking, in reality proved the rule.

Whilst the reef-building Actinozoa — *Poritidæ, Astræidæ, Gemmiporidæ, Madreporidæ, Meandrinidæ*—are limited to the Coral seas, and are not found living at more than 100 feet below the surface, other families of this class have a much wider range. The *Caryophyllidæ* extend from the Equator to the Arctic seas, and live at various depths, some species having been found at more than 200 fathoms; the *Alcyonaria,* in like manner, seem to prefer deep seas, *Corallium* having been found at 120, and *Gorgonia* at nearly 200 fathoms; and M. Sars dredged at Oxfjord *Virgularia Finmarchica* at a depth of 240 fathoms. Although depths equal to, or even exceeding these, have yielded many species of *Zoantharia,* still in general the members of this order are most abundant in seas of not more than from 50 to 100 fathoms deep. The shallow vertical range of the reef-building Polyps has been already explained. Certain species are, however, chiefly found in particular parts of the reef itself, *Astrœidœ* and *Seriatoporidœ* choosing its more submerged portions below the outer exposed edge, upon which *Porites* and its allies flourish. On the surface of the reef, *Astrœidœ* and *Fungidœ* may readily be distinguished, and among these the globular masses of the Brainstone Coral, *Meandrina*, are often conspicuous.

The reef-building Actinozoa have likewise a limited range in space, and certain specific forms appear to characterise the various shores and oceanic regions in which they are found. The existence of natural barriers, whether of land or deep water, of thermal or frigid currents, exercise a marked influence on their distribution; hence we find that the species living in the West Indies, and in the seas of the Antilles, are special to those regions, and none of them are identical with the forms existing in the East Indies and in the Pacific, the central region of that ocean having likewise been found to possess its own species. Although these oceans appear to possess similar physical conditions of depth and temperature, still we find specific Polyp forms limited to certain areal regions of the same, and obeying the great law of their being—"hitherto shalt thou come, but no farther." For of 306 species collected in the East Indies and Pacific, 27 only are common to the two oceans, and there are none between the Great Ocean and the Atlantic.

The proximity of volcanic land, owing to the lime generally evolved from it, has been thought to be favourable to the growth of Coral reefs; but DARWIN * has well remarked, "there is not much foundation for this view, for nowhere are Coral reefs more extensive than on the shores of New Caledonia, and of North-eastern Australia, which consist of primary formations; and in the largest group of Atolls, namely Moldiva, Chagos, Marshall, Gilbert, and the Low Archipelagoes, there is no volcanic or other kind of rock, excepting that formed of Coral."

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* On Coral Reefs, p. 61.

Classification.—Mr. DARWIN has divided Coral reefs into

I. ATOLLS, or Lagoon Islands,
II. BARRIER, or Encircling Reefs,
III. FRINGING, or Shore Reefs.

I. *Atolls,* so named by their inhabitants, consist of a wall of Coral rock rising in the ocean from a considerable depth, and returning into itself, so as to form a calcareous ring, more or less complete, having a sheet of shallow water, or lagoon, within the circle. The wall is breached in general, in one or more places, and when sufficiently wide and deep to admit a vessel, it may form a convenient harbour. The outer side of the reef slopes away at an angle of 45° or more, to a depth of from two to five hundred fathoms, whilst the inner side inclines gently towards the middle of the lagoon, forming a saucer-shaped cavity, having a depth of water from one to fifty fathoms. The annexed sketch of Whitsunday Island, in the South Pacific, taken from Admiral BEECHEY's work, affords a faint idea of the general aspect of one of these Atolls, or lagoon islands.

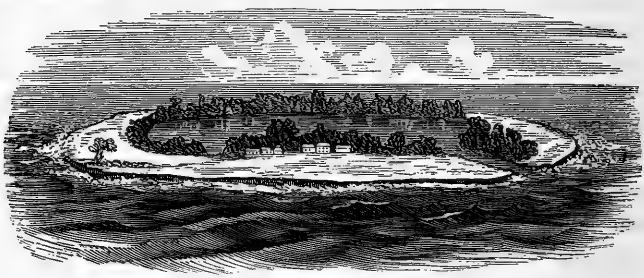

Fig. 1.—Whitsunday Island.

M. DARWIN remarks, * that "this island is one of the smallest in size, one mile and a half long, and has its narrow islets united together in a ring of land, which is comparatively rare, so that it does not represent the singular aspect of one of these islands. The immensity of the ocean, the fury of the breakers, contrasted with the lowness of the land and the smoothness of the bright green water within the lagoon, can hardly be imagined without having been seen."

* Naturalists' Voyage, p. 466.

The summit of the outer wall of an Atoll is entirely composed of masses of living Actinozoa; numerous species of *Porites, Milleporæ, Astreæ,* and *Meandrinæ,* flourish there in luxuriance, forming mounds of Coral from four to eight feet wide, and as many thick, and separated from each other by narrow winding channels, six feet deep, which intersect the entire line of reef at right angles. The cells in the upper tier of the rock are empty, as the Polyps cannot endure exposure to the sun's rays at low water; hence this check to their upward development occasions their lateral expansion into masses having broad flat summits; all below low water-mark, the Coral wall teems with life; and the dead portions of Coral are covered over with layers Nullipore, one of the calcareous Algæ, which can bear any amount of exposure; this marine plant envelopes the exposed Coral like Lichens coating an old tree. The reef-forming Polyps thrive best in the surf occasioned by the breakers, and hence, where the surge rages most furiously, there these tiny architects work with the greatest activity. The violence of the waves frequently breaches the reef, and detached portions are driven inwards towards the lagoon, where they form, with other masses of similar origin, an inner reef; thus the ring of rock is enlarged along its inner circle, and the active development of the *Porites* living on the outer wall soon repairs the damage done by the storm. So rapidly does the wall of Keeling Atoll shelve downward, that Admiral FITZROY, at a distance of 2200 yards from the breakers, found no bottom with a line 7200 feet in length; hence the submarine slope of this Atoll is steeper than that of any volcanic cone.

The lagoon, it would appear, has a fauna of its own; distinct species of Actinozoa with delicate branching stems, multitudes of Radiata and Mollusca indigenous to it nestle among the shallow waters, and fishes breed abundantly in the winding channels and crooked crannies of the Coral rock.

II. *Barrier Reefs* are similar to Atolls in structure, but differ in physical arrangement. They run parallel with the shores of some continent, or larger island, separated from the

* Naturalists' Voyage, p. 466.

land by a broad and deep channel of smooth water; the outer side of the encircling reef plunges into very deep water, whilst the intervening channel represents the lagoon of an Atoll.

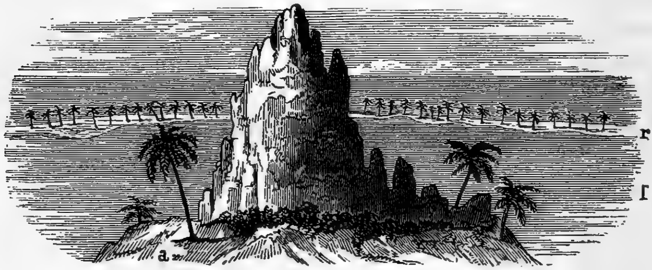

Fig. 2.—Bolabola Island.

The accompanying sketch (Fig. 2) taken from the voyage of the *Coquille*, representing the Barrier reef seen from within, from one of the high peaks of the Island of Bolabola, gives a good idea of this form of encircling reef, which imparts a most singular and picturesque character to the scenery of the islands they surround. As in Whitsunday Island, the whole of that part of the reef which is above water is converted into land: this is a circumstance of rare occurrence; more usually a snow-white line of great breakers, with here and there an islet crowned by cocoa-nut trees, separates the smooth waters of the lagoon channel from the waves of the open sea.

Balbi called Barrier reefs, Atolls "with high land rising from within their central expanse," and Darwin has shewn that they are Atolls in one phase of their growth. Ellis, in his "Polynesian Researches," states that these reefs lie in general at a distance of from one to one-and-a-half miles, or even three miles, from the shore. The central mountains are generally bordered by a fringe of flat, marshy land, from one to four miles in width, consisting of Coral sand, and other *detritus*, derived from the lagoon channel, or soil washed down from the hills; this silting-up process is only the slow conversion of the lagoon channel into dry land, by the gradual sinking of the island and the upward growth of the Coral forming the Barrier reef out at sea.

Lagoon channels of Barrier reefs represent in every respect the true lagoons of Atolls; they have a shallow level bottom of fine sand, and are filled with a fauna analogous to those living in lagoons; they have a depth of water of from 30 to 50 fathoms. The lagoon channel round the Society Islands varies from 3 to 30 fathoms; at Vanikoro, from 30 to 56½; at Gambier Islands, from 23 to 29. Some Barrier reefs have only a few islets on them, whilst that which encircles Bolabola is converted into a strip of land.

The heights of the islands encircled by Barrier reefs vary: Tahiti, according to BEECHEY, is 7000 feet; Bolabola, (LESSON,) 4026 feet; Maurua, (BENNETT,) 800 feet; Aitutaki, (FITZROY,) 360 feet; and Manouai, (WILLIAMS,) 50 feet. Some of these islands, like New Caledonia, are formed of primary strata; others, like Tàhiti, of madreporic Limestone; and many are composed of volcanic rocks. The central land consists either of one island, or of several, encircled by a Barrier reef. There is no essential difference between Barrier reefs and Atolls: the latter enclose a lagoon in a circle of Coral rock, the former surround an island, or group of islands, at some distance from the shore, with a reef having a lagoon channel separating it from the island. Were the central land being removed by subsidence, as in the case of Bolabola, there would remain a circular Atoll, formed of numerous Coral islets, clothed with cocoa-nut trees, having in the centre a deep lagoon.

The Barrier reefs of Australia and of New Caledonia, from their immense extent, are marvellous structures. The reef on the West Coast of New Caledonia is 400 miles in length, and for many leagues is distant eight miles from the shore, and near the southern end of the island it is about sixteen miles in width. The great Australian Barrier reef extends, with few interruptions, for nearly one thousand miles, and its average distance from the land is from twenty to thirty miles, and in some parts from fifty to seventy. The lagoon channel in this case becomes a great arm of the sea, having an average depth of from ten to twenty-five fathoms where the reef is near the island, but where it is most distant the depth is from fifty to sixty fathoms. The sea close outside the reef is profoundly deep, but soundings may sometimes be obtained from some of the breaches.

III. *Fringing Reefs* skirt the shores, from which they are not far removed; they have much shallower water on their oceanic side, and a narrower lagoon channel between the reef and mainland, of which they in general form a sloping portion. The reefs fringing the Island of Mauritius afford a good type of this class. Many of these reefs are found in the Red Sea, on the East Coast of Africa, Madagascar, and the adjacent islands on the North, in the Indian Archipelago, between the Bay of Bengal and New Guinea, and as far as the Salomons Isles; they may be traced at intervals to the south of the Society Isles, in longitude 150°W., and northwards through the Phillipines; they also occur in the West Indies, and the Peninsula of Florida, forming the keys and reefs that jut out from the mainland into the Gulf of Mexico. As some important observations have of late years been made on the Fringing reefs of this region, I purpose giving in detail the facts related by Professor Agassiz,[1] as they throw much additional light on the natural history of Coral formations. The Florida Keys are a line of small islands a few miles from the southern extremity of the main land, at different distances from the shore, stretching gradually seaward, in the form of an open crescent, from Virginia Key, and Key Biscayne, to Key West, at a distance of twelve miles from the coast, which does not, however, terminate the series, for sixty miles farther west stands the group of Tortugas, isolated in the Gulf of Mexico. Although disconnected, these islands are so many parts of a submerged Coral reef, parallel with the shore of the peninsula, and continuous beneath the water, the parts visible above the surface being portions of the reef that have completed their growth, and been elevated above low water-mark:—

[1] Proceedings of the American Association for the Advancement of Science, p. 81: Fifth Meeting, Washington, 1851; and in more detail in his Methods of Study in Natural History.

"Several of the Florida Keys, such as Key West and Indian Key, are already large, inhabited islands, several miles in extent. The interval between them and the mainland is gradually filling up, by a process similar to that by which the islands themselves were formed.

"The gentle landward slope of the reef, and the channel between it and the shore, are covered with a growth of the more branching lighter Corals, such as Sea-Fans, Corallines, &c., answering the same purpose as the intricate roots of the Mangrove tree. All the *débris* of the reef, as well as the sand and mud washed from the shore, collect in this net-work of Coral growth within the channel, and soon transform it into a continuous mass, with a certain degree of consistence and solidity. This forms the foundation of the mud-flats which are now rapidly filling the channel, and must eventually connect the Keys of Florida with the present shore of the peninsula.

"Outside the Keys, but not separated from them by so great a distance as that which intervenes between them and the mainland, there stretches beneath the water another reef, abrupt, like the first, on its seaward side, but sloping gently toward the inner reef, and divided from it by a channel. This outer reef and channel are, however, in a much less advanced state than the preceding ones. Only here and there a sand-flat large enough to afford a foundation for a beacon, or a light-house, shows that this reef also is gradually coming to the surface, and that a series of islands corresponding to the Keys must eventually be formed upon its summit.

"What is now the rate of growth of these Coral reefs? We cannot, perhaps, estimate it with absolute accuracy, since they are now so nearly completed; but Coral growth is constantly springing up wherever it can find a foot-hold, and it is not difficult to ascertain approximately the rate of growth of the different kinds. Even this, however, would give us far too high a standard; for the rise of the Coral reef is not in proportion to the height of the living Corals but to their solid parts, which never decompose. Add to this, that there are many brittle, delicate kinds that have a considerable height when alive, but contribute to the increase of the reef only so much additional thickness as their branches would have if broken and crushed down upon its surface. A forest in its decay does not add to the soil of the earth a thickness corresponding to the height of its trees, but only such a thin layer as would be left by the decomposition of its whole vegetation. In the Coral reef also we must allow not only for the deduction of the soft parts, but also for the comminution of all these little branches, which would be broken and crushed by the action of the storms and tides, and add, therefore, but little to the reef, in proportion to their size when alive.

"The foundations of Fort Jefferson, which is built entirely of Coral rock, were laid on the Tortugas Islands in the year 1846. A very intelligent head-workman watched the growth of certain Corals that established themselves on these foundations, and recorded their rate of increase. He has shown me the rocks on which Corals had been growing for some dozen years, during which they had increased at the rate of about half-an-inch in ten years. I have collected facts from a variety of sources and localities that confirm this testimony. A brick placed under water, in the year 1850, by Captain WOODBURY, of Tortugas, with the view of determining the rate of growth of Corals, when taken up, in 1858, had a crust of Mæandrina upon it a little more than half-an-inch in thickness. Mr. ALLEN also sent me from Key West a number of fragments of Mæandrina from the breakwater at Fort Taylor; they had been growing from twelve to fifteen years, and have an average thickness of about an inch. The specimens vary in this respect, some of them being a little more than an inch in thickness, others not more than half-an-inch. Fragments of Oculina gathered at the same place, and of the same age, are from one to three inches in height and width; but these belong to the lighter, more branching kinds of Corals, which, as we have seen, cannot, from their brittle character, be supposed to add their whole height to the solid mass of the Coral wall. Millepore gives a similar result.

"Estimating the growth of the Coral reef according to these and other data of the same character, it should be about half-a-foot in a century; and a careful comparison which I have made of the condition of the reef, as recorded in an English survey made about a century ago, with its present state, would justify this conclusion. But allowing a wide margin for inaccuracy of observation, or for any circumstances that might accelerate the growth, and leaving out of consideration the decay of the soft parts and the comminution of the brittle ones, which would subtract so largely from the actual rate of growth, let us double this estimate, and call the average increase a foot for every century. In so doing, we are no doubt greatly over-rating the rapidity of the progress, and our calculation of the period that must have elapsed in the formation of the reef will be far within the truth. The outer reef, still incomplete, as I have stated, and therefore, of course, somewhat lower than the inner one, measures about 70 feet in height. Allowing a foot of growth for every century, not less than seven thousand years must have elapsed since this reef began to grow. Some miles nearer the mainland are the Keys, or the inner reef; and though this must have been longer in the process of formation than the outer one, since its growth is completed, and nearly the whole extent of its surface is transformed into islands, with here and there a narrow break separating them, yet, in order to keep fully within the evidence of the facts, I will allow only seven thousand years for the formation of this reef also, making fourteen thousand for the two.

"This brings us to the Shore-bluffs, consisting simply of another reef exactly like those already described, except that in course of time it has been united to the mainland by the complete filling up and consolidation of the channel which once divided it from the extremity of the peninsula, as a channel now separates the Keys from the Shore-bluffs, and the outer reef again from the Keys. These three concentric reefs, then,—the outer reef, the Keys, and the Shore-bluffs,—if we measure the growth of the two latter on the same low estimate by which I have calculated the rate of progress of the former, cannot have reached their present condition in less than twenty thousand years.

"But this is not the end of the story. Travelling inland from the Shore-bluffs, we cross a low, flat expanse of land, the Indian hunting-ground, which brings us to a row of elevations called the Hummocks. This hunting-ground, or Ever-glade, as it is also called, is an old channel changed first to mud-flats and then to dry land, by the same kind of accumulation that is filling up the present channels, and the row of Hummocks is but an old Coral reef with the Keys, or islands, of past days upon its summit. Seven such reefs and channels of former times have already been traced between the Shore-bluffs and Lake Okee-cho-bee, adding some fifty thousand years to our previous estimate. Indeed, upon the lowest calculation, based upon the facts thus far ascertained as to their growth, we cannot suppose that less than seventy thousand years have elapsed since the Coral reefs already known to exist in Florida began to grow. So much for the duration of the reefs themselves. What, now, do they tell us of the permanence of the species by which they were formed? In these seventy thousand years has there been any change in the Corals living in the Gulf of Mexico? I answer most emphatically, *No.* Astræans, Porites, Mæandrinas, and Madrepores, were represented by exactly the same species seventy thousand years ago as they are now. Were we to classify the Florida Corals from the reefs of the interior, the result would correspond exactly to a classification founded upon the living Corals of the outer reef to-day. There would be among the Astræans the different species of Astræa proper, forming the close roundheads,—the *Mussa,* growing in smaller stocks, where the mouths coalesce and run into each other, as in the Brain-Corals, but in which the depressions formed by the mouths are deeper,—and the Caryophyllians, in which the single individuals stand out more distinctly from the stock; among Porites, the *P. Astræoides,* with pits resembling those of the Astræans in form, though smaller in size, and growing also in solid heads, though these masses are covered with club-shaped protrusions, instead of presenting a smooth, even surface, like the Astræans,—and the *P. Clavaria,* in which the stocks are divided in short stumpy branches, with club-shaped ends, instead of growing in close compact heads; among the Mæandrinas we should have the round-heads we know as Brain-Corals, with their wavy lines over the surface; and the *Manicina,* differing again from the preceding by certain details of structure; among the Madrepores we should have the *Madrepora prolifera*, with its small, short branches, broken up by very frequent ramifications; the *M. cervicornis*, with longer and stouter branches, and less frequent ramifications, and the cup-like *M. palmata*, resembling an open sponge in form. Every species, in short, that lives upon the present reef is found in the more ancient ones. They all belong to our own geological period, and we cannot, upon the evidence before us, estimate its duration at less than seventy thousand years, during which time we have no evidence of any change in species, but, on the contrary, the strongest proof of the absolute permanence of those species, whose past history we have been able to trace."*

Theory of the Formation of Coral Reefs.—M. DARWIN, during his voyage as Naturalist to H.M.S. *Beagle*, between the years 1835 and 1840, was the first to explain the manner by which Barrier and Atoll reefs had been formed from ordinary Fringing reefs, on the principle of the depression of the land; and from that time to the present nearly all geologists have admitted this to be the true explanation of the phenomena, and of which the following account is a brief *resumé*.

Assuming that the outer edge of a Barrier reef marks the position, or nearly so, of a Fringing reef that was constructed along the shore when the island around which it formed stood at a higher level out of the water than it does now, we should have a condition of things which would be represented by Fig. 3, where (a, a, b) represents the section of an island surrounded by a Fringing reef, (r, r,) rising to the surface of the sea.

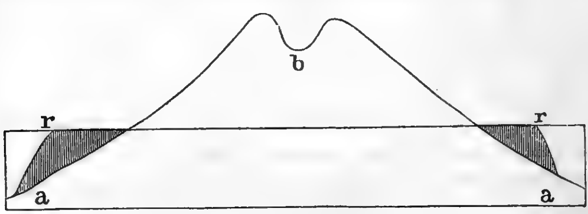

Fig. 3.

As the sloping shore slowly subsides by the depression of the land, the sea necessarily flows farther over it, and in course of ages the outer margin of the reef (Fig. 3, r) would

* L. AGASSIZ, Methods of Study in Natural History, pp. 185-192.

recede farther and farther from its former relation to the island. The Polyps, however, ever most active where most exposed to the play of the waves, have grown vertically upwards at the outer edge of the reef, and build here energetically, to regain the position most favourable for their development; but this subsiding island is becoming lower and smaller, and the space between the edge of the reef (r, r,) and the beach, proportionately broader. This is filled with a channel of shallow water, into which masses of Coral, torn from the outer margin, are hurled by the fury of the stormy waves. These become thickly coated with *Nulliporæ,* to a thickness of 2 or 3 feet. The lagoon channel is filled likewise by other *débris,* and crowded with other species of Polypifera that luxuriate in shallow water. A section of the island, after a subsidence of several hundred feet, is given in Fig. 4. The former living margin of the reef (r) is now dead

Fig. 4.

Coral, dragged down to a depth at which the Polyps could not live; but their progeny, working onwards and upwards in proportion as the land was subsiding, have maintained their position, and now form the margin of the outer Coral circle surrounding the land, where they form a Barrier reef, (r' r) separated by the lagoon channel (l, l) from the remnant of the land, (a, a, b) as already described in the case of the island of Bolabola, (Fig. 2) where the Barrier reef is seen from within, from one of the high peaks of the island.

If the land continues to subside, and the Coral reef continues to grow upwards on its old foundations, whilst the water gains on the land until the highest peak is submerged, there will remain only a perfect Atoll, of which Fig. 5 represents a vertical

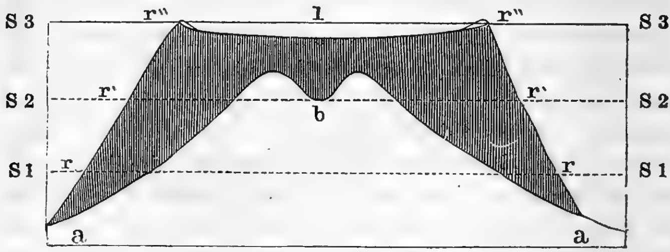

Fig. 5.

section. In this figure (r'' r'') is the living and growing outer margin of the reef, and the lagoon channel is now converted into the calm central lagoon (l) of the Atoll, as seen in Whitsunday Island (Fig. 1.)

This internal lagoon is itself often encumbered by inner reefs of Coral, growing on banks formed of Coral sand and other *débris*, or perhaps springing, like an old stunted branch or crag of rock, from one of the peaks of the Coral strand. In Fig. 6 an

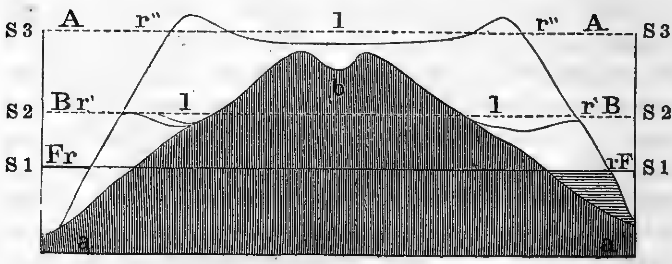

Fig. 6.

attempt is made to illustrate these changes of land level, in relation to the unchanging sea level, by drawing three successive lines S 1, S 2, S 3, to represent the surface of the sea at three different periods of time, as if the sea had risen, instead of the land forming the sea bottom having been depressed.

The island (a, a, b) represented in section, is surrounded by a Coral strand or Fringing reef, (Fr, rF, S1) which grew in shallow water, like the Florida Keys, or Coral banks of the present day. Then suppose the island to sink slowly and gradually, so that the sea flows more and more over it, (S2) until the reef stands at a distance from the land, and separated therefrom by a shallow channel or encircling lagoon, (l, l) the reef forms a Barrier round the subsiding island, as in the case of the island of Bolabola. As the land sinks, the distance between the Barrier reef (Br', r'B) and the land (a, a, b) increases, and the lagoon channel widens. When the highest peak of the land disappears, (S 3) and the Barrier reef becomes an Atoll (Ar'') or ring reef, without a central island, then the lagoon channels unite and form a central lake (l.)

Although this theory cannot be supported by proofs as direct and positive as those which result from observations long continued on the same points, or be proved by geometrical measurements made to attest the change of level on the land, still there are facts which are highly significant in support of the explanation. For example, we remark that the Atolls show, in their general distribution, the form or the direction of the land around which the base of the reefs had been originally constructed. In the South Pacific Ocean three principal groups of islands lie in a direction of north-west by south-east, like almost all the land in this part of the globe. North of the Equator the Caroline Archipelago extends east and west; and south of the line, the islands of Ceram, New Britain, and New Ireland, have a similar direction. In the Indian Ocean the Laccadives and the Maldivas Atolls extend in a line parallel with the chain of the Ghauts on the adjoining Asiatic continent. There is likewise a considerable resemblance between the general form and disposition of the Atolls and that of ordinary islands.

All are elongated in the direction of the group of which they form a part; and thus a series of Atolls, forming an Archipelago, would be but the translation to the surface, so to speak, of the submarine land which support the Atolls themselves.

If Barrier reefs and Atolls indicate great areas of subsidence, Fringing reefs, bordering the shores of emerged lands, are often stationary, or give evidence of a slow and gradual elevation of the continent they fringe. In the islands of Mauritius, Bourbon, Timor, and New Guinea; in the Mariana Isles, the Sandwich Archipelago, and other Fringing regions, there has been a modern elevation of the land, as proved by beds of recent shells in raised beaches, which the highest tides do not now attain. The shores of the Red Sea have experienced similar elevatory movements, followed by a movement of depression; and many of the Friendly Isles are but ancient Atolls, that have been submitted to oscillations of the same kind. The Keys of Florida, and the Great Reef itself, attest the slow growth of the Coral formation in this part of the peninsula; and the gradual rise of the same to form new land in this region has been already fully explained. Fringing reefs, therefore, shew that the shores which they skirt are stationary or rising; whilst Atolls and Barrier reefs attest that subsidence has taken place.

If we examine attentively the map coloured by Mr. Charles Darwin, shewing the geographical distribution of the different kinds of Coral reefs, we become impressed with the vastness of the areas occupied by reefs and islands of Coral formation, none of which rise to a greater height above the level of the ocean than that attained by matter thrown up by the winds and waves of an open sea. In the Pacific Ocean there is a band of groups of Atolls, which, measuring from the south end of the Low Archipelago to the northern termination of the Marshall islands, is 4500 statute miles long, and varying from 200 to 600 miles broad: to this may be added the Caroline and Pelew Archipelagoes, stretching more than another 1000 miles to the westward. The great Barrier reefs on the north-east coast of Australia are 1250 statute miles in length, and from 10 to 90 miles in width. The Laccadive, Maldiva, and Chagos groups, in the Indian Ocean, stretch along a line 1500 miles in length, the Maldivas themselves being 470 miles long by 60 miles in breadth.

The lowness of the islands of Coral formation, over all this vast area, depends upon the fact that Coral-Polyps are powerless to raise their structures higher than the line of low water-mark. To elevate them higher than this, various agencies are at work, but chiefly those of the winds and waves, the force of which detaches masses from the reefs, and piles these up in shallow water, where the interstices become silted up by Coral sand, fine mud, and other *débris*, of the reef. The general theory of elevation and subsidence of the sea-bottom within the area of the Corallian sea, the conversion of the irregular surface of the reef into one continuous level, and the alterations which its dead and deeply-submerged portions become exposed to in the lapse of time,—are subjects that belong to the consideration of the philosophic geologist, and which have received the most ample illustration and most satisfactory explanation by Mr. C. Darwin's admirable researches on this most interesting subject.*

As monuments of past changes, Coral reefs form the basis of some of the most important inductions that have been made in this branch of dynamical geology, and they open up a field of investigation, which has recently yielded some valuable facts regarding the long duration of the life of species in time, and to which I have given full prominence in the section on Fringing reefs. The palæontologist studies in these modern reefs all the slow processes by which the multiplication of the same specific forms through long lapses of time produce changes in the earth's surface, and he is prepared thereby for the investigation of those ancient reefs which existed in the seas of all past ages. Having ascertained that an island occupied each region where now the calm waters of the lagoon lave the Coral strand, he sees in every Atoll a living monument of land that

* Geological observations on Coral reefs and volcanic islands must be consulted by all who wish to understand the numerous details connected with this subject.

has now sunk beneath the waves; and the inference becomes conclusive, that tropical seas must have rolled over those existing continents, amid whose mountain-chains the remains of ancient Coral reefs are found.

Ancient Coral Reefs.

A. *Structure and Classification of Fossil Corals.*

As the study of all the known facts connected with the Natural History of modern Coral reefs is necessary to a correct appreciation of the probable conditions under which those of past time were formed, I have devoted a greater space to the consideration of this part of the subject than it was my intention to have done when I commenced this paper; however, these observations are so numerous and important, and so interesting and instructive at the same time, that I have ventured to introduce them here even at the risk of being thought tedious. The careful investigation of the *modus operandi* of modern agents is indispensable to the right comprehension of those which prevailed in ancient time; for every thing concurs to show that the past resembled the present, as the present is but a continuation of the past: and the student who most cautiously proceeds from the investigation of the known, to the study of the unknown, is pursuing the only true method by which he can hope to arrive at a sound induction respecting the conditions under which phenomena of an analogous or identical nature were produced in former periods of the earth's history.

All the great epochs into which Geologists have divided the fossiliferous rocks contain, in greater or less abundance, the remains of the fossil skeletons of Actinozoa. Sometimes their accumulation is so considerable, that strata of great thickness and vast extent may be said to be composed of the extinct forms of Corals; whilst the name commonly given to some formations, as Coral beds, or Coralline Limestone, is sufficient to shew that field Geologists, in the study of the Devonian and Carboniferous Limestones, and in the Coralline strata of the Oolites, have discovered the striking resemblance existing between ancient and modern Coralliferous structures.

Fossil Corals are important objects to the palæontologist, inasmuch as these organisms formed an integral portion of the body of the Polyp, and are not an inert secretion therefrom, as was formerly supposed. The characters furnished, therefore, by the corallum, or skeleton, being the petrified details of the chorion, have a well defined zoological value, and afford good characters for the bases of their classification. These organisms further attest the fact, that the regions of the globe in which fossil Corals are found, were formed under physical conditions similar to those that now prevail in the Indo-Pacific Ocean: we have every reason for believing that the growth and development of ancient reefs were regulated by laws similar to those which govern like phenomena in modern time. It has, however, been shewn by MM Edwards and Haime,—the highest authorities on this class,—that there is a palæozoic, or ancient type of Coral organization represented by the order Zoantharia rugosa, and a modern or neozoic type by the order Zoantharia aporosa; still we do not suppose that this difference affected the relations subsisting between the Polyps' life and the physical conditions under which both ancient and modern were developed. Sir Charles Lyell, * however, suggests that such might have been the case, although I fail to see any reasonable ground to support the learned author's opinion. The following is the passage referred to:—"It is not enough, therefore, to say that the primary, or more ancient Corals are generically and specifically dissimilar from the secondary, tertiary, and living Corals—for, more than this, all the most conspicuous forms, viz.:—the cup, and star Corals, belong to a distinct order, although they are often so like in outward form as to have been referred in many cases to reef-building genera. Hence we must not too confidently draw conclusions from the modern to the palæozoic Polyps, respecting climate and the

* Elements of Geology, page 512, 6th Edition, 1865.

temperature of the waters of the primeval seas, inasmuch as the two groups of Zoophytes are constructed on essentially different types."

On the contrary, I believe, there is abundant evidence for concluding that like conditions prevailed wherever reef-building Corals worked; for the associated Mollusca *Trigoniæ,* in the secondary, and Echinoderms *Crinoidiæ* in the palæozoic rocks, point to tropical seas as the true home of these animals.

The palæontological history of the Actinozoa yields results perfectly analogous to those offered by other classes of the animal kingdom.

1.—The genera and species of each of the great groups into which Zoologists divide these animals have had a limited duration in time and space,—no genus of the Palæozoic epoch having been found in any of the subsequent epochs, and no living genus having been discovered in rocks older than those of the Jurassic period.

2.—There is no evidence of any gradual development having taken place in this class from a lower to a higher type of Coralligenous structure; the old Corals of the ancient reefs appear to have been as highly organised, and as elaborately constructed as the modern Corals, now building reefs, in our tropical seas.

MM. Edwards and Haime have made most important and accurate studies on the structure and development of Corals, and have embodied their observations in a series of valuable memoirs.* From these we learn that the term *Corallum* is employed to designate all that distinct mass formed by the hard parts of one or many Polyps, united organically together, and is synonymous with *Polypidom* or *Polypary,* signifying the hard or calcified parts of the body of the animal or Polyp, possessing a radiate structure, a protractile mouth, surrounded by non-ciliate tentacula, and a large well-organised digestive cavity, but no vent.

The *Sclerenchyma,* or hardened tissue of Polypi by which Corals are formed, is always a portion of their tegumentary

* Annales des Sciences Naturelles, 3me. sèrie, tom. ix.

system; sometimes it grows on certain parts of the surface of that membrane, and forms a kind of calciferous epidermis similar to that which covers the skin of Mollusca and Crustacea. This epidermic *sclerenchyma* is the "foot secretion" of DANA, or "sclerobassic corallum;" it forms the Red Coral, *Corallium*, and the stems of *Isis*, and *Mopsea*, likewise the tubular horny sheaths of *Sertularia*, *Campanularia*, and other Hydroid Zoophytes, and the rooted, branched, plant-like stem of the sea shrubs or *Gorgonidæ*. The *dermic sclerenchyma*, or ossified chorion, is deposited within the bodies of Polyps: the calcification of this tissue always commences in the centre of the lower part of the Polyp, and extending, gradually rises as the animal grows, so as to enclose the lower part of the gastric cavity, and to constitute a sort of cup or cell which is broad, or shallow, long, or tubular, according to the destined condition of the Polypi; in fact, the "sclerodermic corallum" may be likened to the body walls of an *Actinia*, hardened by the deposition of inorganic matter therein, and thus petrifying all the delicate structures of its walls, base, and septa, by an interstitial deposit of calcareous salts, forming, so to speak, a mould of the organism: and as the whole body of an actinozöon may be made up either of one Polype, or of several united together by a cœnosarc, so may the fully developed sclerodermic corallum consist of a single Corallite, or of several connected by a cœnenchyma.

The corallum, or skeleton, is simple, when it belongs to a single isolated individual, and compound, when it results from the union of many bound together by a cœnenchyma or connecting calcareous tissue. The following definition of the terminology employed in the description of Corals will assist the student to understand the diagnosis of the different groups.

The parts of a typical *Corallite*, or simple Polyp skeleton, are the following. First, an outer wall or *theca*, somewhat cylindrical in form, terminating distally in a cup-like excavation or *chalice*, and having its central axis traversed by a stem or *columella*. The space between this and the theca is divided into *loculi* or chambers, by a number of radiating vertical partitions or *septa*, which do not always reach the columella, but are broken up into upright pillars or *pali*, arranged in one, two, or three rows, termed *coronets*. A transverse section of a simple corallum exposes all these parts. A longitudinal division shows sometimes the existence of imperfect transverse partitions or *dissepiments*, which, growing from the sides of the septa, interrupt the continuity of the loculi.

The septa have their sides sometimes covered with styliform processes, which in general meet and form numerous *synapticulæ*, or transverse props, extending across the loculi like the bars of a grate. In other cases the dissepiments are replaced by the development of successive horizontal floors or *tabulæ*, which do not grow from the septa, but extend without interruption across the entire space bounded by the theca. The *costæ* are vertical lines on the outer surface of the Polypary, corresponding in position to the septa within. The *epitheca* is an external continuous calcareous sheath of epithelic sclerenchyma which invests the Polypary. The visceral chamber is the central cavity in which the body of the Polyp is lodged; in some species it remains completely pervious from one extremity of the Polypary to the other, and the membranous appendages containing the reproductive organs situated in the loculi extend to its bases: in other species a number of synapticulæ extend from one septum to another, at various heights, fill up the lower part of the loculi, or partition it off by transverse laminæ or dissepiments, which grow from the sides of the septa in an irregular manner, and do not form complete divisions. In some Corals, where the septal apparatus is in a rudimentary condition, the bottom of the visceral chamber is successively raised by the formation of new floors or tabulæ, which extend horizontally across the Polypary, and form a series of cells or chambers below the calices.

Professor J. D. DANA,* in his great work on Zoophytes, has divided this class into two orders—1st, the ACTINOIDEA,—2nd, the HYDROIDEA.

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* JAMES D. DANA, History and Classification of Zoophytes. Plates. United States' Exploring Expedition. Philadelphia, 1846.

MM. EDWARDS and HAIME* have adopted a similar binary division; as the name Actinoidea had been previously employed in another and more limited sense, they have proposed the term CORALLARIA for the first sub-class, and HYDRARIA for the second. The following is a condensed summary of their classification:—

Sub-class CORALLARIA.—The Polypi possess distinct internal reproductive organs, and their gastric cavity or visceral chamber is surrounded by vertical radiating membranaceous lamellæ. The corallum is in general calcareous, and may be either tubular, cyathoid, discoidal, or basal.

Sub-class HYDRARIA.—The Polypi have a simple gastric cavity without vertical lamellæ, and internal reproductive organs. This group, which affords curious examples of alternate generations, now forms an important division of the HYDROZOA, and is connected with the *Acalephæ* by morphological relations not as yet fully understood.

The CORALLARIA, or true Polyps, present three principal modifications of structure, and are, therefore, divisible into as many orders: the ZOANTHARIA, ALCYONARIA, and PODACTINARIA.

1*st Order.*—ZOANTHARIA.—Have conical tubular tentacula, simple or arborescent, but not bipinnate, and with numerous perigastric membranaceous laminæ containing the reproductive organs. They are in general coralligenous, and almost all the known fossil Polypidoms belong to this order, which is divisible into two sections; in one the dermal tissue remains soft and flexible, the *Malacodermous Zoantharia*, the type of which is the *Actinia* or common Sea Anemone,—and the other, the *Sclerenchymatous Zoantharia*, possessing a solid skeleton or Polypidom, formed by the calcification of the chorion—the type of which is *Turbinolia*, *Astræa*, &c., and other reef-building Corals, living and fossil.

2*nd Order.*—ALCYONARIA.—The Polypi, with eight bi-pinnate tentacula, and eight perigastric lamellæ, containing the reproductive organs; the dermal tissue is in general consolidated by isolated spiculæ or nodular concretions; the corallum in

* Annales des Sciences Naturelles, 3e série, tom. ix.

general is composed of epidermic tissue, and constitutes a stem or axis in the centre of the compound mass formed by the gemmation of the Polypi. This sclerobasis is always covered by soft dermic tissue, and increases by the addition of concentric layers. It comprises three families,—*Alcyonidæ, Gorgonidæ, Pennatulidæ.*

3rd Order.—Podactinaria.—The Polypi have the gastric cavity surrounded by four vertical membranaceous septa, at the upper end of which four pairs of intestiniform reproductive organs are situated. The tentacula, discoidal, pedunculated, not tubular, as in Zoantharia and Alcyonaria The mouth proboscidiform, and the fauces surrounded by numerous internal filiform, contractile appendages. The only known representative of this order is the genus *Lucernaria,* Müller, which has no coralligenous form, and is now removed to the class *Hydrozoa.*

1st *Order.*—ZOANTHARIA.

The sclerenchymatous Zoantharia are in fact the group to which the true living and fossil Corals belong. Six principal divisions may be made of this section, and these are, the

Zoantharia aporosa	*Zoantharia rugosa*
———— *tabulata*	———— *tubulosa*
———— *perforata*	———— *cauliculata*

The Zoantharia aporosa have the corallum composed essentially of lamellar dermic sclerenchyma, the septal system is highly developed, and constructed of six primitive elements, the laminæ are imperforate, and they are the most stellular of all.

The Zoantharia perforata have the corallum composed of a porous or reticulate sclerenchyma, with a septal system of six elements, represented only by a series of trabiculæ; dissepiments rudimentary; and no tabulæ.

The Zoantharia tabulata have the corallum composed of a well developed mural system, and the visceral chambers divided into a series of stories by complete transverse diaphragms or tabulæ. The septal apparatus is rudimentary.

The ZOANTHARIA RUGOSA have a simple or compound corallum, composed of a septal apparatus derived from four primary elements, instead of six as in the preceding groups. The septa are incomplete, but never porous, and the visceral chamber is filled from the bottom by a series of transverse tabulæ, or by a vesicular structure which often constitutes the principal part of the Polypary.

The ZOANTHARIA TUBULOSA have a simple or compound corallum with imperforate walls; the septa, columella, and tabulæ are absent from the visceral chamber, and some feeble striæ are only visible. They form a single family, the *Auliporidæ.*

The ZOANTHARIA CAULICULATA have a dendroidal skeleton or sclerobase for supporting the Polypi, as in many Alcyonia, Gorgonia, and Isis. Its surface is smooth or spinulous, and not sulcated as in *Alcyonaria.*

2nd Order.—ALCYONARIA.

The Alcyonaria have a somewhat exceptional history: one singular family referred to this order, the Graptolithidæ, appertain to the Lower Silurian rocks, to which they are special. No other family of this division is found between that epoch and the White Chalk, where they are sparsely distributed. Alcyonaria continue to increase in numbers and genera through the Tertiary epoch, and attained their greatest development in our present seas.

The sclerenchymatous Zoantharia are divided into the following six sub-orders:—

1*st Sub-Order.*—The ZOANTHARIA APOROSA—are characterized by posessing a corallum composed essentially of lamellar dermic sclerenchyma, with the septal apparatus highly developed, completely lamellar, destitute of pores, and consisting of six elements, and no tabulæ. The foliaceous or lamellar structure of the calcified tissue, which furnishes one of the principal characters of these Corals, is always recognisable in the external part of the septa. This order includes four families: TURBINOLIDÆ, OCULINIDÆ, ASTREIDÆ, and FUNGIDÆ. These four families have nearly the same palæontological history, in this, that they date their origin from the commencement of the secondary epoch, and are represented in our present seas. There is one important exception formed by the genus *Palæocyclus,* one of the FUNGIDÆ which belongs to the Silurian period. The family ASTREIDÆ dates from the Trias; the TURBINOLIDÆ and FUNGIDÆ, with the exception enumerated, date from the Lias, and the OCULINIDÆ from the Great Oolite.

2nd Sub-Order.—The ZOANTHARIA PERFORATA—have the corallum composed essentially of porous sclerenchyma, the septal apparatus is well developed, and consists of six primitive elements. The plates are never imperforate, as in the preceding sub-order APOROSA, but the septa are always porous, or even reticulate. The visceral chamber is almost completely open from top to bottom, and never filled up with dessepiments or synapticulæ, as in most of the APOROSA, or with tabulæ. This sub-order includes two families—the MADREPORIDÆ, and the PORITIDÆ.

The first family, MADREPORIDÆ, characterises in a great measure the Tertiary epoch and our modern seas; one genus, *Discopsammia,* is special to the Upper Chalk.

The second family, PORITIDÆ, includes the Silurian genus, *Protaræa,* the Devonian genus, *Pleurodyctium,* four Jurassic, and several tertiary and existing genera.

From this analysis it appears that these two sub-orders, ZOANTHARIA APOROSA and ZOANTHARIA PERFORATA, lived in the Silurian period, and have continued to flourish throughout all the subsequent epochs. They are rare in the Palæozoic, more numerous in the Mesozoic, and attain their full development in the Tertiary epoch, and in the seas of the present time, forming the reef-builders of many Coral formations in the Indo-Pacific.

3rd Sub-Order.—ZOANTHARIA TABULATA—have the corallum composed of a well-developed mural system, with the septa rudimentary or absent. The visceral chambers are divided into a series of stories by complete transverse tabulæ or diaphragms; these floors differ from those of the ASTREIDÆ in being independent of the septa, and forming as many complete horizontal divisions extending from side to side of the general cavity, instead of occupying only one or two of the loculi, and closing the visceral chamber of the Corallites at different heights.

We divide the sub-order into four families—MILLEPORIDÆ, FAVOSITIDÆ, SERIATOPORIDÆ, and THECIDÆ.

The MILLEPORIDÆ have the corallum principally composed of a very abundant cœnenchyma, distinct from the walls of the Corallites, and of a tubular or cellular structure; the tabulæ are numerous and well formed; the septa not abundant.

All the genera of this family are special to the Palæozoic epoch except those now living, and the genus *Axopora*, which is Eocene.

The FAVOSITIDÆ have the corallum formed essentially by lamellar walls, with little or no cœnenchyma. The visceral chambers are divided by numerous well-developed complete tabulæ. Nearly all the genera of this family are special to the Palæozoic epoch—a single genus, *Koninckia*, is represented in the Upper Chalk. *Pocillopora* dates from the Miocene, and lives in the present seas.

The SERIATOPORIDÆ have the corallum bushy or arborescent, with an abundant and compact cœnenchyma, the visceral chambers being filled up by the growth of the columella and walls, and showing few traces of tabulæ.

This small family includes the living genus *Seriatopora*, one Carboniferous, *Rhabdopora*, and two Devonian, *Dendropora* and *Tachypora*.

The THECIDÆ have the corallum massive, with an abundant compact spurious cœnenchyma, produced by the septa becoming cemented laterally together. The tabulæ are numerous and well developed. It includes two genera, *Thecia* and *Columnaria*, which are special to the Silurian period.

4th Sub-Order.—ZOANTHARIA RUGOSA.—The corallum is simple or compound, and the septal system derived from four primary elements, instead of six, as in the other sub-orders. Sometimes this quadrate character is manifested by the existence of four well marked primary septa, or of an equal number of depressions occupying the bottom of the calyx, and assuming a crucial appearance; in other cases only one of these primary septa is well developed, and in others no trace of the septal groups can be seen; the whole apparatus is represented by numerous equally developed radiate striæ rising on the surface of the tabulæ, and extending up the inner side of its walls.

The Corallites are always perfectly distinct, and never united by means of a cœnenchyma; nor do they ever form a linear series, as is often the case in the preceding groups. They multiply by gemmation, and the reproductive buds are in general developed on the surface of the calices of the parents; this often arrests the growth of the latter, and gives rise to a super-position of generations. The septa, although in general very incomplete, are never porous, nor bear synapticulæ, but the visceral chamber is in general filled up from the bottom by a series of transverse tabulæ, or by a vesicular structure, which often constitutes the principal part of the corallum. We divide this sub-order into three families—the STAURIDÆ, the CYATHAXONIDÆ, the CYATHOPHYLLIDÆ.

The STAURIDÆ have a simple or compound corallum, with well-developed septa extending, without interruption, from the bottom to the top of the visceral chamber, and arranged in four systems by an equal number of primary septa.

The CYATHAXONIDÆ have a simple corallum, with the septa complete, and well developed; extending from the bottom to the top of the visceral chamber, and not forming a regular radiate circle; there are no dessepiments nor tabulæ.

The CYATHOPHYLLIDÆ have a corallum with incomplete septa, that do not extend from the bottom to the top of the visceral chamber in the form of uninterrupted laminæ: the visceral chamber is divided by a series of super-imposed tabulæ.

All the genera composing this sub-order, with one exception, are special to the Palæozoic epoch; the *Holocystis* belonging to the family STAURIDÆ has been found in the Lower Greensand. Of the forty other genera comprised in the group RUGOSA, seventeen date from the Silurian period, and six are special to it; six extend into the Devonian period, and four into the Carboniferous. Of seventeen genera that date from the Devonian period, eleven are special to it, and five pass into the Carboniferous period, which has seven genera special to it. The Permian has only one proper to it, the *Polycœlia.*

5th Sub-Order.—Zoantharia tubulosa are characterised by negative rather than by positive characters. They have neither septa, columella, nor tabulæ in the visceral chamber, and we distinguish only some feeble striæ on the walls, which are imperforate. They form one family, the Auloporidæ, special to the Palæozoic epoch.

6th Sub-Order.—Zoantharia cauliculata are composed of Polypes, supported on a sclerobasic corallum, similar to those of *Isis* and *Gorgonia.* The surface of the Polypary is smooth or spinous, but wants the longitudinal striæ observed on the sclerobasis of the genera belonging to the order Alcyonaria. This small group is represented by the family Antipathidæ.

The Alcyonian Polypi are provided with bi-pinnate tentacula, and only eight perigastric membranaceous laminæ, containing the reproductive organs. Their dermal tissue is consolidated by isolated spiculæ or nodular concretions, and the Polypary has a stem-like arborescent character. As the visceral chamber is not sub-divided by longitudinal septa, the chalice never presents any appearance of radii. The corallum is in general composed of epidermic tissue, and forms a ramose stem or axis in the centre of the compound mass formed by the gemmation of the Polypi. The sclerobasis (or foot secretion) is always covered by a soft dermic tissue, and increases by the addition of concentric layers. This order includes four families, Alcyonidæ, Gorgonidæ, Pennatulidæ, and Graptolithidæ.

The Alcyonidæ have a dermic tissue, consolidated by spiculæ, but no trace of a central stem. In one of the groups—Tubipora—the Polypi are enclosed in tubular pipes, associated or connected together by super-imposed horizontal floors.

The GORGONIDÆ are characterised by their shrub-like ramose Polypary, which is a central stem produced by an epidermic sclerenchyma fixed to submarine bodies and consisting of a horny axis for supporting the common tissue of the associated Polypi. This family includes GORGONIA, which belongs only to our modern seas; ISIS, found fossil in the Upper Chalk and Miocene, and living; CORALLIUM (Red Coral) in the Upper Chalk, Miocene, and living.

The PENNATULIDÆ form free floating colonies of Polyps, aggregated upon a common hollow pedicle; containing in general a solid styliform axis, and having a free cænosarc.

The GRAPTOLITHIDÆ have a solid horny axis often striated longitudinally, and prolonged into the lines of the cellules. Sometimes the axis is straight, or coiled into a spiral, either wholly or in part; or it forms a helix. After much difference of opinion as to their true position, these remarkable fossils are now considered to form a family of the ALCYONARIA.

They are all special to the Silurian period, and date among the first animal forms of the old Lower Silurian deposits, extending upwards into their upper strata; but none are found in rocks of more recent formation.

M. DE FROMENTEL* divides the class CORALLIARIA into two sub-classes—

CORALLIARIA having tentacula	disposed in a crown, tubular, and communicating with the visceral chambers.	Sub-class CNIDAIRIA.
	fasciculated, non-tubular, and not communicating with the visceral chambers.	Sub-class PODACTINAIRIA.

The anatomical disposition of the tentacula serves still farther to enable us to sub-divide the CNIDAIRIA into two orders, according as their number is fixed or variable, or as they are

* Palèontologie Française Ter. Crétacé Zoophytes, tom. viii.. p. 155., 1863.

regularly pinnate or simply ramified;—these two orders having the following characters:—

CNIDAIRIA having tentacula	simple or ramified irregularly, and in a variable number.	Order ZOANTHARIA.
	regularly pinnate, and invariably of the number eight.	Order ALCYONARIA.

The order ZOANTHARIA is sub-divided into three sub-orders, according to the nature of the integument. This may be—1st, permanently completely soft; 2nd, transformed into a sclerenchymatous tissue, and constituting a true Polypary; or 3rd, it may be provided with spiculæ, and forming by means of an epithelic tissue a central stem.

ZOANTHARIA of which the integument	is soft and never forming a sclerenchmatous or epithelic Polypary.	Z. MALACODERMA or ACTINIARIA.
	is solidified by calcareous salts so as to form a Polypary.	Z. SCLERODERMA or MADREPORARIA.
	contains calcareous spiculæ, and produces a sclerobasic tissue, which forms a solid stem in the axis of the Polypary.	Z. CAULICULA or ALCYONARIA.

B. *Stratigraphical Distribution of Fossil Corals.*

SILURIAN CORALS.

The Silurian strata of the British Islands admit of the following subdivision:—

Upper Silurian	Tilestone and Upper Ludlow rocks	Ludlow series
	Aymestry Limestone	
	Lower Ludlow rocks	
	Wenlock Limestone	Wenlock series
	Wenlock shale	
	Woolhope Limestone and shale	
	Denbighshire Sandstone and shale	
	Tarannon shale	

Lower Silurian	Upper Llandovery beds	Llandovery series
	Lower Llandovery beds	
	Hirnant Limestone	Caradoc series
	Caradoc	
	Bala Limestone	
	Caradoc	
	Llandeilo	

After a re-examination of the Shropshire rocks it was ascertained by M. Aveline, and corroborated by my friend Professor Ramsay,* that the beds with *Pentamerus lœvis* in the Llandovery series lie quite unconformably on the true Caradoc Sandstone, and that there is a great physical break between the Upper Llandovery beds and the Silurian strata below. "In Shropshire the unconformity is visible. The Upper Llandovery beds on the banks of the Onny lie on the higher part of the Caradoc Sandstone, (the Bala beds,) and as they strike northward gradually overlap the higher strata, till, on the banks of the Severn, near Buildwas Abbey, they rest on the lower beds of the same formation. A few miles from Wenlock Edge they lie on the nearly vertical edges of the Cambrian or Longmynd rocks, and also on Lingula and Llandeilo flags between Church Stretton and Chirbury. In South Wales, between Builth and Newbridge, they lie equally unconformably on the Llandeilo beds." The break or unconformity between the Upper and Lower Silurian rocks in South Wales is therefore complete, and affords physical evidence of the vast period of time that must have elapsed during the deposition of these formations. This break likewise accounts for the difference observed between the specific forms of the Fossils contained in the upper and lower divisions.

In Bohemia M. Barrande has divided the Silurian period into eight stages—of which four appertain to the lower and four to the upper division. In the lower stages, A and B are non-fossiliferous, C and D fossiliferous; the upper stages, E, F, G, H, are all fossiliferous. In other European countries, where Silurian rocks are found, they admit of a like sub-division. In fact,

* Memoirs of the Geological Survey, Geology of North Wales, Vol. 3, page 5, 1866.

these two great divisions of the Silurian period, considered in a palæontological point of view, are as distinct from each other as the Devonian is from the Carboniferous period. In North America, where the Silurian rocks are fully developed, the same grouping holds true; and Professor DANA has well expressed the physical by a statement of the palæontological fact, when he says:—In the Lower Silurian era at least 1000 species of animals became extinct in America, and 600 in Great Britain, and in the Upper Silurian, 800 or more in America—clearly proving how distinct the fauna of the Lower is from that of the Upper Silurian rocks. This description of the change in the fauna as a whole is found to apply with equal truth to the class now under consideration.

In the Lower Silurian rocks, Corals are not abundant: *Favosites*, *Nebulipora*, *Halysites*, *Heliolites* and *Petraia* date from the Bala beds. *Petraia rugosa* was the first fossil I found in the Ash beds of the Bala series on the summit of Snowdon.

In the Trenton Limestone, Lower Silurian of North America, some ZOANTHARIA TABULATA attained a great development, as *Chœtetes Lycoperdon* and *Columnaria alveolata*; masses of the latter, consisting of congeries of columns one-sixth of an inch in diameter, are found, which weigh between two and three thousand pounds; this Coral, therefore, was one of the great reef-builders in the Lower Silurian seas.

In the Upper Silurian rocks, Corals are very abundant, and constituted an important part of the marine fauna of the period. The number of species is likewise considerable, and the very fine state of preservation in which most of the specimens are found, renders their study comparatively easy, and the determination of the species most satisfactory.

It is in the Wenlock Limestone, however, that Corals are most abundant; ancient reefs of considerable extent and thickness are seen in this formation at May Hill, Tortworth, Dudley, Wenlock Edge, Walsall, and other localities.

With a few exceptions the Reef-building Corals of the Silurian age belong to the ZOANTHARIA TABULATA, and the ZOANTHARIA RUGOSA. The species found in British strata resemble those found in other European deposits with which they have been compared, as those of Gothland, and Bohemia, but they are in general distinct from the species found in the Silurian rocks of North America. We are, in all, acquainted with about 130 species of Silurian Corals; 120 of these belong to the groups *Z. tabulata*, and *Z. rugosa*. Seventy-six of these Corals are found in England, and about half of them have not been met with elsewhere. Most of the British species belong to the families Favositidæ and Cyathophyllidæ, four species of *Palæocyclus*, of the family Fungidæ, and *Protaræa*, Poritidæ, are the only generic exceptions at present known.

The Zoantharia tabulata attain a great development in the Silurian period, and are represented by the following genera:

Milleporidæ

Heliolites	*Propora*
Plasmopora	*Lyellia*

Favositidæ

Favosites	*Dekayia*
Emmonsia	*Labecheia*
Alveolites	*Halysites*
Chætetes	*Syringopora*
Monticulipora	*Fletcheria*
Dania	

Thecidæ

Thecia	*Columnaria*

The Zoantharia rugosa, which are limited to the Palæozoic epoch, are very abundant in the Silurian rocks.

Stauridæ	Cyathaxonidæ
Stauria	*Cyathaxonia*

Cyathophyllidæ

Zaphrentis	*Ptychophyllum*
Aulacophyllum	*Syringophyllum*
Cyathophyllum	*Eridophyllum*
Streptelasma	*Strombodes*
Omphyma	*Clisiophyllum*
Goniophyllum	*Cystiphyllum*

The order Alcyonaria is represented in the Silurian rocks by the singular family of Graptolites, which are special to this period.

Graptolithidæ

Graptolithus	*Cladograpsus*
Rastrites	*Didymograpsus*
Diprion	*Gladiolites*

Devonian Corals.

The Devonian series of North Devon, as exposed in the coast section on the Bristol Channel between Barnstaple and the North Foreland, consists of the

Upper or Pilton group,
Middle or Ilfracombe group,
Lower or Linton group.

The *Pilton group* is composed of *(a)* calcareous brown Slate, with fossils resembling those of the Carboniferous Limestone above; and *(b)* brown and yellow Sandstone, with marine shells and land plants.

The *Ilfracombe group* of hard, grey and reddish Sandstones, and micaceous flaggy beds without fossils, resting on a considerable thickness of soft, greenish Schists; these overlie calcareous Slates, with eight or nine courses of Limestone, full of shells and Corals. We here find *Favosites polymorpha*, *Cyathophyllum cæspitosum*, and other species.

The *Linton group* consists of hard red, green, and purple Sandstones, with a few fossils, overlying soft chloritic Slates and Sandstones, containing Brachiopoda and Corals.

The Limestones of Newton Bushel, Torquay, Plymouth, and Ilfracombe have yielded the most abundant supply of fossil Corals; unfortunately, however, the structure of these organisms is so entirely filled in with the calcareous matrix, and so completely imbedded in it, that we can only study the species in cut and polished specimens.

The French Corals are known to me by a series I possess from the Devonian Limestone of the Boulonnais, all of which are figured by MM. Edwards and Haime; the German Corals from the Devonian of the Eifel have been long known to Geologists by the fine figures given of them by M. Hohe, in the *Petrefacta Germaniæ* of Goldfuss, to which the student is referred.

The Devonian rocks attain a great thickness and development in the state of New York, where they are nearly horizontal and undisturbed, so that the natural order of their super-position can be satisfactorily deciphered; they admit of a subdivision into an Upper and Lower series:—

Upper Devonian	Catskill period=Old Red Sandstone of Europe Chemung period Hamilton period
Lower Devonian	Corniferous period Oriskany period

The upper division consists for the most part of arenaceous rocks of great thickness—Catskill and Chemung; and of black shaley beds—Hamilton, which stretch away into the far west.

The lower division, consisting of the Corniferous and Onondago Limestones, which have only a thickness of fifty feet, constitute an almost continuous Coral reef, over an area of not less than 500,000 square miles, from the state of New York to the Mississippi, and between Lakes Huron and Michigan in the North, and the Ohio river and Tennessee in the South. Professor James Dana * says "the Limestone is literally an ancient reef. It contains Corals in vast numbers and of great variety; and in some places, as near Louisville, Kentucky, at the falls on the Ohio, the resemblance to a modern reef is perfect. Some of the Coral masses at that place are 6 or 8 feet in diameter; and single Polyps of the Cyathophylloid Corals had in some species a diameter of 2 or 3 inches, and in one 6 or 7 inches. The same reef-rock occurs near Lake Memphremagog, on the borders of Vermont and Canada, but the Corals have been partly obliterated by metamorphism." The early Devonian, observes our author, was the Coral period of the ancient

* Text Book of Geology, p. 105.

world. In no age before or since, not even at the present time, have Coral reefs of greater extent been formed. *Favosites Goldfussii; Cyathophyllum rugosum, Zaphrentis Rafinesquii; Syringopora Maclurii* and *Aulopora cornuta,* were some of the reef-building Corals of this period, and these denizens of the ancient reef are weathered out to perfection on the horizontal ledges of the rock. When the water is low, the softer portions of the matrix having been removed, and the mud of the reef cleared away by the running water, the Corals stand out in relief, in all their pristine beauty, with their branching stems or massive corallums, as when living in the lagoons of the Devonian sea.

In Canada, the Devonian rocks, according to Sir WILLIAM LOGAN, attain a thickness of 7000 feet, and contain extensive beds of Coralligenous Limestones, having a reef-like character similar to those described. Sir WILLIAM informed me, in the Exhibition of 1862, when shewing the oil obtained from the Devonian Coral rocks of Canada, that he was of opinion much of this oil had an animal origin, and was derived from the reef-building Polyps that lived in the Devonian period.

The Devonian Corals all belong to the same groups as those of the Silurian period. The species, however, are distinct, although the general *facies* of the fauna has a strong family resemblance. The ZOANTHARIA APOROSA are absent, and the ZOANTHARIA PERFORATA is represented by a single doubtful form the genus *Pleurodyctium.*

The ZOANTHARIA TABULATA are very abundant; they belong to the families MILLEPORIDÆ, FAVOSITIDÆ, and SERIATOPORIDÆ.

MILLEPORIDÆ

Heliolites — *Battersbya*
Plasmopora

FAVOSITIDÆ

Favosites — *Monticulipora*
Emmonsia — *Beaumontia*
Rœmeria — *Syringopora*
Michelinia — *Thecostegites*
Alveolitis — *Chonostegites*
Chætetes

SERIATOPORIDÆ

Dendropora	*Tachypora*

The ZOANTHARIA RUGOSA attained a greater development in the Devonian than in the Silurian period, and almost entirely belong to the family CYATHOPHYLLIDÆ.

STAURIDÆ

Metriophyllum

CYATHOPHYLLIDÆ

Zaphrentis	*Pachyphyllum*
Amplexus	*Chonophyllum*
Lobophyllum	*Ptychophyllum*
Anisophyllum	*Heliophyllum*
Baryphyllum	*Acervularia*
Hadrophyllum	*Smithia*
Hallia	*Phillipsastræa*
Aulacophyllum	*Syringophyllum*
Combophyllum	*Spongophyllum*
Cyathophyllum	*Lithostrotion*
Endophyllum	*Cystiphyllum*
Campophyllum	*Eridophyllum*

The ZOANTHARIA TUBULOSA are represented by the genus *Aulopora*.

CARBONIFEROUS CORALS.

The Carboniferous, or Mountain Limestone, contains a vast assemblage of Brachiopoda, Crinoidea, and Actinozoa. Many of the thick-bedded Limestones of this formation are composed for the most part of the stems and other fragments of the skeletons of Crinoids, or of masses of coralline structure interspersed with the shells of *Productæ*, *Spiriferæ*, and other Brachiopoda.

One of the most instructive localities, within an easy distance of the Cotteswold country, is the fine section exposed in the gorge of the Avon, near Bristol, where the Carboniferous Limestone is well seen in its relative position to the Old Red Sandstone below, and the Millstone Grit above; the various changes in the sea bottoms, in which this vast accumulation of mineral and organic matter was deposited, may be here studied with much advantage. The entire thickness of the rocks exposed is about 4056 feet; of this the Millstone Grit is 950 feet, the Carboniferous Limestone 2,338, and the Old Red Sandstone 768.

This magnificent section in former years was the subject of several memoirs by BUCKLAND,[1] and CONYBEARE,[2] BRIGHT,[3] and CUMBERLAND. A very detailed examination of it was made by Mr. DAVID WILLIAMS, of the Geological Survey, who has carefully described all the beds, and given the chief palæontological features of each. This work is quoted in full in Sir HENRY DE LA BECHE's admirable essay[4] on the formation of the rocks in South Wales and South-western England, to which I must refer the student desirous of more details.

The lower portion of the series contains Brachiopoda, as *Spiriferæ, Productæ,* and *Leptæna depressa,* with Encrinites and Corals. The middle portion is not so fossiliferous. The upper division contains gray compact Limestones, with Brachiopoda, and an abundance of Corals. Many of the Coral beds are extremely interesting, from their resemblance to Fringing or Shore reefs of modern times.

In the Carboniferous Limestone of Ireland, my friend Professor JUKES, states that Corals grow to a large size, a foot or two in diameter. In the explanation of sheet 145 of the maps of the Geological Survey of Ireland, Mr. WYNNE has figured a *Lithostrotion* from Tipperary, which measured 9 feet across.

"The Corals sometimes occur in beds, a number of species growing together, and forming a regular wide-spread Coral bed, that might be likened to a small Fringing or Shore reef. They may, however, perhaps have been deep water species, and at all events there is not the slightest appearance of any

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[1] On the South Eastern Coal District of England. Geol. Trans., 2nd series, vol. 1.

[2] Geol. Trans., 1st series, vol. 4.

[3] On the Limestone beds of the River Avon, near Bristol. Geol. Trans., 1st series, vol. 5.

[4] Memoirs of the Geological Survey, vol. 1, p. 113.

approach to the form of one of the Atoll or Barrier reefs of the present day, either in the Carboniferous or any other Palæozoic Limestone."[5]

The fauna of the Mountain Limestone is extremely rich in Actinozoa, about eighty species of Corals having been found in its different beds, and none of these have been discovered in any other formation. About one-half of this number are British: they all belong to families which prevailed during the Palæozoic epoch, and a great many of the genera now appear for the last time.

The Zoantharia aporosa, and the Zoantharia perforata, are not represented.

The Zoantharia tabulata diminish in number and importance: they are represented by—

Milleporidæ.

Fistulipora *Propora*

Favositidæ.

Favosites *Beaumontia*
Emmonsia *Chœtetes*
Michelinia *Syringopora*
Alveolites

Seriatoporidæ
Rhabdopora

The Zoantharia rugosa are numerous in genera, and appear for the last time.

Cyathaxonidæ
Cyathaxonia

Cyathophyllidæ

Zaphrentis *Phillipsastrœa*
Amplexus *Lithostrotion*
Menophyllum *Clisiophyllum*
Labophyllum *Chonaxis*
Trochophyllum *Petalaxis*
Cyathophyllum *Axophyllum*
Campophyllum *Lonsdalia*
Aulophyllum

[5] Jukes' Student's Manual of Geology, 1862. 2nd. Ed., p. 537.

The Zoantharia tubulosa is represented by the genera *Pyrgia* and *Cladochonus*.

Permian Corals.

The Permian deposits appear to be barren in radiate animals, of the Echinodermata, *Archæocidaris* representing the order Ehinoidea, and *Cyathocrinus* representing the Crinoidea are present. The Actinozoa are equally rare; the few Corals that are present belong to the orders Z. tabulata, and Z. rugosa.

Milleporidæ
Fistulipora

Favositidæ
Chætetes

Stauridæ
Polycœlia

GENERIC DISTRIBUTION OF PALÆOZOIC CORALS.

NAMES OF GENERA	Silurian	Devonian	Carboniferous	Permian
ZOANTHARIA TABULATA				
MILLEPORIDÆ				
Heliolites	*	*		
Plasmopora	*	*		
Propora	*		*	
Lyellia	*			
Battersbya		*		
Fistulipora			*	*
FAVOSITIDÆ				
Favosites	*	*	*	
Emmonsia	*	*	*	
Alveolites	*	*	*	
Chætetes	*	*	*	
Monticulipora	*	*		
Dania	*			
Dekayia	*			
Labecheia	*			
Halysites	*			
Syringopora	*	*	*	
Fletcheria	*			
Rœmeria		*		
Michelinia		*	*	
Beaumontia		*	*	
Thecostegites		*		
Chonostegites		*		
SERIATOPORIDÆ				
Dendropora		*		
Tachypora		*		
Rhabdopora			*	
THECIDÆ				
Thecia	*			
Columnaria	*			
ZOANTHARIA RUGOSA				
STAURIDÆ				
Stauria	*			
Metriophyllum		*		
Polycœlia				*
CYATHAXONIDÆ				
Cyathaxonia	*		*	
CYATHOPHYLLIDÆ				
Zaphrentis	*	*	*	
Aulacophyllum	*	*		

GENERIC DISTRIBUTION OF PALÆOZOIC CORALS—*Continued.*

NAMES OF GENERA	Silurian	Devonian	Carboniferous	Permian
CYATHOPHYLLIDÆ—*Continued*				
Cyathophyllum	*	*	*	
Streptelasma	*			
Omphyma	*			
Goniophyllum	*			
Ptychophyllum	*	*		
Syringophyllum	*			
Eridophyllum	*	*		
Strombodes	*			
Clisiophyllum	*		*	
Cystiphyllum	*	*		
Lobophyllum		*	*	
Anisophyllum		*		
Baryphyllum		*		
Hadrophyllum		*		
Hallia		*		
Combophyllum		*		
Pachyphyllum		*		
Chonophyllum		*		
Heliophyllum		*		
Acervularia		*		
Smithia		*		
Phillipsastrœa		*	*	
Syringophyllum		*		
Spongophyllum		*		
Lithostrotion		*	*	
Chonaxis			*	
Petalaxis			*	
Axophyllum			*	
Lonsdalia			*	
Menophyllum			*	
Trochophyllum			*	
ZOANTHARIA TUBULOSA				
AULOPORIDÆ				
Aulopora		*		
Pyrgia			*	
Cladochonus			*	
ORDER ALCYONARIA				
GRAPTOLITHIDÆ				
Graptolithus	*			
Rastrites	*			
Diprion	*			
Cladograpsus	*			
Didymograpsus	*			
Gladiolites	*			

Oolitic Corals.

The Oolitic formations will long remain classic ground to English Geologists, as it was during the study of these rocks that Dr. William Smith first obtained the facts which enabled him to "identify strata by organic remains," and thereby to establish a true natural system of Stratigraphical Geology.

The Oolitic period admits of a sub-division into three groups, —the Lower, Middle, and Upper. Each of these is based on a great argillaceous formation, on which rest minor beds of Sands and Limestones, mostly Oolitic or Pisolitic, in lithological character. The argillaceous formations form broad valleys, for the most part extending diagonally across England, in a direction north-east by south-west. The Sands and Limestones, resting upon the Clays, form low ranges of hills, with an escarpment facing the south-west and overlooking the valley. The base of the Lower Oolites is the Lias; that of the Middle Oolites, the Oxford Clay; and the Upper, the Kimmeridge Clay.

In studying the Oolitic Corals, it is important to keep this classification in view, as not only the groups, but the subordinate members of each, possess specific forms which characterise them.

Classification of the Oolitic Formations.

Period.	Groups.	Formations.	Thickness.
Oolitic or Jurassic Period	Portland or Upper Oolites, 900 feet thick	Purbeck beds ...	150 ft.
		Portland beds ...	170 "
		Kimmeridge Clay	600 "
	Oxford or Middle Oolites, 800 feet thick	Coral Rag	180 "
		Oxford Clay ...	600 "
	Cotteswold or Lower Oolites, 600 feet thick	Cornbrash	80 "
		Great Oolite ...	130 "
		Fullers Earth ...	130 "
		Inferior Oolite ...	230 "
	Lias formation, 1100 feet thick	Upper Lias	300 "
		Middle Lias	200 "
		Lower Lias	600 "

The *Avicula contorta* group, lying between the lowest of the Ostrea beds of the zone of *Ammonites planorbis*, and the uppermost strata of the Marls of the Keuper, have of late years formed the subject of many important memoirs, one section of Geologists regarding these beds as the highest member of the Trias, another as the lowest of the Lias. They are probably intermediate between the two, and contemporaneous with the *Kössener schichten* or Upper St. Cassion beds of Escher and Merian. This group is finely exposed at Garden Cliff, on the Severn; and our members are familiar with the locality, both from personal examination, and from the fine detailed section given thereof by my friend R. Etheridge, Esq., F.G.S., in the volume of our Transactions for 1864, p. 218, to which I must refer for further details. In many other localities the group is well developed; and wherever the junction of the Lias and the Keuper is exposed *in situ*, in most cases will the *Avicula contorta* beds be found interposed between them; although only of about 35 feet in thickness in England, these beds represent a most important series of strata on the continent of Europe.

Having examined the *Avicula contorta* series with much care in several localities in the counties of Gloucester, Somerset, Warwick, Dorset, and Glamorgan, I can state that Corals are extremely rare in the cream-coloured Limestones of the series, a few stunted *Montlivaltia* having been the only Actinozoa I have found, and these were indeterminable from their imperfect preservation.

In Lombardy, however, the Abbé Antoine Stoppani has discovered a remarkable Coral fauna in the *Azzarola* beds, and the fossils therefrom he has figured and described in his memoir [6] on that formation. The Madrepore bed, so called by the author, is seen above the *Azzarola* beds, with *Cardium Rhæticum*, *Myophoria inflata*, *Mytilus Psilonoti*, and *Avicula contorta*, all leading fossils of the *Avicula contorta* group, wherever the succession of the rocks can be made out. The Abbé Stoppani has likewise described the Coral bed as occurring below and in the midst of the *Azzarola* beds, and forming a dense layer, from 8 to 10 yards in thickness, the prevailing species in this ancient reef being a branching Coral, *Rhabdophyllia Langobardica*, Stop., with three other congeneric forms, together with species of *Montlivaltia*, *Stylina*, and *Thamnastræa*.

[6] A. Stoppani, Monogr. des foss. de l'Azzarola.

It would appear, therefore, at the close of the Triassic period, several typical forms of Actinozoa, that were to play an important part in the seas of the Oolitic period, had made their appearance before its dawn.

The Lias formation at one time was supposed to be destitute of a Coral fauna, but the progress of discovery has shown that this was a hasty conclusion. Many years ago I collected masses of *Septastræa* from the Lower Lias near Evesham and Worcester, and from the *A. planorbis* beds of Street, which satisfied me that in process of time specimens of these Corals would be found in other localities. The late Mr. Hugh Miller[7] has given an account of a Coral bed in the Lower Lias which he observed at Skye. "The stratum," he says, "of from two to three feet in thickness, seems wholly built up of irregularly formed rubbly concretions, and that every seeming concretion in the bed is a perfectly formed Coral of the genus *Astræa*. Their surfaces, wherever they have been washed by the sea, are of great beauty; nothing can be more irregular than the outline of each mass, and yet scarce anything more regular than the sculpturings on every part of it. We find them fretted over with polygons like those of a honeycomb, only somewhat less mathematically exact, and the centre of every polygon contains its many-rayed star." This is, doubtless, the same Coral bed that was found by my friend A. Geikie, Esq., F.G.S.,[8] at Lussay, Isle of Skye, underlying the Calcareous Grit and Sandstone of the Lower Lias, and resting on a thin band of hard blue Limestone, beneath which is a stratum of greenish micaceous nodular Sandstone, containing *Cardinia concinna*, Ziet. These Corals had been noticed by Sir R. Murchison[9] as Polypifers of the genus *Astræa*, and compared to the Coralline bodies found in the Lias at Ledbury, near Bridgwater.

In describing this Coral (which I dedicated to my friend Sir Roderick Murchison, who had first noticed it *in situ)* I observed[10]

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[7] Cruise of the Betsy, p. 144.

[8] Quart. Jour. Geol. Soc., vol. xiv, p. 21.

[9] Trans. Geol. Soc., 2 series, vol. ii, p. 368.

[10] Quar. Jour. Geol. Soc., vol. xiv., p. 35.

that "the Lower Lias is represented at Lussay by a greenish micaceous Sandstone overlaid by a hard blue Limestone on which rests a bed of Corals (*Isastræa Murchisonæ*, Wr.) wrapped up in a dark Mudstone, the Coral very closely resembling a species found in the Lower Lias of Warwickshire. The Coral bed, three feet in thickness, is overlain by calcareous Sandstone and blue compact Limestones. Unfortunately no Ammonite has been found in these beds, so that their precise age cannot be determined; still, however, the presence of *Cardinia concinna*, Ziet., is, *per se*, good evidence that the greenish micaceous Sandstones with *Cardinia*, belong to the Lower Lias, as that shell is found only in the lower beds of France and Germany, its true position in Wurtemberg having been ascertained to be below the Bucklandi bed where it is associated with *Ammonites angulatus*, Schloth." In the Lower Lias of Warwickshire I have found several large masses of *Septastra Haimei*, Wr., the precise position of which I could not accurately determine; but in the *A. planorbis* beds at Street I extracted the same species from the clay *in situ*. Lias Corals have long engaged the attention of my friend the Rev. P. B. Brodie, whose cabinet contains a very fine series from these beds, and his observations thereon are recorded in a paper on that subject.[11] Dr. Duncan[12] has very recently made an important contribution on the Madreporia of the Lower Lias; from this we learn that Brocastle and Ewenny are localities a short distance from Bridgend in Glamorganshire, which have yielded fossiliferous liassic deposits resting on the mountain Limestone, and filling up depressions on its surface. The Coral fauna consists of *Isastræa globosa*, Dunc., and several species of *Astrocœnia*, *Thecosmilia*, *Montlivaltia*, *Latomeandra*, *Cyathocœnia*, and *Septastræa*. The Sutton stone and Southerndown beds have likewise yielded many Corals. All these different formations (about the respective ages of which opposing opinions prevail) Dr. Duncan co-relates with the *Calcaire de Valogne*, the *Foie de Veau*, or the zone of *Ammonites Moreanus*, and the *Grès calcareux*, which are the

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[11] Edinburgh New Philosophical Jour., April, 1857.

[12] Quar. Jour. Geol. Soc., vol. xxiii, p. 12, 1867.

equivalents of our zone of *Ammonites angulatus*,—the position I assigned to *Isastræa Murchisonæ*, Wr., ten years ago, from the Coral bed of the Isle of Skye, on the evidence of its associated *Cardinia concinna* alone.

The Inferior Oolite.—This formation has long engaged the attention of different members of the Cotteswold Club, and the rich fauna it contains has afforded materials for many important palæontological researches. The Coral beds, hitherto described in connection with the rocks in which they occur, had not received the special attention they merit, until the visit to Brown's Hill last June awakened a new interest in the subject. Having been, for the last 20 years, a student of these beds, and collected therefrom a fine series of specimens, I was enabled to supply MM. Edwards and Haime with most of the species found in the Inferior Oolite, and figured by them in their valuable Monograph of British Oolitic Corals, published by the Palæontographical Society. The true position and co-relations of these Coral beds, with their organic remains, I have already described in different memoirs[13] on the Inferior Oolite.

This formation admits of a division into three stages, each characterised by a leading Ammonite,—the lower, *Ammonites Murchisonæ;* the middle, *Ammonites Humphriesianus;* the upper, *Ammonites Parkinsoni.* The relation of these divisions to each other is well exemplified in the diagram of Cleeve Hill section, given in the volume of our Proceedings for 1865. Of the three Coral beds found in the Inferior Oolite, two belong to the zone of *Ammonites Murchisonæ,* and the third to the zone of *Ammonites Parkinsoni.* The lower reef rests upon the Pea-grit; the middle reef forms part of the Oolite Marl; and the upper reef is built on the *Terebratula globata* bed of the Trigonia Grit.

Crickley Hill first afforded me the clue to the true position of these Coral zones. Many years ago, in a field behind the Bell Inn, I found several large massive blocks of Coralline Limestone, that had long fallen from the adjoining escarpment, the bed of which, however, was not then exposed, for *débris* had covered

[13] On the Sub-divisions of the Inferior Oolite, Quarterly Jour. of the Geol. Soc., vol. xxi, p. 13, 1860; and Additional Notes on the Cleeve Hill Section, Proceedings of the Cotteswold Naturalists' Field Club for 1865, p. 60.

up the fractured surface. Another exposure, however, showed the true position of the Corals. A few years afterwards the same bed was opened near the Seven Springs, and a large quantity of road material was raised therefrom, consisting chiefly of blocks of Limestone, full of Corals. My friend, the Rev. P. B. Brodie, and myself, made several journeys to these road heaps, for the purpose of collecting specimens. The best exposure of this Coral reef is near Frith quarry, on the northern spur of Brown's Hill, about two miles from Stroud, and visited by the Club last year. The Coral reef formed then a complete bluff of Coral rock; since that time, however, much of it has been removed for road-mending. Still enough remained on the 31st May to enable my friend, W. C. Lucy, Esq., F.G.S., and myself, to make a re-examination of the reef, in order to give a finishing touch to my former notes. This Coral bed is upon the same horizon as the Coral bed on the opposite side of the valley, at Huddinknoll Hill, near the Horsepools, the whole of the intervening space having been removed by denudation. The Coral bed consists of large masses of Coralline Limestone, embedded in a fine grained cream-coloured Mudstone. The Corals are in a highly crystalline state, so that the genera and species are determined with difficulty, unless when they are found in portions of the rock that have been weathered. The bed is from 15 to 20 feet in thickness, and forms one of the finest examples of a fossil Coral reef that I am acquainted with in our district. On the western side of the valley the same bed is exposed, and worked for the roads; and several miles of the highway from the Horsepools to Gloucester is repaired with the product of this lower Coral reef of the Inferior Oolite. The bed may be traced along the escarpment, in a north-westerly direction, for several miles, to Witcomb and Crickley on the west, and to near Cubberley and Cowley on the east, where it was worked several years ago. Judging from the thickness of the bed, and the abundance of Corals it contains, it must have formed a Barrier reef of considerable magnitude in the Jurassic sea. The following section will best exhibit the true relation of the Coral reef to the underlaying and superincumbent strata:—

Section of the Lower Coral Reef, in the Inferior Oolite, at the Quarry, North Frith Wood, near Brown's Hill, Gloucestershire.

Lithological Characters and Thickness.	Beds.	Organic Remains. Leading Fossils.
	Upper Freestones.	
Cream-coloured Marl, with several inconstant layers of Mudstone, upper part passing into a loose, friable Freestone, with large *Terebratula fimbria*. From 20 to 25 feet.	Oolite, Marl. Middle Coral Bed.	*Thamnastræa, Isastræa, Axosmilia, Terebratula fimbria, T. carinata, T. maxillata, Rhyn. Lycetti, Lucina Wrighti, Lima pontonis.*
Fine grained Oolitic Limestone, very white, and emitting a metallic ring when struck with a hammer. 40 to 50 feet.	Freestones.	Shelly fragments, not determinable
Coarse brown ferruginous Oolite	Lower Ragstones.	*Terebratula plicata.*
Masses of Coralline Limestone, embedded in a light coloured Mudstone, the Corals highly crystalline forming the chief part of the bed. 15 to 25 feet.	Lower Coral Reef.	*Latomeandra, Thamnastræa, Isastræa, Axosmilia, Thecosmilia, Pecten Dewalquei, Trichites, Lucina Wrighti.*
Brown ferruginous Pisolitic rock. Pea-grit structure not much exposed.	Pea-grit.	*Lima sulcata, Hinnites abjectus, Ceromya Bajociana, Avicula complicata, Nerita costata, Trochotoma carinata, Pygaster, Hyboclypus, Diadema.*

The Corals collected from the lower Coral reef at Crickley Hill, and which have been figured in MM. Edwards and Haime's Monograph, are the following:—

Montlivaltia De la Bechei, Ed. and Haime
———— *tenuilamellosa*, Ed. and Haime
Axosmilia Wrightii, Ed. and Haime
Latomeandra Flemingii, Ed. and Haime
Isastræa tenuistriata, Ed. and Haime
Thamnastræa Defranciana, Ed. and Haime
———— *Mettensis*, Ed. and Haime

The Middle Coral bed is included in the Oolite Marl, which resembles indurated Chalk, and is interstratified between the Lower and Upper Freestones, forming a division between them. It has a peculiar lithological character, being a kind of Mudstone which, when exposed to atmospheric agency, breaks up into cuboidal masses. In some localities, as at Frith, Leckhampton, Sheepscombe, Swift's Hill, and others, it contains masses of Corals of the genera *Thamnastræa* and *Isastræa.* Sometimes it is largely charged with Brachiopoda, as *Terebratula fimbria, T. maxillata, T. carinata,* and *Rhynchonella Lycetti;* and at Scar Hill, near Nailsworth, it becomes a fine argillaceous Limestone, containing numerous long spiral univalve shells, of the genera *Nerinæa, Chemnitzia,* &c. The Oolite Marl forms a persistent bed in the northern and middle Cotteswolds, extending across this portion of the plateau from the vales of Moreton and Bourton on the east, to the escarpment overlooking the Severn valley on the west; thinning out and disappearing in the southern part of the range.

The Upper Coral reef occupies the horizon of the Upper Trigonia Grit, zone of *Ammonites Parkinsoni,* and is very well exposed in many sections; that of Cleeve Hill (already referred to) may be consulted, as it has yielded the best Corals I have obtained from this bed, and these are figured as type-specimens in the monograph. The following section is open near Frith, and may assist the correct reading of the beds in this locality. Ascending the bank above this quarry for a short distance, some fields of arable land are passed over, in which are several heaps of the Upper Ragstones with *Trigonia costata, Gryphæa subloba,* and other shells of the higher zone. Walking in the direction of the Grove, after passing over the summit of the hill, we descended for a short distance, and at the right hand side of a bridle-road came to Worgin's Quarry, overlooking the Slad Valley, in which there is a very good section of the upper reef.

Section of the Quarry at Worgin's Corner; Upper Zone of Inferior Oolite.

Lithology.	Beds.	Organic Remains.
Masses of Coralline Limestone, 4 feet thick.	UPPER CORAL REEF.	*Thamnastræa, Isastræa, Thecosmilia, Magnotia Forbesi, Stomechinus intermedius, Pecten, Trigonia costata.*
Hard shelly Limestone, full of the shells of Brachiopoda, 5 feet.	TEREBRATULA GLOBATA BED.	*Terebratula globata, Rhynconella spinosa, Pholadomya fidicula, P. Heraulti Ostræa, Gervillia, Trichites.*
Hard shelly sandy Oolite, full of Gryphæa, 6 feet.	GRYPHÆA BED.	*Gryphæa subloba, Lima proboscida.*

FOSSIL CORALS FROM THE UPPER REEF.

Anabacia orbulites, Lamouroux
Calamophyllia
Thecosmilia gregarea, Ed. and Hame
Isastræa tenuistriata, Ed. and Haime
Thamnastræa Turquemi, Ed. and Haime
Latomeandra Davidsonii, Ed. and Haime
Montlivaltia
Cladophyllia
Montlivaltia trochoides, Ed. and Haime
Trochocyathus Magnevillianus, Michelin
Discocyathus Eudesii, Michelin

The Great Oolite.—Above the upper zone of the Inferior Oolite comes a thick bed of Clay—the Fullers Earth—in which no remains of Corals are found. The Great Oolite of Bath is arranged into—1st, Upper Ragstones; 2nd, Fine Freestones; 3rd, Lower Ragstones. It is in the Upper Ragstones underlaying the Bradford Clay that Polypifera are found in considerable numbers, some beds consisting principally of *Polypariæ*; it is this portion of the series that has been identified as the true equivalent of the *Calcaire à Polypiers* at Caen, in Normandy. At Minchinhampton Common, the Great Oolite contains chiefly Mollusca; the Coral beds belonging to a higher portion of the formation are absent in this locality. The Great Oolite near Bath contains several Corals which are figured in MM. Edwards and Haime's Monograph; some large masses of *Calamophyllia radiata*, several feet in diameter, are very conspicuous; associated with the Corals are the roots, stems, and heads of *Apiocrinites rotundus*, Mill., which flourished like a miniature forest on the reef, and luxuriated among the Polyps for ages, until the clear still water was invaded by a current charged with mud, which destroyed the Pear Encrinites, and brought the life of the Polypifera to a termination. It is the ruins of the sea lilies of this reef that are so miraculously preserved in the Bradford Clay. I have a series of roots and stems and heads from this bed, as they were thrown down in the ancient lagoon and buried up with mud.

Corals from the Great Oolite near Bath.

Stylina conifera, Ed. and Haime, and 2 other sp.
Cyathophora Luciensis, Ed. and Haime, and 1 other sp.
Convexastræa Waltoni, Ed. and Haime
Montlivaltia Smithii, Ed. and Haime
Calamophyllia radiata, Lamour.
Cladophyllia Babeana, d'Orbig.
Isastræa limitata, Lamour., and 3 other sp.
Clausastrea Pratti, Ed. and Haime
Thamnastræa mammosa, Ed. and Haime, and 3 other sp.
Anabacia orbulites, Lamour.
Comoseris vermicularis, McCoy
Microsolena excelsa, Ed. and Haime

All the species in the above list are distinct from those of the Inferior Oolite.

The Forest Marble near Fairford, a few years ago was found to contain a very rich bed of Corals, from whence numerous specimens were obtained. Many of these are now in the British Museum, the School of Mines, and Museum at Gloucester.

Many of the specimens at the time of the discovery were exhibited to the Club by our old friend, Mr. JOHN JONES, late of Gloucester. *Montlivaltia*, *Isastræa*, *Thamnastræa*, and *Stylina*, are represented by several new species in this collection. The Cornbrash near Chippenham has yielded a few specimens of *Cladophyllia*.

The Oxford Clay afforded many Ammonites, but no Corals; in France, however, some species have been found. Like the Lias, future observers may yet discover that this great argillaceous formation is not destitute of Actinozoa.

The Coral Rag.—This formation has long been considered to be the great metropolis of Jurassic Corals; and although in certain regions reef structures are found, the specimens are for the most part collected from beds that crop out at the surface of arable lands. The number of species found in this formation is by no means proportionate to the individuals collected therefrom. After a careful study of all the best British Coral Rag specimens, MM. EDWARDS and HAIME could only make out fourteen species, of which twelve belonged to the *Astræidæ*, and two to the *Fungidæ;* five of these were identical with the Coral Rag of France and Germany, and nine are found as yet only in British strata. The principal localities for Corals from this formation are Steeple Ashton, Wilts; Osmington, Dorset; Upware, Cambridge; and Malton, Hackness, Ayton, and Seamer, Yorkshire.

The Coral Rag in Wiltshire is divisible into (1) Upper Calcareous Grit, (2) Coral Rag, (3) Clay, (4) Lower Calcareous Grit. It is in the Coral Rag proper (2) that the Coral beds are found. Of these Mr. LONSDALE[14] remarks, "the irregular beds of Polyparia (2 c) consist of nodules or masses of crystallized carbonate of Lime, which afford, invariably, evidences of the labours of the Polypus, and associated with them are others of earthy Limestone, which bear only partial proofs of an organic origin. The whole are connected by a pale blueish or yellowish stiff Clay. It happens frequently that a bed is composed of one genus of Polyparia. At Calne and

[14] Oolitic District of Bath, Trans. Geol. Soc., second series, vol. iii, p. 261.

Westbrook the prevailing fossil is a small species of *Astrea.* At Hannington Hill, near Highworth, *Caryophyllia* form the entire mass of the Coral Rag, but at Steeple Ashton both these genera are associated with *Agaricia.*"

In Yorkshire the Coralline Oolite is well developed, and several reefs are found at Hackness, Ayton, Seamer, &c. I am indebted to my friend JOHN LECKENBY, Esq., F.G.S., of Scarborough, who kindly undertook, at my request, for this paper, an examination of the Coral beds at Hackness, and Ayton, &c., and has contributed the following important note on the subject:—

"In various parts of the district occupied by the Coralline Oolite around Scarborough, are found patches of Coral reef sometimes occupying an area of fully an acre; and although never attaining an altitude so high as the beds on the inclined surfaces of which they rest, they are truly the uppermost beds of the formation.

"They are sometimes from 10 to 15 feet in thickness, and consist of a series of layers of crystallized Coral from 18 to 24 inches in thickness, of the species *Thamnastræa concinna,* Goldf., (which is the *T. micraston,* Phillips,) each layer being separated by rubbly Clay and mud, in all probability being the decomposition of each successive reef. The rock is quarried to supply material for repairing the roads of the district, but it is by no means so well adapted for the purpose as the adjacent Calcareous Grit, which, at the cost of a little additional labour, would furnish a material much more durable. The crystalline Coral reef is quickly ground to powder, and its use affords less satisfaction to the traveller than to the Geologist, as the blocks which are stored up for use along the sides of the road yield many a handsome specimen to adorn his collection.

"The largest deposit is near the village of Ayton; there are others not quite so extensive: one near the village of Seamer, another close to the hamlet of Irton, and others in the neighbourhood of Wykeham and Brompton—the intervening distances being about a mile in every case.

"Embedded in the substance of the Coral is a *Gastrochæna, (Gastrochæna Moreana,* Buvignier,) and the surface is sometimes obscured by a slender species of *Vermilia.* Near the bottom of each layer, and also in the Rubble and indurated Clay forming the separations between each growth of Coral, are found abundantly, *Littorina muricata,* and more rarely *Trochotoma ternata, Turbo funiculatus, Nerita lævigata,* and other littoral gasteropods. Commonest amongst the bivalves are *Gastrochæna Moreana, Arca æmula, Cucullæa pectinata,* and *Modiola inclusa.* Of the large bivalves, the abundance and character of which in the true Coralline Oolite indicate deeper water and an undisturbed condition of the sea, there are few or none.

"*Cidaris Smithii* has been discovered in the Ayton Quarry only, but *Pseudodiadema versipora* is not uncommon in them all.

"The inference suggested is, that after the elevation of the Coralline Oolite proper, has come a period of depression, during which the land has again been partially submerged and the Coral reefs constructed—this period having preceded the commencement of the Cretaceous era, the Geological evidence of the transition to which is involved in much obscurity in this vicinity.

"The Mollusca of the subjoined list are found in the Coral.

"MOLLUSCA IN THE CORAL REEFS.

Turbo funiculatus, Phillips
Trochotoma ternata, Phillips
Littorina muricata, Sowerby
Phasianella striata, Sowerby
Natica clymenia, D'Orbigny
Nerita lævigata, Sowerby
—— ——— Phillips
—— *(bellulata,)* Bean, MS.
Neritopsis Guerrei, Deslongchamps
Cerithium Limæformis, Röemer
Nerinea fasciata, Voltz.
——— *fusiformis,* D'Orb.
Exogyra mima, Phillips

Placunopsis inæqualis, Phillips
Pecten vagans (var. subfibrosus,) Sowerby
Myoconcha texta, Buvignier
Modiola Lycetti, Whiteaves
——— *inclusa*, Phillips
Arca quadrisulcata, Sowerby
—— *æmula*, Phillips
Cucullæa pectinata, Phillips
Astarte rhromboidalis, Phillips
Sowerbia triangularis, Phillips
Gastrochæna Moreana, Buvignier."

Since sending the foregoing pages to press, I have had the pleasure of visiting the Coral reefs in the Coralline Oolite, near Scarborough, in company with my esteemed friend, J. Leckenby, Esq., and Mr. Peter Cullen. One quarry, near Ayton, which may be considered as a type of the others, consisted of masses of Crystalline Coralline Limestone, the beds having an irregular undulating appearance. The Corals appear to have grown in areas of depression of the Coralline sea; the rock consists of large masses of highly Crystalline Limestone, forming nodulated eminences, and concave curves, in beds of from 12 to 18 inches in thickness, having a stratum of yellowish Clay filling up the hollows, and forming a horizontal line again to the stratification; then follows another stratum of Crystalline Limestone, which assumes the same nodulated condition as the one below it; the surface of the Coral masses, where exposed, shewing that the whole is almost entirely composed of a small celled *Astræa, Thamnastræa concinna*, Goldf., *Micraston*, Phillips, in some altered condition; the reef is exposed to about ten feet in section, and rests on another, forming the floor of the quarry, and which descends many feet deeper; the Corals are bored by *Gastrochænæ*, and numerous shells were seen embedded in the Coral mass, which had nestled in the crannies of the reef. *Phasianella striata*, Sow., *Pecten vemineus*, Sow., *Pecten lens*, Sow., *Turbo muricata*, Sow., were the most conspicuous, besides numerous other shells, as *Chemnitzia, Nerinæa,* and other PYRAMIDALIDÆ, which had made their home in the lagoon. It is truly astonishing to observe the immense masses of nodulated Crystalline Limestone, formed entirely of Corals, that are raised and sent out of these old reefs for road material; the Clay parting at intervals of about 16 to 18 inches, is a remarkable character in these Yorkshire reefs.

In the Museum of the Yorkshire Philosophical Society, I was fortunate in finding Mr. DALLAS at home, and he kindly opened the glass cases to enable me to examine the specimens of all the Corals that had been found in the Coralline Oolite of Yorkshire: I was delighted to discover some fine specimens of all the species collected in Wiltshire. The following is the list I made out:—

CORALS FROM THE CORALLINE OOLITE OF YORKSHIRE.

Montlivaltia dispar, Phill.,	Malton
Rhabdophyllia Phillipsii, Ed. and Haime,	Malton
Thecosmilia annularis, Flem.,	Malton
Thamnastræa concinna, Goldf.,	Malton
——— *arachnoides,* Park.,	Malton
Stylina tubulifera, Phill.,	Malton
Isastræa explanata, Goldf.,	Malton
Comoseris irradians, Ed. and Haime,	Malton
Isastræa inæqualis, Phill.,	Malton

In Dorsetshire we find evidence of the same Coral formation in the Coral Rag near Osmington Mills, where *Thamnastræa arachnoides,* Park., and *Thecosmilia annularis,* Flem., are sometimes found.

ZOANTHARIA, FROM THE CORAL RAG AND CORALLINE OOLITE.

Stylina tubulifera, Phill. and 1 other sp.
Montlivaltia dispar, Phill.
Thecosmilia annularis, Flem.
Rhabdophyllia Phillipsii, Ed. and Haime
Calamophyllia Stokesi, Ed. and Haime
Cladophyllia Conybearii, Ed. and Haime

Goniocora socialis, Römer
Isastræa explanata, Goldf. and 1 other sp.
Thamnastræa arachnoides, Park.
——— *concinna*, Goldf.
Comoseris irradians, Ed. and Haime
Protoseris Waltoni, Ed. and Haime

In France the *Étage Corallien* is largely developed and rich in Corals. Some of the best type localities are Saint-Mihiel, (Meuse,) Tonnerre, (Yonne,) Angoulême, (Charente-Inférieure,) and Nantua, (Ain).

In Savoy, it is found at Mont Salève, and in different cantons in Switzerland, as in Neufchâtel, Berne, and Bâle. In Bavaria, at Essingen and Regensburg; in Wurtemberg, at Nattheim, Muggendorf, and near Heidenham; and in other localities in Germany, as Streitberg, near Hanover, &c. It is likewise found in the Morea.

From this general view of the geographical distribution of the Corallian zone, it would appear that this formation was composed of a series of Coral reefs in the Jurassic sea, which, during the period of their construction, occupied a large portion of the region now constituting the soil of modern Europe; and that the bed of the Jurassic sea was a slowly-subsiding area of great extent, like many parts of the Coral Sea in the Indo-Pacific Ocean of our day.

A TABLE SHOWING THE GENERIC DISTRIBUTION OF JURASSIC CORALS.

Genera of Zoantharia aporosa	Lias	Inferior Oolite	Great Oolite	Oxford Clay	Coral Rag	Kimmeridge Clay	Portland Oolite
Trochocyathus		*		*			
Thecocyathus	*						
Enhallhelia					*		
Evhelia			*				
Trochosmilia					*		
Axosmilia	*	*					
Placophyllia					*		
Stylosmilia					*		
Aplosmilia					*		
Phytogyra					*		
Stylogyra					*		
Pachygyra					*		
Stylina			*	*	*		
Lobocœnia					*		
Conocœnia					*		
Tremocœnia			*	*	*		
Dendrocœnia			*		*		
Pseudocœnia					*		
Convexastrœa			*		*		
Astrocœnia	*				*		
Enallocœnia					*		
Stephanocœnia ...	*	*	*	*	*		
Dactylocœnia			*				
Octocœnia	*						
Decacœnia					*		
Montlivaltia	*	*	*	*	*	*	*
Thecosmilia	*	*		*	*		
Lasmosmilia		*					
Amblophyllia				*	*		
Eunomya	*	*	*	*	*	*	*

A TABLE SHOWING THE GENERIC DISTRIBUTION OF JURASSIC CORALS—*Continued.*

Genera of Zoantharia aporosa	Lias	Inferior Oolite	Great Oolite	Oxford Clay	Coral Rag	Kimmeridge Clay	Portland Oolite
Rhabdophyllia	*				*		
Aplophyllia					*		
Oulophyllia					*		
Latomeandra	*	*			*		
Axophyllia					*		
Myriophyllia					*		
Microphyllia					*		
Comophyllia					*		
Meandrophyllia					*		
Meandrina			*		*		
Goniocora					*		
Confusastrœa			*		*		
Isastrœa	*	*	*	*	*		*
Dendrastrœa			*				
Clausastrœa		*					
Thamnastrœa ...	*	*	*	*	*		
Polyphyllastrœa					*		
Pavastrœa					*		
Oralastrœa					*		
Anabacia	*	*	*				
Genabacia			*				
Protoseris					*		
Oroseris			*		*		
Microsolena			*		*		
Dendrarea					*		
Dactylarœa					*		
Actinarœa					*		

Cretaceous Corals.

The Cretaceous period was one of long duration, and almost as important, in a palæontological point of view, as the Jurassic. Its various stages cover a great part of the earth's surface, and contain the remains of a fauna which impart well marked characters to them. The Cretaceous group in England comprises the following formations, ascending from the base to summit:—

1. *The Lower Greensand.*—The lowest stage, which rests conformably on the Wealden formation, and is extremely well exposed in the fine coast sections on the western shores of the Isle of Wight and Coast of Kent, is a great arenaceous formation, composed of ferruginous Sands with green grains, dark-coloured Clays, and clayey Sands. In some localities, as at Hythe and Maidstone, there are bands of Limestone known as Kentish Rag. The equivalent of this formation is the *Terrain Néocomien* of Swiss and French authors, and it is the *Étage Aptien* of D'Orbigny. The Lower Greensand attains a thickness of 800 feet in the Isle of Wight.

2. *The Speeton Clay.*—A local formation found at Filey Bay, on the Yorkshire coast, near Flamborough Head. It is a grayish-coloured Clay, its upper portion containing Neocomian, and the lower portion Portlandian species of fossil shells.

3. *The Red Chalk,* another local member of the Cretaceous group, consists of a thin bed of hard, red Chalk, deeply coloured by the peroxide of Iron, and having numerous small siliceous grains and pebbles of Quartz, &c., strewed throughout the mass. It forms a conspicuous member of the fine picturesque section of Hunstanton Cliff, Norfolk, and is seen *in situ* in Filey Bay, Yorkshire. It is supposed to be the equivalent in these regions of the next stage.

4. *The Gault,* a dark-blue tenacious Clay, sometimes marly, and containing concretions. It is well exposed in the Isle of Wight, and at Folkestone, Charmouth, and Cambridge, and has yielded a fauna of beautiful fossils which are special to it. The Gault forms the *Étage Albien* of D'Orbigny, and is about 100 feet in thickness.

5. *The Upper Greensand* consists of a siliceous Sand or calcareous Sand, with green grains. It often contains nodules of Chert and masses of Limestone, and concretions containing phosphate of Lime, which are probably coprolitic in their character, and valuable to the agriculturist. It is well exposed at Warminster and Devizes, in Wilts; in the Isle of Wight; at Charmouth, Dorset; and in Cambridgeshire.

6. *The Chloritic Marl* appears to form a portion of the previous formation. It is a light-coloured Marl, full of green specks of silicate of Iron, with numerous fossils; and is exposed at Chard, Chardstock, and St. Catherine's Down, Isle of Wight, where it is above 150 feet thick. The Upper Greensand is the equivalent of the *Glauconie crayeuse* of the French, the *Tourtia* of the Belgians, and the *Étage Cénomanien* of D'ORBIGNY. Covering all these, more or less argillo-arenaceous formations just described, is the Chalk proper, which is divisible into Chalk Marl, White Chalk without flints, and White Chalk with flints.

7. *The Chalk Marl* consists of hard Chalk, passing sometimes into Chalk Marl or hard gray Chalk. The transition from the Upper Greensand into this formation is sometimes so gradual that it is difficult to define the line of separation. It is well developed at Dover, Folkestone, Kent, and Lewes, Sussex, and at Swaffham, Norfolk. The Chalk Marl is the *Pläner* of the Germans, the *Craie tuffeau* of the French, and the *Étage Turonien* of D'ORBIGNY.

8. *The White Chalk without Flints* is a great mass of soft thick-bedded Limestone, with obscure indications of stratification from the obliteration of the planes of bedding and the character of the joints. It contains numerous nodular balls of Iron Pyrites, radiated internally, which, on decomposing, produce rusty stains on the rock.

9. *The White Chalk with Flints* resembles the preceding lithologically, but differs from it in containing rows of nodules of black Flint, interstratified at certain distances apart, or having occasionally tabular layers of dark Silex coincident with the plane of stratification, or seams of the same extending along the line of bedding. The White Chalk itself is nearly a pure

carbonate of Lime, often soft and pulverulent, and containing large numbers of the minute shells of *Foraminifera*, beautiful star-fishes, and *Echinidæ*, in admirable preservation, and with a large assemblage of *Mollusca*. It is well exposed in the Isle of Wight, Kent, and Sussex, and at Flamborough Head, Yorkshire. The White Chalk forms the *Craie blanche* of the French, and the *Étage Sénonien* of D'Orbigny.

Palæontologically considered, the Cretaceous period presents certain remarkable characters, which appear to indicate that it was a great marine formation deposited far away from land. For although mammalia and birds are found in the Jurassic rocks, no remains of either of these classes, with the exception of the bone of a bird from the Upper Greensand, have been as yet discovered in any formation of the Cretaceous group. The Dinosaurian, Enalosaurian, and Pterodactylian reptiles, which played so important a part in the Jurassic period, continued to maintain a high development in the Cretaceous, but towards its close they all became extinct. Fishes, anterior to the Cretaceous era, were represented by ancient forms of the Placoid and Ganoid orders; with the commencement of the Cretaceous formations, the Teleosteian or true bony fishes (including the Ctenoid and Cycloid orders, containing three-fourths of the eight thousand known species of living fishes) appear for the first time, when many of the preceding fossil genera of the two first orders representing the most ancient types of ichthoidal structure had become extinct.

Among the Mollusca, the great family of *Ammonitidæ* continued to flourish in vast numbers, exhibiting remarkable forms that are special to this period. All these became extinct with its close, not one representative of its long line of ancestry having survived in the seas of the Tertiary epoch. One singular family of the Conchifera, the *Rudistidæ*, which present so many curious forms in certain superior Cretaceous rocks, are altogether special to them.

The Polyzoa have a very large number of beautiful forms in the White Chalk, which are well figured in Dixon's Sussex.

The Echinoderms were largely represented by many genera that now appear for the first time, belonging to the orders Echinoidea, Asteroidea and Crinoidea, and well characterise the rocks in which their remains are entombed.

The *Foraminifera* are largely represented in the rocks of this period, both in genera, species, and individuals. Some parts of the White Chalk appears to be almost entirely composed of the minute shells of *Rotalia*, *Spirulina* and *Textularia*, mixed with fine pulverulent carbonate of Lime.

The Zoantharia are represented by numerous genera of Corals, which, for the most part, belong to the Aporosa. The family *Madreporidæ*, represented by the genus *Discopsammia*, which is special to the Chalk, now appears for the first time. The Tabulata is represented by two genera. The Rugosa, which formed so important a group in the Palæozoic rocks, is represented in the Lower Greensand by the genus *Holocystis*.

I am unacquainted with any evidence of reef-like structure in the Cretaceous rocks of the British Islands similar to those already described in the Oolitic and other older formations, although such may exist in some of the continental stages of the Cretaceous group unknown to me; as a general rule, however, I think it may be stated that the Cretaceous rocks were deposited under conditions unfavourable to the growth and development of reef-building Corals. In the following table I have given a list of those genera only, with their distribution, which are special to the Cretaceous period.

GENERIC DISTRIBUTION OF CRETACEOUS CORALS SPECIAL TO THE PERIOD.

Names of Genera	Neocomian	Gault	Upper Greensand	Chalk
ZOANTHARIA APOROSA.				
TURBINOLIDÆ.				
Brachycyathus	*			
Cyclocyathus		*		
Stylocyathus			*	
Smilotrochus			*	
OCULINIDÆ.				
Synhelia			*	*
Actnacis				*
Polytremacis			*	*
ASTRÆIDÆ.				
Placosmilia				*
Diploctenium				*
Peplosmilia			*	
Barysmilia	*		*	*
Dactylosmilia			*	
Pentacœnia	*			
Acanthocœnia	*			
Ellipsocœnia	*			
Placocœnia				*
Heterocœnia			*	*
Elasmocœnia			*	
Hymenophyllia				*
Heterophyllia				*
Stelloria			*	
Diploria				*
Pleurocora			*	*
Dimorphastrœa			*	
FUNGIDÆ.				
Micrabacia			*	
Cyclolites	*		*	*
ZOANTHARIA PERFORATA.				
MADREPORIDÆ.				
Discopsammia				*
ZOANTHARIA TABULATA.				
FAVOSITIDÆ.				
Koninckia				*
ZOANTHARIA RUGOSA.				
STAURIDÆ.				
Holocystis	*			

Tertiary Corals.

The Tertiary epoch admits of a division into four periods,—Eocene, Meiocene, Pleiocene, and Pleistocene,—based on the gradual increase in the number of existing species in the newer rocks. In the Eocene, there is a dawning of recent forms 3½ per cent.; in the Meiocene, (μειων) there is a minority 17 per cent.; in the Pleiocene, (πλειων) a plurality 35 to 50 per cent.; and in the Pleistocene, a larger proportion of living species, 90 per cent.; this general law, which was first established in 1833, by Lyell and Deshayes, from a careful study by the latter learned Conchologist of a large assemblage of about 3000 species of fossil shells collected from the different Tertiary rocks of Europe, and which he compared with 5000 living species, has in the main stood the test of time, and is now almost universally adopted.

The British Eocene Zoantharian Corals belong to the families Turbinolidæ, Cyathininæ, Oculinidæ, Astræidæ, Eupsammidæ, and Poritidæ; most of the species grouped into these different families are nearly allied to species, (according to MM. Edwards and Haime,) "which are now found in very deep water, and seem to be particularly organised for living on a loose muddy or sandy ground; whereas many of the French Eocene Corals, from the *Calcaire grossier*, resemble those which now inhabit rocky shores, and are seen very near the surface of the sea." The families Pennatulidæ and Gorgonidæ now appear for the first time, and are feebly represented by a few species from the London Clay.

The Meiocene Corals are best known to me by the fine suite of specimens collected by the Earl of Ducie, in the Island of Malta, and now preserved in his lordship's museum at Tortworth Court, Gloucestershire, and which I examined in connection with the *Echinidæ* associated with them. For details, I must refer to my memoirs on this subject.[15]

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[15] On the Fossil Echinoderms from the Island of Malta, Proceedings of the Cotteswold Club, vol. i., p. 55. Quart. Jour. of the Geol. Society, vol. xx., p. 470, 1864.

The Corals of the English Crag may belong to this period. At one time it was believed that the Crag was very rich in Corals, and one division of this formation was called Coralline, from the supposed abundance of Corals therein. A careful study of these fossils, however, has shewn that it is the Polyzoa, and not the Zoantharia, that abound. True Corals are very rare in the English Crag, and still more so in its equivalent formation at Antwerp. The Crag Corals belong to four distinct genera, each of which is represented by different species in other Meiocene formations; three of the genera have living representatives in our present seas, but none of them have been found in the secondary rocks.

The Pleiocene formations have no representative in the British Islands, unless the Crag may turn out to be of that age. They consist of the sub-Apennine strata found reposing on the secondary rocks along the shores of the Adriatic and the Mediterranean, and the newer formations of the same period in Sicily.

Many genera of Actinozoa have species living in our modern seas; the recent, however, are all distinct from the Tertiary species. In the following table I have given a list of those genera only which are extinct and special to the Tertiaries.

GENERIC DISTRIBUTION OF TERTIARY CORALS SPECIAL TO THE PERIOD.

Names of the Genera	Eocene	Meiocene	Pleiocene
ZOANTHARIA APOROSA.			
Turbinolidæ.			
Conocyathus		*	
Paracyathus	*	*	*
Delthocyathus		*	
Turbinolia	*		
Sphenotrochus	*	*	
Platytrochus	*		
Ceratotrochus	*	*	
Discotrochus	*		
Flabellum	*	*	*
Dasmia	*		
Oculinidæ.			
Diplhelia	*	*	
Astrhelia		*	
Areacis	*		
Astræidæ.			
Cyclosmilia	*		
Dendrosmilia	*		
Circophyllia	*		
Gyrophyllia	*		
Plerastrœa		*	
Cryptangia			
Rhizangia	*	*	
Cladangia		*	
Fungidæ.			
Trochoseris	*		
Cyathoseris	*		
ZOANTHARIA PERFORATA.			
Madreporidæ.			
Lobopsammia	*		
Stereopsammia	*		
Dendracis	*		
Poritidæ.			
Litharœa	*		
Rhodarœa		*	
ZOANTHARIA TABULATA.			
Milleporidæ.			
Axopora	*		
ALCYONARIA.			
Pennatulidæ.			
Graphularia			

In the foregoing table I have shewn the distribution of the genera that are special to the Tertiary epoch, and in the following I have arranged those which have representatives in our present seas. The living species, however, are quite distinct from the fossil forms. This table shews, as far as Zoophytes are concerned, how gradually changes have taken place in organic nature, by the dying out of one group of forms and the introduction of others; and it at the same time illustrates the general principle which is found to govern all other classes of the animal kingdom, that every organism has a limited life in time, and a limited range in space.

A TABLE OF TERTIARY GENERA THAT OCCUR IN MORE THAN ONE PERIOD.

Names of Genera	Tertiary	Modern
ZOANTHARIA APOROSA.		
TURBINOLIDÆ.		
Acanthocyathus	*	*
Paracyathus	*	*
Sphenotrochus	*	*
Desmophyllum	*	*
Flabellum	*	*
OCULINIDÆ.		
Oculina	*	*
Stylophora	*	*
Galaxea...	*	*
CARYOPHYLLIDÆ.		
Mussa	*	*
Dasyphyllia	*	*
Mycetophyllia	*	*
MEANDRINIDÆ.		
Meandrina	*	*
Leptoria	*	*
Diploria	*	*
Hydnopora	*	*
Cladocora	*	*

A TABLE OF TERTIARY GENERA THAT OCCUR IN MORE THAN ONE PERIOD—*Continued.*

Names of Genera	Tertiary	Modern
Astreidæ.		
Astræa	*	*
Plesiastræa	*	*
Prionastræa	*	*
Siderastræa	*	*
Goniastræa	*	*
Parastræa	*	*
Astrangia	*	*
Phyllangia	*	*
ZOANTHARIA PERFORATA.		
Madreporidæ.		
Endopachys	*	*
Balanophyllia	*	*
Dendrophyllia	*	*
Madrepora	*	*
Turbinaria	*	*
Poritidæ.		
Porites		
ALCYONARIA.		
Gorgonidæ.		
Isis	*	*
Mopsea	*	*
Corallium	*	*
Pennatulidæ.		
Virgularia	*	*

I have thus endeavoured to trace a simple outline of Polyp life, past and present, with the view of shewing—1st, how large a portion of the earth's crust is due to the secreting energies of these tiny architects, and to prove the vast importance in the economy of nature of the combined living forces of the simplest animals; 2nd, that the importance of organised beings in the composition of the fossiliferous rocks is in an inverse ratio to their magnitude, and the place they occupy in the Zoological series; 3rd, the unity of the organic law which appears to have regulated the structure, growth and development of Corals from their first appearance in the Silurian seas, down to those of the present, each distinct geological period being characterised by a greater or less development of forms that are special to it, the Devonian and Carboniferous in Palæozoic time, and the Inferior Oolite and Corallian in Mesozoic, being the great reef-building ages of the ancient world; 4th, that the modern period possesses probably a greater development of reef building Corals than ever existed in any previous epoch; and that the areal extent of Coralligenous structures within 28° of each side of the Equator forms one of its most remarkable Geological characters; the Atolls and Barrier reefs of the Indo-Pacific ocean, for their magnitude, extent, and number, having nothing approaching to them, either in the Devonian or Carboniferous periods of Palæozoic or the Jurassic age of Mesozoic time.

In conclusion, I would quote the words I recently addressed to the members of the Woolhope, Malvern, and Cotteswold Field Clubs, assembled in Dr. Grindrod's Museum at Malvern, whilst demonstrating the remarkable collection of ancient organisms exhibited there for our study on that occasion. "If I might be permitted to express the thought that rose in my mind at this moment, when contemplating so grand a display of the denizens of the old Silurian beach, it was this, that the Almighty Author of all things had revealed to us in these His works, how unchangeable was His character, for the details of their structure, the laws of their being, and other phenomena by which the present organisms of the animal creation are characterised, were found by us alike in these oldest forms of earth's first inhabitants: so that if it was true that hundreds of thousands of ages had rolled away since these creatures lived in the primeval seas, the same laws that governed their being, regulated their life, and assigned them their place in creation, were presiding over the countless organisms of the present time: and if it was possible to realise, in a material form, the words of Scripture, that the Great Author of our being was 'the same yesterday, to-day, and for ever,' he would point to the Corals, Crinoids, Star-fishes, and Trilobites of the Silurian beach now before them, and say, there are evidences which declare the truth, and prove the reality of these all-comforting words."[16]

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[16] Transactions of the Woolhope Naturalists' Field Club, 1866, p. 268.

SECTION OF THE TRANSITION BEDS

OF THE

OLD RED SANDSTONE & CARBONIFEROUS LIMESTONE

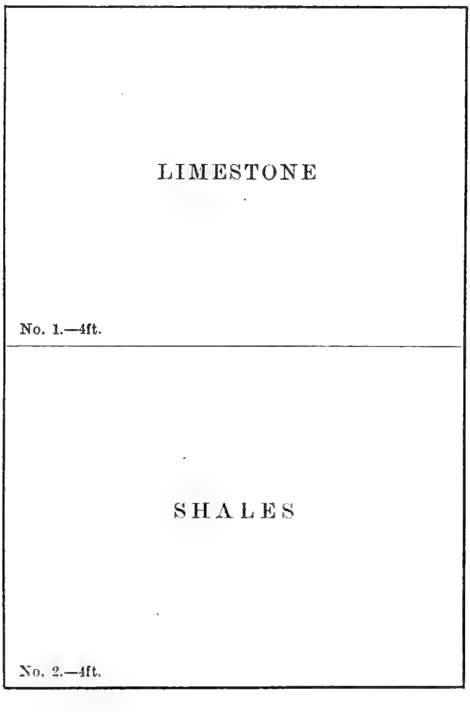
At Drybrook, in the Forest of Dean.

BY JOHN JONES AND W. C. LUCY.

Referred to by the President in his Annual Address on the 29th of March, 1867.

Scale half-an-inch to the foot. Beds given in descending order.

Although the Section is called Drybrook, it is fully a mile from the village—is near the Hawthorns—and occurs in that part of the road from Ross to Drybrook, known as the Deep Cutting. It can be reached either from the Longhope or Mitcheldean Road Stations of the Hereford, Ross, and Gloucester Railway—the distance being nearly the same from each, about two-and-a-half miles. The latter route is perhaps the better one, the beds being seen in ascending order. The dip of the beds is from N.N.W. to S.S.E., at an angle of 22° to 32°. W. C. L.



[Drybrook Section—*continued.*]

No. 3.—4in.	RUBBLY STONE
No. 4.—6in.	SHALE
No. 5.—3in.	RUBBLY STONE
No. 6.—1ft. 3in.	SHALE
No. 7.—3in.	RUBBLY STONE
No. 8.—1ft. 3in.	SHALE
No. 9.—2in.	RUBBLY STONE
No. 10.—2ft.	SHALE WITH INDURATED BEDS
No. 11.—8in.	RUBBLY STONE
No. 12.—6in.	SHALE
No. 13.—2in.	CLAY STONE
No. 14.—6in.	SHALE
No. 15.—3in.	STONE
No. 16.—2½in.	SHALE
No. 17.—9in.	LIMESTONE
No. 18.—6in.	SHALE
No. 19.—4in.	RUBBLY STONE
No. 20.—1ft. 10in.	SHALE WITH THIN STONY BANDS
No. 21.—1ft.	LIMESTONE

[DRYBROOK SECTION—*continued.*]

No. 22.—10in.	SHALE
No. 23.—3in.	RUBBLY STONE
No. 24.—6in.	SHALE
No. 25.—1ft. 6in.	LIMESTONE
No. 26.—15ft.	BEDS COVERED UP
No. 27—8in.	CLAYSTONE BAND
No. 28—1ft.	SANDY SHALE
No. 29—1ft. 3in.	LIMESTONE
No. 30—2in.	ASHY SHALE
No. 31—3in.	RUBBLY STONE
No. 32—4in.	MARL SHALE

No. 33—4in. RUBBLY STONE

No. 34—3in. BLUE ASH COLOURED SHALE

No. 35—2in. LIME STONE

No. 36—One-and-half-inch. HARD CLAY

RUBBLY LIMESTONE

No. 37—1ft. 6in.

STIFF YELLOW CLAY

No. 38—2ft.

LIMESTONE FULL OF ENCRINITAL STEMS

No. 39—1ft.

YELLOW AND BLUISH MARLS ALSO WITH ENCRINITAL STEMS

No. 40—6in.

LIMESTONE AS ABOVE WITH ENCRINITES

No. 41—2ft.

BROWN OR YELLOW MARLS ALTERNATING WITH YELLOW SANDY BANDS

No. 42—15ft.

[DRYBROOK SECTION—*continued.*]

No. 43—6in.	BLACK SANDY BED
No. 44—2in.	FINE YELLOW SAND.
No. 45—5in.	YELLOW CLAY STONE
No. 46—2in.	GREEN MARL
No. 47—1in.	CLAY STONE
No. 48—6in.	COARSE YELLOW SANDSTONE PASSING UPWARDS INTO GREEN MARL
No. 49—1ft.	GREEN AND RED MARL
No 50—One-and-half-inch.	INDURATED CLAY
No. 51—6in.	RED MARL
No. 52—6in.	GREEN SANDY MARL
No. 53—10in.	YELLOW SANDSTONE DIVIDED BY TWO INCHES OF VARIEGATED MARL
No. 54—2ft.	VARIEGATED SANDY MARLS
No. 55—6in.	LAMINATED YELLOW SANDSTONE
No. 56—6in.	MOTTLED BEDS OF SANDY CLAY
No. 57—3in.	YELLOWISH SANDSTONE
No. 58—2in.	MOTTLED CLAY
No. 59—2in.	YELLOWISH SANDSTONE
No. 60—1in	CLAY, half-inch—STONE, half-inch
No. 61—One-and-half-inch.	CLAY
No. 62—One-and-half-inch.	STONE
No. 63—2 in.	MOTTLED GRITTY CLAY
No. 64—4in.	GRIT
No. 65—4in.	LIGHT MOTTLED CLAY
No. 66—4ft. 6in.	GRIT

[DRYBROOK SECTION—*continued.*]

No. 67—4in.	GREEN MARL
No. 68—6in.	FERRUGINOUS NODULE BAND
No. 69—7in.	YELLOW SAND AND GREEN MARL
No. 70—1ft. 6in.	RED MARL
No. 71—1ft. 11in.	CLAYEY SANDSTONE
No. 72—5in.	RED AND GREEN MARL
No. 73—7in.	CLAY STONE
No. 74—2ft. 6in.	DARK RED SANDY BED WITH BANDS OF MARL
No. 75—1 in.	SAND AND CLAYSTONE
No. 76—1ft. 6in.	RED AND GREEN MARLS, RED PREDOMINATING
No. 77—1ft. 6in.	YELLOW SANDSTONE
No. 78—8in.	RED AND GREEN MOTTLED CLAYS
No. 79—6in,	YELLOW SANDSTONE
No. 80—6in.	LIGHT GREEN CLAY

[DRYBROOK SECTION—*continued.*]

No. 81—6in.	YELLOW SANDSTONE
No. 82—2in.	GREEN AND YELLOW CLAY
No. 83—6 in.	SANDSTONE
No. 84—8 in.	LIGHT GREEN CLAY
No. 85—6 in.	GRIT
No. 86—6 in.	GREENISH BLUE CLAY
No. 87—10 in.	GRIT
No. 88—10 in.	GRIT LIGHTER IN COLOUR
No 89—1 ft.	VARIEGATED MARLS, PRINCIPALLY GREEN
No. 90—14 ft.	YELLOWISH GRIT

[Drybrook Section—*continued.*]

RED MARL, PASSING INTO A YELLOWISH BAND AT THE TOP

No. 91—20 ft

GREY FLAGGY SANDSTONE

No. 92—6 ft.

[DRYBROOK SECTION—*continued.*]

LAMINATED BEDS WITH IRREGULAR DARK RED MARL	No. 93—1 ft. 6 in.
A WEDGE OF GREY SANDSTONE	No. 94—1 ft. 6 in.
RED MARL	No. 95—3 in.
GREY SANDSTONE	No. 96—2 ft.
YELLOWISH BAND WITH DARK RED MARL NODULES	No. 97—1 ft.
GREENISH MICACEOUS SAND	No. 98—6 in.
GREENISH-GREY HIGHLY MICACEOUS LAMINATED SANDSTONE	No. 99—6 ft.
GREY INDURATED SHALE Two Beds	No. 100—1 ft.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

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GREY CONGLOMERITIC SANDSTONE No. 101—4 ft.
VARIEGATED SANDY SHALES No. 102—5 ft.
GREY SANDSTONE No. 103—1 ft. 6 in.
GREY & RED INDURATED SANDY SHALES No. 104—3 ft.

GREY AND PINK SANDY SHALES No. 105—2 ft.
GREY SANDSTONE No. 106—1 ft. 3 in.
PINK AND GREY INDURATED MARLS No. 107—20ft.

GREY GRIT

No. 108—3ft.

RED AND GREEN MARLS

No. 109—12 ft.

No. 110—7 ft.	PINK GREY SANDSTONE
No. 111—2 ft.	DARK RED SANDY SHALE, WITH BRIGHT GREEN PATCHES
No. 112—2 ft.	GREENISH-GREY SANDSTONE
No. 113—6 in.	GREEN AND PUCE SAND
No. 114—4 ft.	PINKISH GRIT, WITH OCCASIONAL QUARTZ PEBBLES

GREY SANDSTONE No. 115—3 ft.
PUCE SANDY SHALES, WITH A FEW BANDS OF GREEN No. 116—2 ft. 6 in.
GREY STONE (INDURATED SAND) No. 117—1 ft.
ALTERNATING GREEN AND PUCE SANDY SHALES No. 118—1 ft. 6 in.
RED SANDSTONE No. 119—3 ft.
RED AND GREY LAMINATED SANDSTONE, WITH OCCASIONAL SHALEY LAYERS No. 120—10 ft.

GREY SANDY CONGLOMERATES No. 121—6ft.
GREY SANDSTONE No. 122—1ft. 6in.
No. 123—3in. GREEN MARL, WITH SMALL QUARTZ PEBBLES
GREY SANDSTONE No. 124—6ft.

No. 125—6in.	GREEN MARL
No. 126—1ft.	GREY SANDY SHALE
No. 127—7ft.	GREY SANDSTONE
No. 128—4ft.	INDURATED GREY SAND PASSING UPWARDS INTO SANDY GREEN MARL

No. 129—8ft.	LIGHT GREY SANDSTONE WITH OCCASIONAL MICACEOUS BEDS
No. 130—4in.	MICACEOUS BED
No. 131—1ft. 6in.	LIGHT GREY SANDSTONE
No. 132—15ft.	VARIEGATED YELLOW, PUCE, GREEN, AND PINK SAND, WITH SHALEY SANDSTONE

[DRYBROOK SECTION—*continued*.]

No. 133—1 ft.	LIGHT GREY SANDSTONE
No. 134—1 ft. 6 in.	PINK AND GREEN MICACEOUS SANDS
No. 135—1 ft. 6 in.	YELLOWISH SANDSTONE
No. 136—2 ft.	GREY AND YELLOW INDURATED SANDS
No. 137—3 ft.	YELLOWISH SANDSTONE
No. 138—3 in.	SANDY MARL
No. 139—3 in.	GREY SANDY SHALE
No. 140—1 ft.	GREY SANDSTONE
No. 141—4 ft.	VARIEGATED SANDY SHALES

[DRYBROOK SECTION—*continued*.]

No. 142—1 ft.	YELLOWISH SANDSTONE
No. 143—1 ft. 3 in.	GREY SHALE
No. 144—1 ft.	GREY SANDSTONE
No. 145—3 in.	GREEN SANDY SHALE
No. 146—3 in.	RED MARL
No. 147—10 in.	GREY SANDSTONE
No. 148—1 ft. 6 in.	RED MARL
No. 149—1 ft. 6 in.	GREY SANDSTONE

Remarks on Drybrook Section. *By* John Jones, F.G.S., F.A.S.L., &c.

As the Cotteswold Club has determined to publish in detail the Section measured and taken by Mr. Lucy and myself at this place, I beg leave to offer the following remarks upon it, by way of explanation. Since I assisted in taking this Section, I have had the privilege of visiting many localities in Belgium, where the Carboniferous Limestone is developed to an extent which can hardly be paralleled in any part of the world; and I can conscientiously state, that I have never seen such a series of beds intermediate between the upper beds of the universally recognized Old Red Sandstone formation, and that of the Carboniferous Limestone, as at Drybrook. They are, so far as my information extends, strictly local, as there are others differing remarkably in character, underlying the Carboniferous Limestone, at no greater distance than the Lea Bailey, upon the north-east extremity of the Forest of Dean coal basin, which are easily accessible, and which I would suggest, should be published by the Club in similar form, and upon a like scale, as a proper collateral with the present.

We must recollect, that shallow-sea and deep-sea conditions must at all times have been coincident, and that the beds at Drybrook, without fossils until we come to their upper portion, may represent one state of things, and those of the Lea Bailey with the *Spirorbis* band, the other. I remember having found some flakes of the latter, which are very thin. I think Lord Ducie has the specimens, with other fossils found upon the occasion of our visit, at a Mitcheldean meeting.

In contemplating the great number of beds here deposited, we must remember that millions of others must have occupied the same area, and have been swept away without leaving a trace, like those which we see daily in the neighbouring estuary of the Severn, before the conditions under which they were formed, became such as to admit of their preservation in the order in which they now appear, whether by gradual alteration of level or otherwise. That the change from one series of deposits to the other was gradual, we may surely infer from an inspection of this Section. At the close of the epoch marked by the deposition of the vast masses of Marls and Conglomerates, characterized by the presence of peroxide of Iron as the colouring matter of their minute particles, we see that detrital deposits were introduced from other sources, in which colour, as derived from Iron, was nearly if not entirely absent. Yet the original source of the bulk of the "Old Red" formation had not been entirely exhausted, but was still subject to periodical breakings-up and re-deposit, as we may see in the occasional recurrence of red beds, not differing in lithological character from those far beneath them, which subsequently attain to their fullest development in the Grits of the Coal measures, and finally supplement them. The Encrinite, which appears in the layers indicated as fossiliferous, is the *Actinocrinus triacontadactylus.* None of the beds, other than those especially indicated, so far as we observed in our cursory inspection of them, contained any fossils. No period of geological time seems to have been more distinctly characterized by the action of disturbing forces, than that of the close of the Carboniferous system, and this disturbing force has apparently been much greater upon those parts of the continent known to me, than in our own district. I send with the present notes, for the service of such members of the club as may be inclined to make use of them, the admirable Sections of the corresponding beds in Belgium, and the "Essai d'une Carte Géologique des Environs de Dinant," given to me by my friend Dr. Edouard Dupont, of that place.

John Jones.

Annual Address to the Cotteswold Naturalists' Field Club. Read by the President, Sir W. V. Guise, Bart., F.L.S., F.G.S., *March 25th,* 1868.

Gentlemen,—

In presenting my Annual Report to the members of the Cotteswold Field Club, I rejoice in again having it in my power to congratulate them upon the prosperity of their Society, which in all respects continues to maintain the position by universal assent accorded to it, as amongst the most distinguished of those local Associations which have done so much of late years to disseminate and foster amongst us a love of natural science.

I regret that our Secretary, Dr. Paine, to whom we owe so much for his unremitting exertions in our service, is prevented by illness from being present with us to-day; and from the same cause the auditing of the accounts has been unavoidably postponed. I am able, however, to assure you, upon his authority, that our financial condition is satisfactory. The annual volume of Transactions will shortly be in the hands of members, when I think it will be found to be in no degree inferior in interest to any of our previous issues.

I must not pass over without notice the splendid contribution to our volume for 1866, by our esteemed colleague, Dr. Wright, on "Coral Reefs Present and Past," which gave value and importance to our last year's volume, in other respects somewhat more meagre than usual. The expense incurred in the production of that volume was the reason why the "Ammonites" were not proceeded with. Since then one more plate has been done, and Dr. Wright proposes to complete the corresponding portion of text for the next part, if well enough to do so.

I take this opportunity of drawing the attention of members to a beautifully executed volume on "The Old Crosses of Gloucestershire," from the pen of one of the oldest members of the Club—Dr. Pooley, of Weston-super-Mare. Some portions of the work have already appeared in our Transactions. The whole forms an interesting record of a class of memorials which time and other destroying agents are rapidly obliterating. Though a labour of love, it has been to our colleague a cause of considerable outlay, which will not be more than covered by the sale of the whole edition. I think I am justified, therefore, in calling upon the members of the Club—the antiquarians in particular—to subscribe for copies.

Our numbers are fully maintained, and judging from the list of those who have signified their desire to join us as vacancies arise, there is no reason to expect any falling off in that respect. During the past year twelve vacancies have occurred, through death or retirement, and ten new members have been elected. One only has been removed from amongst us by death; but in him not only do we mourn the loss of one of the original founders of our Society, but, in common with the whole scientific world, we lament the departure of one of the veterans of science, whose name will ever be associated, on the roll of fame, with that bright galaxy of names which has done honour to our Universities, and has made the first half of the present century so pre-eminent in the march of intellectual progress and development.

Dr. Giles Bridle Daubeney, F.R.S., was a Gloucestershire man. He was the younger son of the Rev. James Daubeney, rector of Stratton, in this county. He was born in 1795, and graduated B.A. at Oxford in 1814, at the age of 18. In 1818 he undertook his first journey of exploration in the volcanic district of Auvergne; and in 1822 was appointed Professor of Chemistry at Oxford, having then been recently elected a Fellow of the Royal Society, at the early age of 27. In 1834 he was appointed Professor of Botany at Oxford, to which the Professorship of Rural Economy was added in 1840. In 1856 he occupied, at Cheltenham, the distinguished position of President of the British Association for the Advancement of Science.

Dr. Daubeney's future fame will rest chiefly upon his standard work on Volcanoes, first published in 1836, of which a second edition, much enlarged and improved, was issued in 1848. This work brought him into relation with scientific men everywhere, and gained for him a world-wide reputation.

As a member of the Cotteswold Club, as he was one of its original founders, so he ceased not to take interest in its success; and though never a contributor to our Annals, was a regular subscriber up to the year of his death.

Our meetings during the past season were in all respects successful and well attended, and there was no lack of papers nor of subjects of interest for discussion. I am justified especially in noting the entire success of our meeting at Bridgend, for the examination of the Sutton and Southerndown beds, which I believe enabled us to arrive at a satisfactory conclusion respecting the age and position of that much-debated section—the more satisfactory inasmuch as it tended to confirm the views from the first persistently urged by our colleague, Mr. Charles Moore—views in harmony with those long since advocated by Sir Henry De la Beche, but which had been called in question by later Geologists. Mr. Moore, as it seems to me, has had but scanty justice done him in this matter. It is due to our colleague and fellow-worker that the share he has had in elucidating this question should be fairly stated; and, as your President, I claim the privilege of putting the facts of the case on record.

It will be in the recollection of members that in the month of May, 1866, a paper by Mr. Tawney appeared in the Quarterly Journal of the Geological Society, in which the Sutton and Southerndown beds were regarded as Rhætic, with a suggested affinity to the St. Cassian beds; which view was at the same time sustained by Dr. Duncan, from an examination of the Madreporaria; his conclusion having been arrived at, as he says, "*quite irrespectively of* Mr. Tawney's *researches*, and it is strengthened by them." These views of Dr. Duncan's appear afterwards to have undergone some modification, as in a paper read by him before the Geological Society of London six months later, viz., in November, 1866, he states the object of the communication to be "to introduce to Palæontologists a new British Coral fauna, from deposits of *Liassic age*," previously referred to as including the beds at Sutton, Southerndown, Brocastle, Ewenny, Langan, Laleston, Cowbridge, and Shepton Mallet, which beds he proposes to correlate with each other and with the Infra-Lias of Normandy. He proposes to follow certain continental authorities in separating the zone of *A. angulatus*, under the name of Infra-Lias, from the *Lias proper*, to which he assigns as a boundary the zone of *A. Bucklandi*. The Rhætic or St. Cassian theory adopted by Dr. DUNCAN in his previous paper appears to be abandoned, and the continental Infra-Lias substituted in its stead. After a lapse of a few months, viz., in March, 1867, a paper by HENRY W. BRISTOW, F.R.S., of the Geological Survey of Great Britain, on "The Lower Lias, or Lias Conglomerate of a part of Glamorganshire," refers the beds at Sutton and Southerndown to the position all along claimed for them by Mr. MOORE, viz., that of true Lower Lias; a determination further corroborated by Mr. TATE's paper, read in May, 1867, on the "Zone of *Ammonites angulatus* in Great Britain." And now what is the position of Mr. MOORE in respect of priority in the matter under discussion? He has always consistently urged the true character of these beds, now admitted on all hands to be of Liassic age. So far back as 1865, an abstract of his views was published in the Proceedings of the Bath Field Club, so that they really have precedence over those of TAWNEY's and DUNCAN's St. Cassian theory, which did not appear until May, 1866. In March, 1867, Mr. MOORE's paper on the "Age of the Sutton and Southerndown Series" was read before the Geological Society, though the publication of it was deferred for nine months, on account of its alleged length, while Mr. BRISTOW's paper, read at the same time, was published previously, as was that of Mr. TATE, read two months later. These two papers serve to confirm in every important particular the views of Mr. MOORE, which correlate the Sutton and Southerndown beds with the Lower Lias. Am I wrong, then, in claiming for our colleague priority in the advocacy of those views which, since 1865, he has publicly demonstrated, and which later investigations have found to be correct?

The following note by Mr. MOORE, at page 530, Quart. Journal, December, 1867, sets the matter in a clear light, and in his own words supplies a suggestive statement of facts, from which unbiassed readers will draw their own conclusions:—

"Immediately after the reading of Mr. TAWNEY'S paper, I communicated my views on the age of the Sutton and Southerndown Series to my Geological friends in London, and I then informed Mr. BRISTOW that they were of Liassic age. He has since surveyed them, and made sections for the Geological Survey. In a short paper, read with my own and published in the last number of the Society's Journal, I was pleased to find him in entire accordance with myself respecting their age. At this time Mr. TATE had an opportunity of inspecting the large collection I forwarded with the Sutton and Brocastle Corals to Dr. DUNCAN, his views then being that they belonged to the *Ammonites planorbis* series; and I informed him they belonged to still higher horizons. Since my paper was read, he has given one on the 'Fossiliferous Development of the *Ammonites angulatus* Zone,' in which there will be seen a repetition of many points in my paper, and a general agreement with its views."

I now take leave of this subject, believing that I have made good my case, and vindicated the claim of our colleague to priority over Messrs. TAWNEY, DUNCAN, BRISTOW, and TATE, in his published views on the Liassic conditions of the Sutton and Southerndown beds.

With these preliminary remarks, I will proceed to give a summary of the work done by the Club during the past season.

The Annual Meeting was held at the Spread Eagle Hotel, Gloucester, on Wednesday, 27th March, when the ordinary routine business was transacted, the accounts were audited and passed, and the officers for the ensuing year were elected, when you again did me the honour to choose me for your President, and we were fortunate in again securing the services of Dr. PAINE as Secretary.

After dinner, the President read his Annual Address; after which a discussion arose, upon the reading of a letter from Mr. CHARLES MOORE, respecting the age of the Sutton and Southerndown beds, when Dr. WRIGHT took strong objection to the term Infra-Lias, proposed to be applied to them by Dr.

Duncan, and Mr. Etheridge combatted Mr. Moore's view of the range of *Gryphœa incurva* at Brocastle and Southerndown, believing, after examining specimens, that they were not true *incurva*, which he held to be limited to the beds above, or those of *A. Bucklandi*. It will be observed that Mr. Moore's view has since been confirmed by Mr. Bristow, who, referring to the point, says:—

"Although exception will be made to the statement of the occurrence of *Gryphœa incurva* and *Ostrea liassica* in these beds, and that the fossils in question will be pronounced by some authorities whom I hold in great respect to be *Gryphœa irregularis* and *Ostrea irregularis*, it is nevertheless my belief that the *Gryphœa* of the beds in dispute, if not identical in form with *Gryphœa incurva*, is yet the representative, and only a variety, of that shell which occurs in such remarkable numbers in the Lias immediately above."

With respect to the term Infra-Lias, proposed by Dr. Duncan, Mr. Bristow rejects it as "both vague and misleading," and prefers the term Lias-Conglomerate, originally applied to the beds in question by Sir Henry De la Beche.

A paper was read by Professor Buckman, on "Roofing Tiles of Roman date," which had been discovered in the course of excavations at Bradford Abbas, Dorsetshire.

The following localities and dates were fixed for the Field Meetings of the season:—

Wednesday, 22nd May	Foss Bridge.
Tuesday, 18th June	Campden.
Wednesday, 17th July	Stanton.
Wednesday, 21st August	Bridgend.
Wednesday, 18th September	Stroud.

The First Field Meeting was held at Foss Bridge Inn, near Cirencester, with a view to the examination of the Roman Villa under Chedworth Woods, in the valley of the Colne, on the estate of the Earl of Eldon. This most interesting relic owes its discovery to the accidental examination of a rabbit's burrow; but its subsequent excavation and preservation in the splendid condition in which it is now exposed is due to the well-directed taste and liberality of the noble proprietor, who has spared no expense in the thorough prosecution of the work, which now presents one of the most remarkable examples of Roman occupation to be seen in this country.

Placed on a rising ground, overlooking the valley of the Colne, the appropriateness and beauty of the site at once commend it to the taste of the beholder—a sentiment which gives place to surprise when, on a nearer approach, the eye realises the extent and perfection of the existing remains, to which additional importance is given by the substantial buildings erected over them by Lord Eldon, to protect them from further decay or wanton destruction. Here every object which has been brought to light has been most carefully preserved. The original walls are still standing to the height of three or four feet. The chambers, the corridors, the baths, the offices, are all there as they existed 1400 years ago, with the very flights of stone steps worn by the feet of Romans and Britons, who, to judge by the marks of usage, must have trodden them for a very lengthened period. The tessellated pavements are in good preservation, and in the principal apartments exhibit much beauty of design. The bath establishment is very complete, and unusually extensive —indeed there appears to have been two sets of baths, one perhaps for the family, the other for the domestics. All, indeed, from its extent and completeness, points to occupation by a proprietor of rank and wealth. The offices, besides baths, bakeries, and other chambers of unknown appropriation, have one of a singular and possibly unique description, in which a floor of large tiles is supported upon stone props about two-and-a-half feet high, which was warmed by hot vapour supplied by flues underneath. Some antiquaries have suggested that the purpose of this apartment was for drying corn in wet seasons. It seems at least as probable that it was used for drying clothes, or as a *sudatorium* in connection with the bath establishment for the domestics. In an apartment placed at a somewhat higher level than the rest of the offices is an octagonal tank or reservoir, into which, the pipes having been restored, water again flows as of yore. Whether this chamber served for a laundry, as seems probable, or was appropriated to other purposes, as has been suggested, is a matter for consideration by antiquaries, of whom a large gathering was present from Bath, as well as from Gloucestershire. The Rev. S. Lysons and Mr. Niblett, of the

Cotteswold Club, have been at great pains in following, step by step, the excavations as they have proceeded, and have thus been enabled to bring their antiquarian knowledge to bear with good effect upon the discoveries which have rewarded the labours of the workmen. A vast quantity of most curious and interesting objects have thus been brought to light, and are carefully preserved within the buildings,—articles of domestic use, in glass, earthenware, and iron; monumental remains, tablets, altars, statuettes, relievos; a large mass of iron, apparently for manufacturing purposes, coins, &c.; and lastly, but not the least interesting amongst these, is the discovery, on the foundation-stone of the Villa, and in four other instances, of stones inscribed with the sacred monogram, the Greek "Chi" and "Rho" in combination, forming CHR, the first letters of the name of Christ, from which Mr. Lysons fairly infers that the original builder was a Christian. There are indications of a considerable settlement having been established at this spot, and one dating from a period far anterior to the Roman occupation. In the immediate neighbourhood of the Villa are the foundations of two temples, one round, the other square; the latter of considerable area, and, from the portions of its massive architrave still preserved, probably a building of architectural importance. These two sacred buildings point to a considerable body of worshippers. But looking to a time beyond these and their Roman devotees, two tumuli close by show that an earlier and ruder race had preceded the Romans at this locality. In one of these mounds, under a great heap of stones, was found a stone cist, containing a black fictile vessel, full of burnt bones. No metal was found with this interment, but a few flint chips, since unhappily lost.

Such is a brief sketch of this most remarkable discovery. Doubtless much remains yet to be discovered; but even in its existing aspect it presents to the mind of the intelligent enquirer a subject of strange and startling interest, carrying the beholder back far into the almost forgotten past, and giving again to the mind's eye, with a vividness and freshness most impressive, the every-day life of those old Romans to whom we owe so much of our language, our laws, and our civilization.

The party, about forty in number, dined at the Foss Bridge Inn.

After dinner, a paper was read by Mr. WITCHELL, of Stroud, on the "Denudation of the Cotteswolds," in which the writer, adopting the principles laid down by Col. GREENWOOD in his book on "Rain and Rivers," argued against the usually accepted theory of marine erosion, in favour of the slow but certain action of atmospheric agencies, as the adequate cause of the present conformation of the valleys and combs of the Cotteswolds. In support of this argument, he adduced a number of local facts bearing upon the points in question, and concluded, amid much applause, a well-arranged and very interesting paper upon an obscure subject, as yet but little understood or investigated, which promises, when thoroughly worked out, to throw much light upon the present conformation of the country, and the causes to which it is due.

Mr. WITCHELL's paper was to have been followed by one on a kindred subject—"The Watershed of the Thames," by Mr. BRAVENDER, of Cirencester. Time, however, not permitting, this paper was postponed to the next meeting of the Field Club.

The Second Meeting of the Club took place, by invitation from Sir MAXWELL STEELE GRAVES, Bart., at Mickleton Manor, near Campden.

Upon arriving at the Campden Station, on the Oxford and Wolverhampton Line, carriages were in waiting to convey the party to Campden, where they were met by the incumbent, the Rev. Canon KENNAWAY, under whose guidance they inspected the fine Church and the numerous objects of interest with which the place abounds. Foremost amongst these is the Church, with its noble tower. Within the edifice a fine brass attracts notice. This is of the best decorated character, and is commemorative of one William Grevel (or Greville) and his wife Mariona, who died respectively in 1401 and 1386. The inscription states that he was "*Quondam Civis London: et Flos Mercatorum Lanæ totius Anglie*" ("Formerly Citizen of London, and Flower of the Wool Merchants of all England.")

At the Vicarage were displayed some beautiful ancient church furniture and vestments, in a fine state of preservation:—An embroidered frontal for an altar, with the Assumption of the Virgin, of fourteenth century work; and a cope of red velvet, richly embroidered with stars and crowns, with *orfrois* of figures of saints, surmounted by canopies, dating from the fifteenth century.

From Campden the party proceeded to Norton, known as "Burnt Norton," where Lord Harrowby has a small country house, on a pleasant slope overlooking the vale of Evesham, and smothered in woods, amidst which are the shattered remains of an old "pleasaunce," all that now remains of a large mansion which, as tradition asserts, was burnt down by its possessor, a mad knight of the name of Keyte, who, Sardanapalus-like, consumed himself together with his abode.

From this point the party diverged to the Railway, near Mickleton tunnel, where they hunted the spoil-banks for fossils, not altogether without success, a tolerably perfect example having been obtained of a Crustacean (? *Eryon,*) with some detached portions of claws, together with *Cardium truncatum, Hemicardium cardioides, Arca elegans, Gervillia lævis, Crenatula ventricosa, Modiola scalprum, Ammonites capricornis, Belemnites, Fucoids,* &c.

Dinner was served at Mickleton Manor, to which about forty sat down.

After dinner, Mr. Bravender read his paper on "The Watershed of the Thames," which had been postponed from the previous meeting. Mr. Bravender's paper went to show that the surface-drainage of the watershed of the Thames, embracing an area of 270 square miles, would suffice, if guarded from loss by percolation through porous strata, over which a considerable portion of its area lies, to supply the City of London with water at the rate of thirty gallons per day to each individual, without diminishing to any appreciable extent the present water supply in the river. He shewed the enormous loss through percolation in the river Churn alone, by the fact that, whereas the volume of water between the Spring-head and Colesborne—a distance of less than three miles—had risen to 375 cubic feet a minute, running over a Clay bed, at

Cirencester, five miles further, over the porous beds of the Inferior Oolite, the volume had diminished to 45 cubic feet per minute,—a very surprising and instructive fact.

Mr. LUCY read some notes by Mr. JOHN JONES, in illustration of a careful diagram of the well-known Drybrook Section in the Forest of Dean, comprising 104 yards, in 154 divisions, of the passage beds between the Old Red and the Carboniferous Limestone. This section, drawn to scale, has since been published in our Club Transactions, in which it forms an important feature.

The reading of this paper was followed by a discussion on Mr. WITCHELL's paper, read at the last meeting of the Club, on "The Denudation of the Cotteswolds." Mr. WITCHELL maintained that the valley of the Severn has no denudation apart from that of the Cotteswolds—that the hollowing out of the valley of the Severn, no less than that of the valleys of the Cotteswolds, is alike due to rain, rivers, and atmospheric forces. This theory he supported by a series of well-observed facts, drawn from the Cotteswold valleys, in which he urged the absence of all *marine* evidence in the gravels and drifts, and argued for their fluviatile or atmospheric origin, from the presence in abundance in such situations of land and freshwater shells. He regarded the gradual denudation of the Fullers Earth as the effective cause of all the phenomena of denudation observable in the Cotteswold combes. Dr. WRIGHT agreed with Mr. WITCHELL in many of the points laid down by him, and was disposed to concede great powers of denudation to the effects of atmospheric agency; but he thought Mr. WITCHELL in error in extending the effects of such agency too widely. It must not be forgotten that the Cotteswold Hills have been under the sea, and are made up of materials of unequal density—that the valleys are probably due to cracks or lines of fissure, along which the eroding forces have worked and sawed their way, while springs have further modified the valleys thus scooped out. But after all allowances have been made for these and other such agencies, it is not possible to look upon such outliers as Bredon, Robin's Wood, and Churchdown hills, without the conviction that other forces have been at work in producing that gigantic denudation, and that those forces were marine.

The hospitality extended to the Club on this occasion by Sir Maxwell and Lady Steele Graves was highly appreciated, and elicited the warm thanks of all the members present.

The Third Field Meeting took place at Stanton Court, near Broadway, by invitation from T. W. Wynniatt, Esq. The rendezvous was at Hayles Abbey, the ruins of which, consisting of a few broken arches, is all that now remains of a vast monastic establishment founded by Richard Earl of Cornwall and King of the Romans, second son of King John, in 1251. So late as the last century, according to Rudder, the cloisters and the Abbot's house were still standing; but the ruthless hand of modern spoliation has removed what time and former depredators had spared, and the pick of the explorer now with difficulty traces the foundations of buildings which have so entirely disappeared that a trench, carried from east to west across the site of the Conventual Church, failed to reveal the slightest vestige of it. Some notes on the Abbey were read by Mr. Pruen, the clergyman of Didbrook, who likewise exhibited some engravings of the ruins in the last century, the position of which could with difficulty be correlated with the existing remains.

At Hayles the party separated, some taking the direction of the Church at Didbrook and Lord Wemyss's fine old residence at Stanway, while the remainder mounted the hill, through Hayles Wood, to the encampment on the summit. By the way, a quarry, in the Middle Lias, yielded an abundant supply of fossils. At Farmcote they were drawn aside to see a small but interesting Chapel, having a Norman belfry and a font of Early English workmanship. The original altar-slab, with its five crosses, was here noticed occupying a place in the stone floor of the chancel. The encampment above Hayles Wood occupies a commanding position on the edge of the escarpment of the Cotteswolds. It is small, probably enclosing less than two acres. The prospect from this point over the broad vales of Evesham and Worcester is singularly extensive, and viewed as it was under most favourable conditions of light, shade, and colour, it presented to the eye a rare scene of beauty and enjoyment.

From hence the party directed their course to the "Jackdaw" Quarry, on Stanway Hill, a splendid development of the Freestones of the Inferior Oolite, 60 feet thick. These beds are wholly unfossiliferous, but a quarry about 50 feet higher yielded a good list of fossils, including *Gryphæa sublobata, Trigonia striata* and *costata, Pholodomya Heraulti, Ceromya bajociana, Lucina bellona,* &c. At the base of this quarry there is a remarkable band of black Shale, about two feet thick, full of *Lucina bellona.* May not this be the equivalent of the Oolite Marl?

From hence a delightful walk of about two miles, through a beautiful wood, in which the botanists of the party gathered *Campanula patula, Paris quadrifolia,* and *Epilobium angustifolium,* brought them out on the summit of the hill above Stanton, from whence a rapid descent led them to the residence of their kind host, Mr. WYNNIATT, who had made hospitable preparations for their reception and entertainment.

After dinner, a short note was read from Mr. JOHN JONES, drawing attention to certain beds at Portskewet, of supposed Permian date, and to others at Newnham, containing fossil remains of fish.

The Fourth Field Meeting was held at Bridgend, on Wednesday, 21st August, with the view, as set forth in the programme of the day, of examining the beds at Sutton, Southerndown, and Dunraven, the Brocastle and Ewenny beds of the Lower Lias, and the relation of the latter formation to the Carboniferous Limestone.

The programme thus laid down was too extensive for one day's work; some of the members, therefore, including the President, Messrs. MOORE and ETHERIDGE, and the Rev. W. S. SYMONDS, proceeded to Bridgend on the previous day, and from thence, under the guidance of Mr. C. MOORE, visited the sections at Ewenny, Brocastle, and Langan, at all of which the Southerndown beds were observed *in situ,* and their position with reference to the Carboniferous Limestone was noted. At the now disused lead mine of Langan, portions of the White Sutton Stone were obtained, associated with Galena (Sulphide of Lead) in great abundance. The Brocastle section, of small extent, is chiefly notable as the locality from whence Mr. Moore obtained most of his Lias Corals, since described by Dr. Duncan. These beds everywhere were seen to partake of the Conglomeratic character, which is one of their marked peculiarities.

On Wednesday (21st) the same party, joined by Dr. Bird, proceeded to the coast *viâ* Ogmore, at which point they were joined by Dr. Wright, the Secretary, and the remainder of the Club-contingent; and the Coast section, from thence by Sutton, Southerndown, and Dunraven, to Truyn-y-witch, was thoroughly and critically examined.

The conclusions arrived at may be briefly summed up as follows:—The Grey beds forming the so-called Southerndown series immediately underlie the *Bucklandi* beds, and are themselves an abnormal development of the zone of *Ammonites angulatus*, which fossil is found throughout of all sizes, from that of a crown-piece to that of a small cart wheel. At the base of these beds, immediately above the White Sutton Stone, was found *A. Johnstoni*, the ribbed representative of *Ammonites planorbis*, and probably marking the same horizon. The White Sutton beds were considered by the majority of those present to represent the White Lias, though Mr. Moore insisted strongly on their true Liassic character, and was certain he had taken *A. angulatus, in situ*, out of these beds; but the most searching investigation failed upon the present occasion to establish that point.

I have already referred at some length to the conclusions arrived at by Messrs. Bristow and Tate, which fully confirm Mr. Moore's previous views concerning the age and relations of these beds; but I note that in a paper read by Mr. W. Stoddart before the Geological Society of London, in January of the present year—"Notes on the Lower Lias of Bristol"—he recognizes the Sutton beds in the Cotham Quarry, near Bristol, as situated *above* the *Ammonites Johnstoni* beds and the White

Lias. At the same time and place a paper was read by C. O. Groom-Napier, Esq., "On the Lower Lias Beds occurring at Cotham, Bedminster, and Keynsham, near Bristol," in which the writer arrived at the conclusion that the Sutton Stone is a Liassic bed, and belongs to the *Planorbis zone;* and that the Planorbis zone and the Sutton series are subdivisions of the White Lias.

After a most acceptable and sumptuous repast, provided by the Dowager Countess of Dunraven at Dunraven Castle, the party, accompanied by the ladies staying in the house, proceeded to the cliffs east of the summer-house, and thence round the Truyn-y-witch point, where the corresponding beds to those examined in the morning were again visited.

This was in all respects a most satisfactory day. More than ordinary interest was felt by members of the Club, in consequence of the diverse views taken by Geologists respecting the age and position of the beds visited; and at the conclusion of their day's labour, they felt how much additional knowledge they had derived from the excursion.

The members present dined at the Wyndham Arms, Bridgend.

After dinner, Mr. Lucy exhibited some fine horns of *Bos longifrons* and deer's antlers, together with part of a cinerary urn and amphora, found in excavating the foundations for the tower of the Roman Catholic Church at Gloucester.

A fine and remarkable Crustacean, found by Mr. G. F. Playne at the recent visit of the Club to Mickleton tunnel, was exhibited by that gentleman. It belonged apparently to the genus *Eryon*, and will probably be figured.

The Fifth and last Meeting of the Club for the season took place at Stroud, on Wednesday, 18th September. Your President, having been prevented from joining the Club in time to accompany them in their rambles a-field, is indebted to the Secretary for details of the day's proceedings.

Those members who arrived by early trains were conveyed along the valley in a waggonette. At a distance of two or three miles they alighted, and proceeded up the hill under the guidance of Mr. Witchell. After walking a few minutes, an excellent opportunity was afforded for examining some Freestone beds of the Inferior Oolite, which are inclined at a high angle towards the valley. A continuation of the walk brought the party to the Quarhouse, where a fine section of the Great Oolite is exposed. These quarries are situated on the very summit of the hill, and most of the beds are fossiliferous. One important feature in these beds is the different angles at which the strata are inclined. The high dip of the beds on the side of the hill was considered by Mr. Witchell to be due to slips, occasioned by the action of water upon the underlying beds of Clay during the general scooping out of the valley; to which cause, likewise, he attributed the high pitch of the beds at Quarhouse,—an opinion combatted by others of the party, who saw in the phenomenon symptoms rather of elevation than of subsidence. At Lypiatt the party visited an interesting old manor-house—now a farm, in a neglected condition—formerly the residence of Judge Coxe, whose family resided here during the last century and were people of position, some of whom represented the borough of Cirencester in Parliament. At Bussage the White Limestone beds of the Great Oolite were examined, which contain a peculiar fossil—*Pachyrisma grande*, Mor. and Lyc.

Bussage Church was visited by many of the members, who were courteously received by the Rev. E. Duncan; after which a halt took place on Mr. Sibree's lawn, preparatory to an excellent luncheon which had been considerately provided for the occasion.

The White Stone of Bussage was next examined, the fossiliferous character of which is such that a stone taken at random out of a wall by Mr. Witchell, measuring 20 in. by 9 in., yielded the following list of fossils:—

Crassostoma discoideum, Mor. and Lyc.
Patella cingulata, Goldfuss.
Monodonta imbricata, Mor. and Lyc.
——— *Lyellii*, D'Archiac.
Nerinœa Dufresnoyii, D'Archiac.
Astarte excentrica, Mor. and Lyc.
Quenstedtia lævigata, Phill.

Pecten arcuatus, Sow.
Gervillia bathonica, Mor. and Lyc.
——— *ovata*, Sow.
Arca minuta, Sow.
—— *æmula* v. *transversa*, Mor. and Lyc.
—— *rudis*, Sow.
Limopsis ooliticus, D'Archiac.
Corbula Buckmanni, Lyc.
Terebratula intermedia.
Ostrea.
Cidaris (plates.)

A walk across the valley, under the guidance of J. E. Dorrington, Esq., brought the party to Lypiatt, an ancient manor-house which, after passing through the hands of many proprietors, was purchased by the present possessor from the late Samuel Baker, father of the now celebrated traveller and Nile-explorer, Sir Samuel White Baker.

From Lypiatt the Geologists of the party proceeded to Swift's Hill, where they examined the well-known section of the Inferior Oolite at the quarries there, and a new section of the Cephalopoda beds at the foot of the hill.

The party dined at Stroud, at the Imperial Hotel.

After dinner, Mr. Witchell exhibited some fine specimens of lobster-like Crustaceans, found by him in the Middle Lias at the Stroud Gas Works.

The President read a paper by Mr. Etheridge, describing the section at Portskewet referred to by Mr. John Jones in a letter read at the Stanton meeting of the Club. In that letter the writer referred to the possibility that the beds in question might prove to be Permian, a view which he was not alone in holding. It had therefore become an interesting point for investigation, and with that object your President and Mr. Etheridge had visited the locality; and the paper by Mr. Etheridge showed most conclusively that the supposed Permian fossils belonged to the Carboniferous Limestone, and that no beds of Permian age were to be found at the spot indicated.

A paper was read by J. H. Taunton, Esq., on "The Watershed of the Upper Thames, in connection with the Water-supply of the Metropolis." Mr. Taunton was of opinion that the rain waters of the Cotteswolds, though now lost in large quantities, might nevertheless, if proper means were adopted, suffice, in connection with the existing supply, for all the wants and purposes of the Metropolis. He also believed that the steps now being taken for preventing the pollution of the river will, when ultimately carried out, do away with the necessity of constructing an aqueduct or any other artificial means for conveying water; and that the supply afforded by the river, unpolluted, will meet all the requirements of those who live on its banks.

With this meeting, which was in all respects a most agreeable one, terminated the field-gatherings of the Club for the season—a season which has been surpassed by none of its forerunners in any of the elements which go to make such Associations as ours useful and successful. Long may such Associations flourish. Their origin dates but from yesterday—the oldest of our Field Clubs has not yet seen a quarter of a century of life—yet in that short time it is impossible to overrate the good they have effected, their importance as a means of education, and last, though not least, their value as a means of bringing together in social and genial fellowship those united in a common love of Nature and Nature's works, who may yet, but for the happy medium afforded by our gatherings, lack means of intercommunication; while amongst others for whom a pleasant ramble has its attractions, a taste is diffused for scientific study, which may one day bear fruit in valuable contributions to the general stock of knowledge, and will certainly amply reward the individual by the increase of bodily health and of intellectual pleasure which he will experience in the pursuit.

On the Denudation of the Cotteswolds, by E. WITCHELL, F.G.S. *Read at Foss Bridge, May 22nd,* 1867.

THE process by which the denudation of a tract of country is effected, can scarcely be studied under more favourable conditions than those which prevail in the Cotteswolds. The high levels at which the rainfall is thrown out in springs—the large number of rivulets which run down the slopes, and which uniting in the valleys become streams of considerable importance —the varying character of the rocks, and their liability to disintegration, are conditions which render the district peculiarly liable to the action of denuding forces. As a necessary consequence, the deep valleys, with their sinuous branches everywhere intersected by those picturesque hollows or "combes," by which the scenery is so charmingly diversified, bear testimony to the action of these forces during a long period of time.

Although we are accustomed to consider the subject of denudation from its results, over large, rather than limited areas, it may be advantageously investigated in the smaller valleys or combes, where, instead of large rivers, we have to regard only the erosive action of brooks and rivulets. In these limited areas the eye can measure the extent of the changes which have been effected in the course of ages, and in many instances can observe the process of denudation still in progress; it may, therefore, be less difficult here than in a wider range of country, to form a correct opinion as to the sufficiency of existing causes to produce the results presented to the view. At the same time it must not be forgotten, that although the formation of a combe is on a limited scale of operations, the forces by which it has been effected are everywhere in a state of activity; and while a spring issuing from a combe is not apparently a very powerful agent by which the face of the country can be altered, the largest rivers are only an aggregation of such springs, with the addition of surface drainage.

It has been frequently held by Geologists whose opinions are entitled to great consideration, that the valleys of the Cotteswolds were in earlier ages subject to marine influences, and that they were, to a great extent, excavated either by the sea, as the land first appeared, or by tidal rivers.* If I could find any evidence at all in support of those opinions, I should not presume to question them; but this I have been unable to do. No doubt, as the land was rising, the action of the waves would tend to degrade the strata exposed to their force, the softer portions of which would be swept away; the *débris* of the harder rocks would be rolled into boulders, or ground into sand, and deposited in beds of drift and shingle. In course of time the ground would probably acquire an undulating character, and the surface drainage would follow the course of the undulations, and so begin to form valleys; but the wash of the sea would have a tendency to wear away all the inequalities of the surface, instead of cutting deep channels, and would, therefore, as regards the formation of valleys, be antagonistic to the action of running streams rather than conducive to similar results. It is by no means improbable, that prior to the upheaval of the Cotteswolds, the Middle and Upper Oolites extended much farther westward than at the present time, and that they were swept away by marine denudation; of course it is impossible to state where was the limit of these formations.

In considering the denudation of the Cotteswolds on the side of the Severn Valley, we have before us the long escarpment extending down the whole range, and presenting such striking indications of a coast-line, that the existence of an arm of the sea between the Bristol Channel and the ancient glacial sea,

* Geol. of Cheltenham. Memoirs of Geol. Survey, &c., &c.

which covered the north and middle of England, might easily be assumed. It has, however, occurred to me as singular, that the marine drifts are found only in the northern parts of the Cotteswolds and the Severn Valley; and as there is no evidence to show that the Cotteswolds were submerged during the glacial period, and particularly as the valley has been since denuded to a considerable extent, I am disposed to suggest the existence of an estuary, rather than a strait, between the Cotteswolds and the Malverns, the estuary, of course, opening northwards, the marine drifts being the remains of its beaches. It would, however, be difficult to observe upon the denudation of the Severn Valley without considering the origin of the drifts scattered over its surface; and in so doing, I should be trespassing upon ground already occupied by one of our most esteemed colleagues, who is devoting much time and attention to the subject. I shall only, therefore, allude to them incidentally, and where it is absolutely necessary to do so.

The escarpment of the Cotteswolds doubtless existed prior to the submergence of the country northwards, though not perhaps in its present form. The drainage of the Welsh hills and the Midland Counties was at that time in the direction of the Bristol Channel: there must therefore have been a river valley between the Cotteswolds on the one side, and the Malverns and the hills of the Dean Forest on the other, and its south-eastern boundary, considering the direction of the dip of the Lias and Oolites, would be a line of cliffs. Who can prescribe the limits of this ancient river valley, or tell us how much of the present Vale of Gloucester it occupied in those bygone ages? Can we restrict the channel of that ancient Severn to the course which it now follows, or say that it never approached the present escarpment of the Cotteswolds? Is it not possible that the Marlstone at one period, and the Lias Limestones at another, might have given an inclination to the river in the direction of the dip of these beds, and consequently of the escarpment, while the overlying Marls and Supra-Liassic Sands could have offered but little resistance to its erosive power? In this view of the subject I think if, without careful consideration, we adopt the theory that the Valley of the Severn and the escarpment of the Cotteswolds were necessarily formed by the sea, however much the escarpment may resemble a coast-line, we may be ultimately landed in a difficulty which may compel a re-consideration of the subject.

Whatever may have been the conditions under which the denudation of the Valley of the Severn took place prior to the emergence of the land at the close of the glacial epoch, and the resumption by the Severn of its ancient functions, there remains a large amount of denudation which can only be referred to sub-ærial influences, whether by rain, frost, springs, or rivers. To support this opinion it is necessary to refer to the changes which have occurred since the river began to excavate its present channel, and during the period in which marine action has been confined within the same boundary. If we take the height of the cliffs on the banks of the Severn, and assume, as I think we fairly may, that at some former period the river bed was as high as the top of the cliffs, or nearly so, and that even then the river ran in the lowest part of the valley, we can, by noting the present general level of the surface, and comparing it with the present height of the cliffs, form some idea of the extent of denudation from atmospheric causes. At Fretherne the river has cut a channel some 40 feet deep, reckoning from low water mark, but the general level of the country below Fretherne is nothing like 40 feet above the river. The land has therefore been denuded at a rate almost as rapid as the Channel has been excavated, because it being at the present day low-lying land, it could not have been relatively lower at the time the excavation commenced. The same observations will apply to most of the cliffs forming the banks of the Severn. If the bed of the river were now raised a few feet, its course would be in many places altogether diverted; collateral denudation is, therefore, in my opinion, clearly established.

In the valleys of the Cotteswolds, there is abundant evidence of denudation, but so far as research has hitherto extended, it appears to be sub-ærial in its character, facilitated and increased by landslips. I am aware that this opinion does not generally obtain, and that the subject is very complicated and difficult to unravel. This is not surprising, considering the great changes which have taken place in the surrounding country since the Cotteswolds first became dry land. It is, however, a subject well worthy our consideration; and in elucidating the truth, we add an interesting chapter to the records of geological science.

I need not, of course, offer to Cotteswold Naturalists any description of the physical character of the district, further than is necessary to illustrate the line of argument which I propose to take in connection with the subject of denudation. I may, however, refer to the geological map, and briefly to note some few particulars. (1.) It is seen that the south-eastern slopes of the upper Cotteswolds are drained into the Thames, those of the lower Cotteswolds into the Avon, while on the north-western side the whole drainage is into the Severn. (2.) The number of streams which are raised to the dignity of rivers, considering the extent of the district, is large; still more striking is the multitude of streamlets which make up the volume of the rivers. The principal streams are the Evenlode, Windrush, Leach, Coln, Churn, and Swill-brook, all tributaries to the Thames; the lower Avon, which has its separate drainage area, and the Chelt, Isborne, Frome, and Cam, with several brooks of considerable volume, which fall into the Severn. (3.) The sources of the rivers are generally near the centre of the range, and though the head-spring is frequently insignificant, the surface drainage of the Lias, the Fullers Earth, the Forest Marble, and Oxford Clay, is considerable, and large quantities of storm waters are thus carried off into the Thames, Severn, and Avon. (4) The sources of the rivers are either in the Lias or Fullers Earth, but as respects those which flow westwards, their valleys have been excavated through the escarpment of the Cotteswolds, although the escarpment must once have been at a greater altitude than the strata on which the rivers have their source.

From these conditions it is only reasonable to suppose that the country would be very much intersected by deep valleys, the character and extent of which would be influenced by the volume of the rivers, their velocity, and the nature of the strata through which their channels were excavated.

It has, however, been held by Geologists, that the action of tides operating along lines of fracture would be essential to the formation of the valleys of the Cotteswolds; and it is an admitted fact, that lines of fracture are found in many valleys: but before this theory can be accepted, the existence of the necessary conditions, which would admit of the operation of tides in lines of fracture, must be shown with reasonable certainty. (1.) The land must have been at a level sufficiently low to admit of being reached by tides. (2). The fractures must have opened into fissures of sufficient width to admit of a large volume of water into them, and of sufficient length to account for the excavation of long valleys as they exist at the present time.

(1) As respects the first condition: I have already remarked upon the action of the sea during the upheaval of land. It must be assumed that there is no evidence to prove that the Cotteswolds were submerged during the glacial epoch, except perhaps their northern extremity; and as the outlets of the valleys are from one to two hundred feet above the sea, it could only have been during the course of upheaval,—if at all,—that the land was subject to marine influence; but from the circumstance of our not being able to find any existing traces of such influence, either in the valleys or on the hills, it becomes difficult to establish the fact of its operation. Surely there should be some remains of ancient beaches at the heads of the valleys; some beds of Shingle; or some fissures in the Oolitic rocks full of sand: but we search in vain for any trace of such evidence. True we have drifts everywhere on the flanks of the Cotteswolds, which following the course of the rivers and brooks extend to the Severn, and sometimes they are found far up the valleys—as, for instance, at Nailsworth. It might be suggested that these drifts testify to the flow of tidal rivers by which they were deposited; but, unfortunately for the suggestion, they are found to contain land and freshwater shells in abundance, but no trace of marine or estuarine shells, leading therefore to the inference that they are not of marine or estuarine origin.

(2.) With regard to the action of tides in fissures: This theory depends upon the question, whether there ever were any considerable fissures in existence in the Cotteswolds adapted to the admission of tides. I think not. The action of the sea as the land rose would scarcely admit of such a state of things. If the fractures had opened to any extent, they would be filled with the detritus of the denuded strata, as the waves rolled over the surface and ground the soft Oolite into sand. Again: if during upheaval the tides acted in fissures, the upper parts of the valleys, instead of being, as we find them, mere undulations of the surface, would be wide and deep, and every valley should commence in a ravine, and not as a gentle slope.

In opposition to the theory of fissures, I may throw out the suggestion, that those fractures of which we have evidence may be attributable, not to the dislocations produced in the course of upheaval, but to the strain upon the surface in consequence of the subsidence of the adjacent land during the glacial epoch; certainly the numerous faults in the Cotteswolds, as traced on the map, generally run from East to West, and this is consistent with the idea of their having been caused by the great subsidence of the country northwards. Of course this hypothesis militates against that of tidal action in the valleys; because if the Cotteswolds were high above the sea during the period of submergence, the fissures, if formed as suggested, would be beyond the reach of tides. If it is contended that the valleys were formed by marine agency, some direct and positive evidence should be adduced in support of that view of the subject.

Considering that the evidence of marine action is in the highest degree unsatisfactory, I am inclined to the opinion that the formation of the valleys is the result of sub-ærial denudation, including springs and rivers, in combination with landslips, and to assign to the same agencies some portion of the denudation of the Valley of the Severn; and if, on investigation, it is found that these causes are sufficient to account for the changes which have taken place in the aspect of the country, it is fair to assert that the view of the subject which I have adopted, is at least as worthy of consideration as any hypothesis resting upon mere speculation.

In estimating the effect of rain, springs, and streams, upon the Cotteswolds, it is necessary to take into account not only the larger streams which act in the bottoms of the valleys, but also the streamlets which issue from the combes, and which, under ordinary observation, would almost escape notice; even the small springs, which flow only in wet seasons, and dry up in summer, play no unimportant part in the general denudation, as shewn in their tendency to promote landslips.

Between the combes of the Cotteswolds and the springs, there appears to be intimate connection; in fact, there is not a combe in the whole district in which there is not a spring issuing, either from the upper part of the slope, or lower down, according to the respective positions of the Fullers Earth, and the Upper Lias, by which the waters are thrown off. In the one instance the combe has a stream running down its bed, which is constantly working deeper into the hill-side; in the other the upper part of the combe is a dry valley. Wherever the spring rises in the Fullers Earth, there is the head of the combe. If the springs are numerous and distant, the combe is enlarged into an amphitheatre—of this many examples may be readily cited; sometimes the combe bifurcates, and we then find a spring in each branch. In fact, whatever may be the number of branches, we may safely predict there will be found as many springs running out of them. It may be suggested that the excavations of the combes by the sea, or tides, would cause the opening of springs, but if the combes were so formed we should expect to find, in some of them at least, no trace of springs at all, as it cannot be supposed that the sea would excavate a combe only in those places where subterranean springs abounded.

This intimate connection of springs with the combes renders it difficult to account for the one, except through the instrumentality of the other; but if we consider the action of springs in causing slips, (and it is, I think, to slips that the widening of the valleys is, to a considerable extent, to be attributed,) this instrumentality becomes the more apparent. Slips arise from two causes, each independent of the other, but both arising from the physical conformation of the district, namely:—1st, those which are caused by the erosive action of the streams running in the bottoms of the valleys, which lead to dislocations of the beds above, and the tumbling of masses of rock from their proper position, and sometimes to a general subsidence of the side of the hill: and 2nd, those which are induced through the slippery state of those beds, from which the springs are thrown out, but in each case the result is the same; large masses slowly and at intervals move down the slopes, and as they reach the base are in course of time eroded by the streams: thus a widening of the valleys is constantly going on. This process is, probably, to some extent, retarded in the present day by the artificial uses to which the streams are applied. Instead of being, as they once were, small rivers of rapid flow, and great erosive power, they now form a succession of levels. This remark applies as well to the manufacturing districts, where every mill-owner raises his weir as high as can be without interfering with his neighbour above, as to those districts where mills do not abound, but where the streams are dammed back to form ornamental ponds. If these impediments were removed there is little doubt the deepening and widening of the valleys would be again accelerated.

This opinion is confirmed by what has occurred in recent times in various localities in the Cotteswolds; the well-known slip at Hewlett's Hill, near Cheltenham, may be mentioned as an instance in point; so also a slip near Nailsworth during the past winter. In the latter instance a large mass of Fullers Earth had formerly moved down the slope until its base rested upon the bottom of the valley, which, for a time, arrested its progress. In making the Nailsworth Railway, the lower part of the slip was cut through. In consequence, the movement of the upper part re-commenced—a large house built upon it parted into two—some cottages were tumbled about, and other damage done, and the railway engineers are now busily engaged in devising means to prevent the slipping of the whole mass on to the Railway.* But these are not solitary instances. During the past winter two slips have taken place within the distance of a mile, on the north side of the valley of the Frome, above Stroud; one was an old slip, which appears to have moved at intervals for several years. In that instance also, a mass of Fullers Earth is passing downwards into the bottom of the valley, and at the time of writing these notes it is moving at the rate of nearly half-an-inch per day. Its progress is registered in this manner:—a tree formerly grew at the edge of the slip, and it took root partly in the firm soil, and partly in that which had slipped, but which had, apparently, for a time, ceased to move. Eventually the slipping was resumed, and the tree was, in consequence, split into two parts, the root of the portion which is in the firm ground now makes a groove along the side of the moving clay, and by marking the clay close to the root, the progress of the slip from day to day can be accurately measured.

Slips from the Fullers Earth are so numerous that it is scarcely possible to find a combe or hollow on a slope, capped by that formation and the Great Oolite, in which there are not one or more slips. Sometimes they are stationary, but frequently in winter, after heavy rains and severe frost, they move a little forward, until, in course of time, the masses reach the bottom of the valleys, where they are eroded by the streams. A good illustration occurs in the Shortwood Valley, above Nailsworth, where, in 1845, an old slip, some 25 to 30 yards wide, and of considerable length, moved downwards, until its lower part filled the bed of the stream, and so dammed it as to form a small pond. Since this date the stream has been clearing out its channel, and, as the work proceeds, smaller slips from the old one periodically take place, so that the process repeats itself in detail. In short, wherever the Fullers Earth is still in position on the escarpments, a great portion of the slopes are at intervals in a state of movement.

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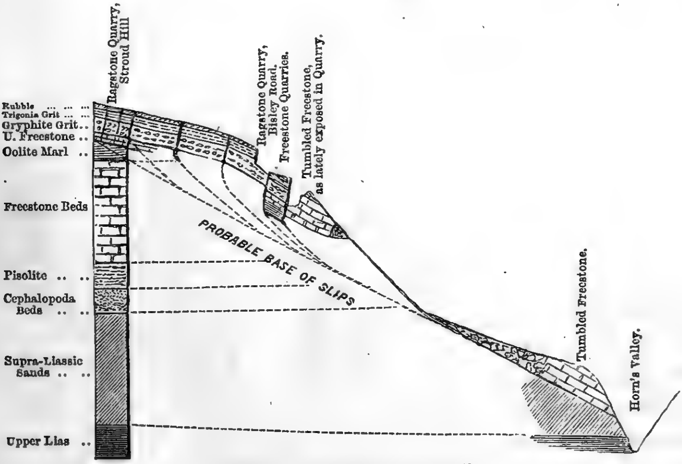
* See notes in postcript, in which more detailed information respecting this slip is given by Mr. G. F. Playne who has been observing it from the time when its recent movement commenced.

The effect of the action of the streams running along the base of the hills is everywhere seen in the tumbled condition of the Inferior Oolite, large masses of which are found at every conceivable height upon the slopes. It is by no means uncommon to see a quarry of Freestone upon the Sands or the the Upper Lias. The subjoined section (No. 1) is intended to illustrate this condition of things. It is taken from the south side of Stroud Hill, and the faults shewn upon it are visible upon the surface of the ground. Slips of this description arise from the deepening of the valleys as before mentioned. The formation of combes is sometimes facilitated by the increased erosion at the base, consequent upon the influx of a tributary stream from a branch valley, by which the main stream is impelled against the slope on the opposite side.



Section 1.—South side of Stroud Hill.

But while the valleys have been deepened by running water and branches or combes have been excavated in the hill sides by springs and rivulets, they have been widened by the action of rain and frost, in addition to land slips.

Denudation by rain can only be appreciated by observing its effect upon the surface in favourable localities. Thus the slopes which are exposed to the south or south-west are more denuded, and much less precipitous than those on the opposite sides of the valleys. I attribute this difference to the washing of rain, which, on the one side, falls with full force upon the slope, while the opposite side is comparatively protected.*

Again, it may be observed, that on the edge of a wood on sloping ground, there is usually a considerable drop from the surface of the woodland to the cleared ground. This is caused by rainfall, and by the water dropping from the overhanging branches. If the wood were to be cleared and converted into tillage land, its ancient boundary would be marked by a terrace which might well be mistaken for an ancient water line.†

Another cause of denudation by rainfall is the carrying away of earthy matter from springs. An analysis of the spring waters from the Fullers Earth gives 28 grains per gallon, and that of the Upper Lias 20 grains per gallon, being an average of 24 grains; 290 gallons would give a pound, and 650,000 gallons a ton; taking the amount of rainfall annually thrown out in springs at 9 inches, would give upwards of 200 tons per square mile, which will roughly represent the same number of cubic yards. Multiply this quantity by the area of the Cotteswolds, and we may form some idea of the prodigious quantity of solid matter abstracted every year in an invisible form in *apparently clear water*. Then we must allow at least as large a quantity of earthy matter to be carried off by storm waters, making a total of 400 yards per mile. At this rate of denudation, in about half the period assigned by Sir Charles Lyell for the subsidence and subsequent upheaval during the glacial epoch, soil would be removed equal to the area of a valley 600 feet wide, and of equal depth in the centre throughout the whole mile of ground from which the above quantities are taken.

It is scarcely necessary to refer to the effects of frost upon the soft Oolite. It is well known what an important agent it is in widening valleys. The Freestone and Oolite Marl beds

* See observations on Denudation by Rainfall in "Rain and Rivers," by Colonel Greenwood, which are peculiarly applicable to the Cotteswold District.

† Vide "Rain and Rivers."

are quite incapable of resisting its action, and a cliff formed of these beds would, under its influence, in a few years become a mere slope, covered with Oolitic detritus; thus the frost, in a certain sense, commences the process, which is subsequently completed by rain. No doubt when a colder climate prevailed in England, the action of frost, ice, and snow was much more effective in denuding the country than in recent times. The accumulation of snow in winter, and its melting in summer, would tend to give increased volume and an excavating force to the rivers, of which no idea can be formed from their present condition. So the accumulation of ice on the slopes, and its periodical removal, would tell with effect upon the soft materials of which the hills are composed.

If we take a general survey of one of the long valleys of the Cotteswolds, with its numerous branches and combes, it is difficult to resist the impression that atmospheric action, running water, and landslips, have together accomplished its formation. As we ascend the valley, we find the stream which runs through it becomes reduced in volume, the denudation is less, until at length the valley becomes a mere undulation of the surface, and finally it ceases to be discernible. But what do we then observe? Why within a few yards, perhaps within a few feet, the surface begins to slope in the opposite direction, and it gradually sinks into a valley, very similar to that we have just ascended; and this condition of things is applicable not only to the main valleys, but, in districts where the country is much intersected, to their branches and combes. I do not give instances, because they are so common as to form the rule rather than the exceptions. Thus the whole of the Cotteswold district is intersected by valleys, running either in the direction of the Severn on the one side, or the Thames and Avon on the other.

I have alluded to some of the combes of the Cotteswolds as dry valleys. They usually commence in undulations on the tops of the hills, form deep hollows in the slopes, and have springs issuing from them at the level of the Upper Lias. The circumstance of these combes being dry might at first appear to militate against the idea of their formation resulting from the action of springs and slips. There is not, however, any difficulty in explaining the seeming anomaly. Although the combes are now dry, such was not always their condition. The Fullers Earth, which now occupies an irregular position behind the escarpment of the Cotteswold range,—its distance backwards from the escarpment varying from a quarter of a mile at Birdlip to three miles at Minchinhampton, two miles at Painswick, fifty yards at the Brick-pits near Stanley Wood, and to about a hundred yards at Frocester Hill,—was once continuous over the whole district comprised in the area between its northern and southern limits; the water was then everywhere thrown off in springs from its surface; it ran down the slopes, and assisted in deepening the valleys, and excavating the combes. As the Fullers Earth, however, was gradually denuded, the springs proportionately diminished, until at last they disappeared entirely. In consequence, the rainfall, instead of being thrown off as before, now sinks into the Inferior Oolite, and where the valleys are sufficiently deep, is thrown out in new springs at the junction of the Sands with the Upper Lias; but from their more recent origin, these springs have not as yet formed deep channels. In some valleys the cessation of the flow of the springs over the escarpments of the Inferior Oolite is quite recent. An instance of the kind occurs on the south-west side of Swift's Hill, near Stroud, where the springs, which flow from the Fullers Earth, and which apparently down to within a comparatively recent date ran over the escarpment of the Inferior Oolite, have, from the causes I have mentioned, ceased to do so, and the water now passes into the beds of the Inferior Oolite, is thrown out at the base of the Sands by the Upper Lias, and forms a new spring near the bottom of the hill. At the head of the combe a water-trough, which the spring once supplied, is still to be seen in its original position. Other instances are by no means rare in the line of the western edge of the Fullers Earth.

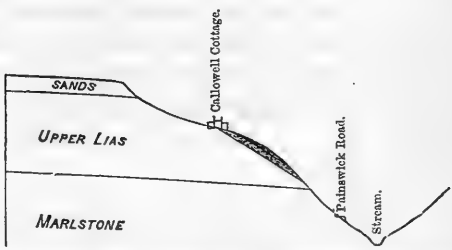
Dry valleys are sometimes formed by surface drainage alone, and the undulations upon the table land of the Cotteswolds may be referred to this cause; but where the slopes are formed on the Supra-Liassic Sands, the action of surface-water in forming combes in the soft material of which the Sands are composed is more strikingly manifest. As an illustration, I may refer to the gorge on the south-west side of Cam Down. Originally a cart track was made down the slope from the quarries on the summit, and where it passes over the Oolite it remains nearly level with the surface, but in the slope it has disappeared as a track, and has been turned into a ravine in the Sands, which at its lower end is thirty feet deep.*

The views which I have expressed in reference to the action of the streams, may, if adopted, possibly lead to the elucidation of another somewhat difficult question, which has from time to time attracted the attention of Geologists. I refer to the ancient Gravel beds on the upper part of the slopes of the Cotteswolds. The Gravels, as is well-known, are very little worn, sometimes not worn at all, and by way of distinguishing them from the drifts of the vale, we call them angular or sub-angular Gravels. Occasionally they are found regularly stratified, but this is not their general condition. Formerly they were called Sea-beaches; then their marine origin was disputed, and the term "so called Sea-beaches" was applied to them. Now they are regarded as the result of the disintegration of Oolitic rocks, by atmospheric influence. This view of their origin is reasonable, and probably correct, but it does not explain the cause of their being found only in certain localities. If we consider the result of disintegration alone, we ought to find these Gravels as *talu* at the base of the Freestones of the Inferior Oolite, and of the Great Oolite in all the valleys, but they are found at various elevations, ranging from 200 to 700 feet above the sea; sometimes they are deposited at the base of the rocks from which they were derived; sometimes as low as the Upper Lias. The beds are of varying thickness—the one at Hyde is 16 feet. I attribute these deposits to the streams which brought the Gravels down the valleys, and left them in positions in which

* The dry valleys of the Chalk formation may owe their origin to conditions analogous to those of the Cotteswolds. A stratum of Tertiary Clay spread over the chalk would inevitably lead to the formation of combes by means of the surface drainage. The denudation of the Clay would leave the combes dry.

they were either protected by the form of the ground, or allowed to accumulate in consequence of the velocity of the stream being reduced by obstructions in the Channel, or by its widening. The small fragments of which they are composed, the absence of large stones in them, and the partially rolled condition in which they are sometimes found, is consistent with the suggestion of their deposition by running water.

In the Painswick valley there are several of these deposits. The one on Painswick Hill has long attracted the attention of Geologists, and from its position at the base of the Freestone beds, there is not much difficulty in accounting for its origin; but a small deposit at the lower end of the valley, near Stratford House, is perhaps more suggestive on account of its position.



Section 2.—Showing Deposit of Angular Gravel in Painswick Valley, near Stroud.

(Section 2.) It is about 10 feet in thickness, and rests on the Upper Lias; the ridge above has been greatly denuded; the whole of the Inferior Oolite, and the Sands nearly down to the Upper Lias having been removed. It is scarcely possible that this deposit of Gravel could have taken place prior to the denudation of the higher ground, as the same agency by which this was effected, would at the same time have prevented the deposition of the Gravel; neither could it have taken place on a slope, as in that case it must have been derived from the beds above, and the same moving force which carried it down over the Sands and Upper Lias, would have deposited it *at the bottom* of the slope. I would, therefore, suggest that the deposit was formed by the stream which ran down the valley, the bed of which was, at that time, as high as the deposit now lies.

If such be the origin of these angular Gravels, it furnishes a conclusive argument in favour of sub-ærial denudation; because, if we consider that the deposits are found in all the valleys at various heights, ranging, as I have stated, from 200 to 700 feet, it is manifest that similar conditions prevailed during the whole period of their formation, and no such deposits could have taken place in valleys washed by tides.

Upon the whole, I think there is little or no evidence of marine action in the valleys, while their present condition is consistent with the theory of their formation by sub-ærial agencies.

P.S.—Since the foregoing paper was read, Mr. G. F. Playne has kindly favoured me with the following notes as matter of information in reference to landslips. They are confirmatory of the facts I have mentioned, and in the instance of the slip on the Nailsworth Railway, they furnish details of a very interesting nature. I have considered them well worthy of the consideration of the Club, and by the permission of Mr. Playne have given them as addenda.

"*Notes on Landslips near Nailsworth, by* G. F. Playne.

"Landslips are very numerous on the steep hill sides which bound the narrow valleys in the neighbourhood of Nailsworth, but perhaps nowhere more so than on the north-east side of the main valley just below the village. In order to give a clearer idea of their extent, and of the effects they have produced in the present configuration of the hill-sides and of the valley, it may be well to mention that the bottom of the valley has been furrowed out in the Upper Lias, and that the stream has at one time run at a lower level than it now does, as the valley, (which is here on an average scarcely a hundred yards wide,) is silted up with beds of gravel, peat, and alluvial soil, in some places to an aggregate thickness of eight or ten feet. The Lias rises on the hill side to a height of about 50 feet, succeeded by the Liassic Sands and Inferior Oolite; and at about 250 feet above the stream, by the Fullers Earth, which is capped by the Great Oolite beds forming the table-land on Minchinhampton Common. Within a mile of the village of Nailsworth this hill has eight hollows, (one of which is a deep combe,) formed in its sides. In most of these hollows *no traces remain expossd to view of the Lias, or its Sands, nor of the Inferior Oolite,* but they are now occupied by *slipped masses of Fullers Earth,* which has carried down portions of its rock bed charged with *Ostrea acuminata,* and also slabs of the basement beds of the Great Oolite. Between these hollows the hill side projects forward, and on three at least of such intervening slopes lie masses of *slipped* Inferior Oolite, which, wherever worked by means of surface quarries, is seen to be much tumbled about, the beds of the blocks lying at all angles. In one place Ragstone has been dug in considerable quantity at least 100 feet below its usual position.

"One mile below Nailsworth, and rather lower down than the junction of the Woodchester Park valley with the main valley, occurs the largest of the landslips. [This is the slip alluded to in the text.] It reaches from the Fullers Earth beds at Amberley Churchyard, 250 feet above the valley, down to the stream side at Dyehouse Mills. It consists of a mass of Fullers Earth, and occupies a hollow in the hill side, and at the base projects forward so as almost to touch the opposite hill slope;—it is probable that at its first descent it reached quite across the bottom of the valley, and dammed back the stream; and this has probably been one cause of the silting up of the valley bottom, (as before alluded to,) as far up as the village of Nailsworth. The stream would, however, after a time, cut its way through this clay *nearly* to its former level; but one effect of this obstruction has been that three millfalls have been obtained, in a distance of about 500 yards, just opposite this landslip, and that with scarcely any artificial embankment. For a long time this slipped mass had shown but little movement, and had been considered a sufficiently safe site for building purposes, so that three cottages and a large dwelling house had been erected on it; but the railway cutting through this landslip near its base, at a place where it is 125 yards wide and its greatest depth 20 feet, caused the upper side of the cutting to shew signs of movement, by slight swellings of the soil at the foot of the bank. This movement increased and extended upwards *throughout the whole mass* to a height above the valley of at least 200 feet, and has now caused the destruction of the dwelling house and cottages, and also made it necessary to demolish a handsome newly erected bridge, which had been constructed to carry a parish road over the railway.

"Besides the slips of Fullers Earth described as now occupying the bottoms *of hollows* in this hill side, there are one or two masses which have not descended far. One of these may be seen just below Amberley Court, which, so recently as 1830, or thereabouts, made a considerable movement, and was only stopped by drains being cut behind it, and by a strong buttressed wall being built against the foot of the slipping mass.

"Another example of a *recent* landslip occurred near the Box village, a mile above Nailsworth. This was a movement of Fullers Earth on a large scale, which took place about the year 1826, when after an unusually wet season an area of five acres moved forward in the course of a single night. A deep drain was immediately cut above the whole of the slipped mass, so as to carry off the water to either side, and this has sufficed to arrest its further downward course."

Notes on the Roman Villa at Chedworth. By the Rev. S. Lysons, M.A., F.S.A.

Read at the Foss Bridge Meeting.

To the accident of a lost ferret we are indebted for the discovery of one of the most interesting Roman or Romano-British Villas existing in this country. The under keeper of the noble Earl to whom we are indebted for the courtesy of this day's treat, in thrusting his arm into a rabbit burrow to pull out the recreant animal, at the same time drew out a number of tesseræ, which, being submitted to the inspection of those who understood such matters, were at once pronounced to be of Roman type, indicating the existence of a pavement at that spot. Further search proved the correctness of the suspicion; and fortunately Mr. James Farrer, the uncle and guardian of the noble Earl, being a man of scientific pursuits, was not one who would allow the suggestion to remain without further enquiry. To his diligence of research, and to his nephew's liberal outlay, antiquaries are indebted for the rescue of this most interesting historic relic—interesting, not only as revealing to us a work of art of the times when the Romans held sway in this country, but still more so from the historic fragments which may be collected from hence, and which, when pieced in with history and tradition, help to restore a link which was well-nigh obliterated, in consequence of the loss of that historic literature which I cannot help thinking we must have once possessed. And thus, like our Geological friends, we are able, if not to assert as positive fact, yet to form very shrewd and not, I think, unfounded guesses as to what have been in former days traces of real history, handed down to us in obscure traditions, not lightly to be discarded, especially when ratified by several concomitant circumstances, small but significant and undesigned coincidences bearing their witness to well-nigh lost history. These discoveries do not stand alone. We are not to look at them as mere single specimens, however beautiful or however curious, but we are to look at them as leaves or pages recovered of the past history of our country, out of which, by patience and perseverance, we may make up a missing chapter; and we shall, I trust, be as thoroughly rewarded as though we had found the long-lost books of the historian Livy.

It is well known that in the second invasion of this island by the Emperor Claudius, the Romans, after a rapid march across the country, advanced with comparatively little opposition on the part of the Britons as far as the county of Gloucester, then inhabited by a people by some historians called the Boduni, by others called the Dobuni, according as might be the auricular perception of the pronunciation of their name by those who recorded it. History also tells us that some of the British princes were favourable, rather than otherwise, to the Romans, and others were soon conquered into obedience. History, such as we have it, relates that Arviragus, King of this country, a King whose name is recorded by Juvenal, made terms with the Emperor, and was permitted to retain possession of his kingdom; that this King, having reigned honourably forty-four years, and having during that time visited Rome, returned to his kingdom, and was eventually buried at Gloucester. At this time Vespasian, father of Titus, the conqueror of Jerusalem, was Lieutenant of the Emperor in Britain, and to him British historians attribute the foundation of the town of Cirencester, or rather its conversion from a British settlement, called Caer Corin, then the capital of the Dobuni, into a Roman fortress, with the Romanised British name of Corinium. Discoveries in that town give reason to believe that there is every probability of the truth of the tradition. Its Roman occupation, its Roman walls, are unquestionable; and why should not Vespasian, whom Roman history tells us was in Britain at that period, have transformed it from a British settlement into a Roman town? But to return to Arviragus.

He is not only said to have been King of this country, but also to have been a Christian—one of the earliest British Christians. Bigland, the county historian, tells us that in this very parish, within a mile of this Roman Villa, about the year 1760, the vestiges of a Roman bath were discovered at Listercomb-bottom; there was a spring and other necessary appendages. Most of the bricks of which it was built were legibly marked ARVIRI, describing probably, says Bigland, by connected initials, the titles of the legion which was stationed here. But as I cannot discover in these letters any Roman legion, in Britain or elsewhere, in any way corresponding with them, and as they do form the very legend upon the coins attributed to Arviragus, I was most anxious, on the discovery of this interesting Villa, to ascertain whether any other evidences might be found connecting this place with the traditionary British King, which might in any way confirm the story of his Christianity.

From our early chroniclers we learn that the Emperor Claudius made friends of some of the British princes, and left them in charge of the governments they had previously held, as the Kings of Oude and Delhi, and other Rajahs, have been left by our Government in India. This view is confirmed by the Roman historians Tacitus and Xiphilinus; and we read in Juvenal that Arviragus was still at his government in the reign of Domitian, in which there is nothing inconsistent, considering the great length attributed to his reign by all the chroniclers. Arviragus, then, being King of the Dobuni, of which Corinium (Cirencester) was the capital, one is not surprised to find the bricks discovered at that city also inscribed with the same mark of ARVIRI. Several of these exist in the Cirencester museum. Whether or not that Sovereign had at so early a period exacted a tax on bricks, and had them stamped with his legend, we cannot now say. They must have got their revenue from something, and therefore such a suggestion has nothing impossible or improbable that I am aware of in it. That both the Romans and Britons imposed taxes upon their people is unquestionable. The British coins marked "taxio" have been considered by some writers as signifying that they were used for paying the taxes. The British word "tâsg" undoubtedly means a task, an imposition, or tax. I see no reason why we should be more surprised to see the Sovereign's name upon these bricks than to see V. R. (our own Sovereign's mark) upon any exciseable article. The Romans had a tax upon salt, and the Emperor Vespasian, the founder of Cirencester, (so says Suetonius) imposed a tax upon urine; a tax upon eatables was imposed by Caligula,—and why not bricks? I may remark that the pigs of lead of the Roman times, of which there are several specimens in the British Museum, invariably have the mark of the Emperor in whose reign they were moulded. It would be interesting to know whether any bricks of the Roman times, with the legend of ARVIRI, are discovered in any other county.

Mr. Farrer kindly invited me to visit this place during the progress of the excavations;* and at the time when the workmen arrived at the foundation-stone of the principal entrance of the Villa, knowing the custom of most nations to inscribe the foundation-stone with some emblem of their faith—the Egyptians with the Scarabæus, the Jews with the ineffable name, &c.—I caused the workmen to turn up the stone, when, to my great interest and delight, I discovered the Christian monogram, the "Chi Rho," the two first letters of the name of Christ, evidently marking that the builder of that Villa was a Christian. This monogram was precisely of the character of those seen on the coins of the Emperor Magnentius and his brother Decentius, who—Britons by their parentage, as we read in Zonaras—reigned A.D. 350. This type, however, I find on the Christian tombs in the catacombs of Rome, reaching back to the times of Hadrian, who commenced his reign in 116 A.D., if not, indeed, to a remoter period, and is, I believe, as old as the Apostolic times. This was not, however, the only specimen of the monogram; on further research I found no less than four other instances of it. It has been the prevailing opinion that the monogram originated in the time of Constantine the Great; but my own reading, confirmed by Signor Erasmo Pistolesi, on the Vatican at Rome, shows that Constantine only adopted a symbol well known among Christians from the earliest period of Christianity.

But the historic chain does not cease here. I received a letter from Mr. Farrer, informing me that a sculptured stone had been found, with letters inscribed on it, requesting me to examine it on my next visit. On having the stone washed, I found the letters PRASVTA, which is the abbreviation of Prasutagus, as ARVIRI is of Arviragus. Here we have the name of another British King, known in history as the Sovereign of the Iceni, who made his will, dividing his property in favour of the Roman Emperor Nero and his own two daughters. Prasitagus, Prasiatagus, or Prasiatogus, as his name is variously written, was the husband of the celebrated Boadicea, also called Bonduca, and Bonidicea, and Voadica, according to the phonetic perceptions of the historians who record it. She was the Queen who revolted against the Romans for taking rather more than the lion's share under her husband's will. I think I have read somewhere that Boadicea was daughter of Arviragus, though I cannot find the passage. It is, however, probable that she had something to do with this county, for the coins bearing her legend "Bodvo," according to Akerman, are not found out of the confines of Oxfordshire and Gloucestershire.

The traces of the early British Christianity, which are so decidedly asserted both by heathen and patristic writers, have been hitherto but scantily discovered; yet every year is producing more specimens. I am inclined to think that they have not been sought after, and when found have been overlooked or not understood. In the present instance the probability is that had I not been present, and searching for these evidences, the stones would have been thrown away with the rest of the rubbish and lost. The same monogram is found in Mosaic on one of the pavements at Frampton, in Dorsetshire. Nor does it argue against the Christianity of the possessors of these residences that the Christian emblems are found mixed up with those of the heathen gods and goddesses, because there is no doubt that intermarriages between heathens and Christians at that period must have been very frequent. Moreover, during the four hundred years' residence of the Romans in this country there must have been many changes of occupants of these Villas, having different religious views. But I have remarked at this Villa the singular absence, for the most part, of heathen emblems.

I have remarked, too, upon the existence of a chamber or building having an apse, presenting every appearance of a baptistery, of an octagonal form, which would scarcely, I think, have served the purpose of a bath, there being already two other bath establishments for the Villa in another locality. In the corner of this building was an altar, but I failed to discover any heathen emblems about it. Whether this building was a baptistery is, of course, a matter of considerable question; but if it was not—what was it? It was scarcely a bath,—it is not deep enough; besides, there are other baths in sufficiency. Neither was it a well, for the same reason: nor a reservoir for the supply of the baths, for either of the large baths would exhaust four times as much as this contains; besides, a well or reservoir would not have required so grand a building. And then what about the altar in the corner of the building, and the space occupied by the apse? This space would give room for the witnesses of the baptismal ceremony, who, by standing in that position, would face nearly, or quite, due east. Again, just over the altar are three peculiar niches. These are very remarkable, as possibly suggesting a Trinitarian worship. These circumstances, at any rate, deserve much consideration. Whether all these circumstances united together may carry any weight in confirmation of some of the traditions of our early historians is for you to judge.

The coincidence, however, of the legends of Arviri and Prasiata with the recurrence of the Christian monogram is curious and interesting, because, whether or not my theories will hold water, there is no doubt as to the Christianity of the builders of this Villa. And when we know how comparatively rare is the discovery of Christian emblems in the Roman or Romano-British excavations in this county, notwithstanding the strong and indubitable records to the fact of its early Christianity, we must treasure up every discovery of this sort, and make notes of them, that they may be had in remembrance; and I trust that I have only to call the attention of my brother antiquaries to the importance of these facts, which, to some, may appear trifles, but which are, to others, so many "stones crying out" to the truth of fragmentary history, and as such serve to elucidate our views, as the Terebratulæ and other minute shells mark the zones of the Geologists, and the pistils and stamina serve to mark the genus and species of the flowers of the Botanist.

Knowing how limited our time is, I will not detain you with a description of the Villa itself, but content myself with bringing before you the peculiar features of this discovery, being the second only in Great Britain as yet discovered which bears the evidence of the Christian faith of its builders; and without in any way wishing to force my own views upon others, I throw out these suggestions that they may be followed out by any upon whom they may make an impression, and whose opportunities may enable them to note and preserve every Christian record.

The Watershed of the Upper Thames. *By* JOHN BRAVENDER, ESQ., F.G.S.

READ AT THE CAMPDEN MEETING.

As the subject of water supply to the inhabitants of towns generally, together with other sanitary improvements, has lately occupied public attention, and is most certain to continue to claim more notice than ever, I hope to be excused for venturing to make a few remarks and observations on the subject, and particularly with regard to the Watershed of the Upper Thames, —that is of the country between the sources of the Thames and the city of Oxford.

The general course of the Thames is eastward. It is not derived from any defined spring at its head, giving out all, or nearly all its waters, but is fed by many small rivers and brooks, most of them having their courses from the north and running southward, or having their courses from the south and running northward.

The Thames, according to the Ordnance Map, commences at a place called Waterhay Bridge, about a mile below Ashton Keynes village, and about three miles West of Cricklade. The river, brook, or stream, above this point, is called Swillbrook, which is joined by a brook running from the Thames Head, past Kemble, through Somerford Keynes, and which joins the Swillbrook, about a mile below Somerford Keynes village; and by another from Braydon, which joins the Swillbrook a little above Waterhay Bridge. The area of the Watershed of this district, called Swillbrook and Thames Head, is 74 square miles. Mr. TAUNTON, I believe, makes this 75 square miles.

The following rivers are on the north side of the Thames, and fall into it, by taking generally a southward or south-eastward course.

The Churn.
Ampney and Marston Brooks.
The Coln.
The Leach.
Small streams in Bampton district.
The Windrush.
The Evenlode, Glyme, and Darne.

Beyond the Watershed of the Evenlode is that of the Cherwell, but as this river falls into the Thames below Oxford, I have not considered it in the Upper Thames area.

The following are on the south side of the Thames, and fall into it, by taking a northward or north-eastward course.

The Ray.
Small streams in the Highworth district.
The Cole.

Beyond Faringdon the Ock has its rise, and falls into the Thames at Abingdon, below Oxford, and therefore beyond the district which I have named. The Watershed of the Ock contains 100 square miles.

The water from the springs of the Watershed, containing 123 square miles on the south side of the Thames, is not so abundant as from the same quantity of square miles on the north side of river. The dip of the strata is south-eastward, and descending from the Thames on the south side, but towards the Thames on the north side. The surface of the country slopes from the Chalk Hills towards the Thames, and the water, which immediately runs off, reaches the Thames, but at a slower rate than that from the north. Part of that which is absorbed by the soil, and part which is lost in the streams in the passage over open and porous beds, sink through those porous beds to the upper surface of the tenacious beds of the Oxford Clay, Kimmeridge Clay, and the Gault; and the water descending the plane of stratification, in a contrary direction to that of the river, is lost to the Thames. The same remarks refer to the Watershed of the Ock.

I have separated the district called Bampton from that of the Windrush and of the Evenlode, because the brooks and rivulets in it, do not finally form a river of much larger size, and then pass on, and into the Thames; but several small brooks take their course into the Thames without uniting, and this renders it incapable of being designated the watershed of any particular brook or river.

The same will refer to the district called Highworth.

The area of the Watershed of the Upper Thames, thus described, is 875 square miles, and is made up as follows:—

	Square Miles.
WEST OF THE THAMES.	
Swillbrook and Thames Head	74
NORTH OF THE THAMES.	
The Churn	73
Ampney and Marston Brooks	32½
The Coln	87
The Leach	36½
The Bampton and Thames Valley District	119
The Windrush	141
The Evenlode	189
SOUTH OF THE THAMES.	
The Ray	65½
Highworth District	9½
The Cole	48
	875

The rainfall over this 875 square miles may be taken at 28 inches per annum, from which 12 inches should be deducted for evaporation. The rainfall on a square mile, with this deduction, will be 1,376,710 cubic yards. But to arrive at the probable available quantity, a further deduction should be made for percolation into porous strata, which may not afterwards be thrown out by springs, and, in consequence, may not reach the Thames, but pass under it. Some of this water we know must be brought to the surface by faults, as at Boxwell Spring, but this can only be *part of what* percolates through the beds of the Upper Oolite to the surface of the Fullers Earth. The water which is absorbed by the very porous beds of the Under Oolite is very large, amounting to a third of the rainfall.

The Churn, Coln, Windrush, and Evenlode, descend through valleys of denudation, the Under Oolite having been cut through to some depth below their junction. A large quantity of the Under Oolite rainfall finds its way into those rivers by springs on the sides of those streams, and particularly by springs on the North-western side of the narrow valleys through which they pass; but some of this is liable to be absorbed again in its passage over the Under Oolite, which occupies the beds of those rivers below the junction.

The loss by percolation through the Upper Oolite, including the Forest Marble and Cornbrash, is to a considerable extent compensated by the immense discharge from the Fullers Earth by Boxwell, Ampney, and Bibury springs; which water, if not so discharged, would pass down the plane of stratification, and would not appear again in the vale of the Thames; and added to which must be reckoned half of the water pumped up from the Fullers Earth by the engine at Thames Head. The summit level of the Thames and Severn Canal extends from Daneway, at the Western end of Sapperton tunnel, to Siddington, near Cirencester, being about eight miles in length. From those two extremities the canal descends, westward towards the vale of the Severn, and eastward to the vale of the Thames. The water being retained on the summit by means of locks, it descends in either direction—about half to the Thames, and the remainder towards the Severn. The principal loss in the Watershed of the Thames occurs in the Under Oolite, the area of which is about 106 square miles. I have many years been aware of the great loss of water in the Churn, Coln, Windrush, and Evenlode, by passing over the open and rubbly rock of the Under Oolite, but until 1859 did not succeed in getting the occupiers of the mills on those streams to fix on the right cause; and this was not accomplished without a thorough investigation of the Churn, in which I lent a helping hand, and which finally established the views I had for years previously entertained. The observations were made in the autumn of a very dry summer, and the loss ascertained must be taken to be the maximum, and what the minimum may be is uncertain. The average yearly loss I think is not less than half the rainfall, after deducting for evaporation, leaving eight or nine inches of water over the Under Oolite. The available depth over the other strata in this Watershed may be taken at twelve inches. Assuming it to be nine inches only, and the inhabitants of London to be 3,250,000, then 272 square miles of Watershed at this depth will supply them with thirty gallons each per day. It will thus appear that the Watersheds of the Churn, Ampney and Marston brooks, the Coln, and of the Ock, amounting to 292½ square miles, will more than supply the entire population of London. The Churn, the Coln, and the Windrush, having an aggregate Watershed of 301 square miles, are more than sufficient for the purpose; and the Watersheds of the Churn, Coln, and the Ock, containing 260 square miles, are nearly sufficient for the purpose. London is at present said to be supplied with 643,000 cubic yards (equal to 108,000,000 gals.) of water daily, which is at the rate of more than thirty-three gallons per head for three millions and a quarter of inhabitants. If this be correct, London is more abundantly supplied than many other towns.

In the summer of 1864, the Earl of St. Germans decided on deepening and improving the Thames below and adjoining his property, with the view of obtaining a better outfall for the drainage which had been executed on the Down Ampney Estate. This estate is bounded by the Thames, from the town of Cricklade to near Castle Eaton, in distance more than three miles.

In August of this year, (1864) we found the water sufficiently low to enable us to commence the works, and on the 24th of that month we succeeded in confining nearly all the water descending the river into a definite space of twelve feet in width. I carefully ascertained the velocity and depth, and found that thirteen millions of gallons were passing in twenty-four hours, with every prospect of fine weather. This observation was made towards the upper part of Marston Meadow, about half a mile to three-quarters of a mile above Castle Eaton Bridge.

On the 13th of September, the water passing down the river was confined to a width of four and a half feet in another part of the river further up. The depth and velocity were carefully taken, and I found that about seven millions of gallons were descending in the twenty-four hours; the river having decreased nearly half in volume in twenty days.

On the 8th of October, the water passing down the river was confined to a width of three feet, a little below the bridge at Water Eaton. I again carefully ascertained the depth and velocity, and found that rather more than one million gallons were descending in the twenty-four hours. In the morning of this day I had ascertained that *no water* was passing down the Thames at the bridge at Cricklade; there was no water in the river there except in the hollows in the bed of the river in a few places. I examined the Churn, which flows into the Thames near Cricklade, and found that river completely dry at South Cerney; and on descending the stream to where the water from Boxwell Spring joins the Churn, I observed a considerable quantity of water flowing into the Churn from Boxwell Spring. On visiting Boxwell Spring, about a quarter of a mile up the brook from this junction, I found it discharging about the usual quantity. I had some time before ascertained the flow of this spring, and did so at this time, and found the discharge to be about 1,100,000 gallons in twenty-four hours. The fact is, that the water passing Water Eaton was from the Boxwell Spring, and in passing over about three miles of porous Gravel and somewhat peaty soil, there was a loss of 100,000 gallons per day at that time. This loss would eventually find its way into the Thames lower down the vale.

It may be observed, that from the middle of August to the middle of October, there was scarcely any rain fell, and that which did fall was absorbed immediately, and made not the least difference to the water in the Thames. Our observations extended over forty-five days—from the 24th of August to the 8th of October,—and during this period the entire supply of the Thames above Water Eaton ceased, except what was supplied by Boxwell Spring.

Having alluded to the great loss in the Churn, by passing over the porous rock of the Under Oolite, I may be excused for quoting a table of the results obtained in 1859; and I do so with the greater confidence, because those results were obtained from a series of observations made by myself and assistants, extending over a period of six weeks.

At the Seven Springs the flow was 11 cubic feet per minute.

At	$\frac{1}{4}$	mile below the Springs the flow was	31 cubic feet per minute.
"	$\frac{3}{4}$	" " " " " "	61 " " "
"	1	" " " " " "	73 " " "
"	2	" " " " " "	105 " " "
"	$2\frac{1}{2}$	" " " " " "	165 " " "
"	$4\frac{3}{4}$	" " " " " "	312 " " "
"	$5\frac{1}{2}$	" " " " " "	320 " " "

At this point, however, the volume of the river, instead of increasing, began to diminish, for—

At	$6\frac{1}{2}$	miles from the Spring the flow had decreased	290 cubic ft. per minute.
"	7	" " " " " " " "	235 " " "
"	$7\frac{3}{8}$	" " " " " " " "	179 " " "
"	$8\frac{1}{8}$	" " " " " " " "	113 " " "
"	$8\frac{7}{8}$	" " " " " " " "	45 " " "
"	$9\frac{3}{4}$	" " " " " " " "	33 " " "
"	$12\frac{1}{2}$	" " " " " " " "	30 " " "

In conclusion, I have only two more observations to make, and I hope to be excused for making them. One is, that the loss of water in descending the Coln, is much greater than the loss to the Churn; and I have no hesitation in stating that if this river (the Coln) were thoroughly puddled, as Mr. Simpson recommended in 1859, in the case of the Churn, that Syreford Spring might be sent down to Cheltenham, and the abstraction of the water would not be felt at Foss Bridge; and it would be an immense boon to the inhabitants of that badly-watered town.

There has been a doubt as to the source of the spring called the Thames Head. The Rev. Mr. Clutterbuck appears to think it is derived from the Oxford Clay, and others from the Forest Marble; but I have for many years considered the Watershed of the Forest Marble to be totally inadequate for the supply of so large a quantity of water as is pumped up by the Thames Head engine, and that the source of this spring must be the

Fullers Earth; and I believe Mr. Taunton agrees with me. I dare say many here have heard of a spring called Winterwell. This spring, like that of the Thames Head, is an *intermittent spring,* that is, only sending out water in very wet seasons, and in dry seasons ceasing to flow altogether. Some years ago I had occasion to deepen a well in Winterwell Bottom, not far below the spring just mentioned. This well was only ten feet deep, and had become dry. We sunk it six feet deeper and obtained an abundance of water, and have had plenty ever since; the summer was a dry one. All the materials which were brought to the surface, I recognized as the Shale and Rough Rag Stone, from the top of the Fullers Earth. I was acquainted with the material, having previously sunk several wells into it, and always obtained an abundance of water. One well at the White Way, near Cirencester, is sixty-five feet deep; another at the Bowling Green Farm, thirty feet deep, and my own well in Thomas-street, Cirencester, twenty-seven feet deep, and I succeeded one dry summer afterwards in getting it three feet deeper into the Fullers Earth. The well in the Market Place at Cirencester, is twenty-six feet deep, and this well has never been known to be entirely dry.

It will be remembered that last autumn we had some wet weather, and being desirous of fixing the source of these *intermittent springs,* I invited Professor Morris, who was then lecturing at the Royal Agricultural College, to go with me to see them. We visited Winterwell Spring first, which is situated in a valley of denudation, and found it discharging an enormous quantity of water. This was on a Friday, and the occupier of the land informed us that "*Winterwell broke out middle day on the previous Sunday.*" We left Winterwell, and drove directly to the Thames Head Spring, which is situate on the south side of the canal, also in a valley of denudation, close to Trewsbury Quarry, where a quarry-man lives. We inquired of him when Thames Head broke out, and were informed, "On the previous Sunday," shewing, as I think, the two springs have the same source, and continue to flow only while the rock above the Fullers Earth is saturated up to a line above the surface of the valleys of denudation. The surface at Winterwell Spring is about twenty feet above the Fullers Earth, and that of the Thames Head a little more. I think Mr. Taunton says twenty-nine feet, but I have been unable to ascertain this myself. These remarks on springs are incidentally introduced, but at a future period I may return to this subject, and the Springs of the Upper Thames Watershed and their volume, will afford abundant matter for another paper.

Remarks on the Watershed of the Cotteswolds, in connexion with the Water Supply to the Metropolis. *By* J. H. TAUNTON, Esq., M.I.C.E.

THE Watershed of the Upper Thames occupies so much of the hunting-ground of the Cotteswold Field Club, that I hope I may be permitted to refer to the subject again, in connexion with Mr. BRAVENDER's paper, and the remarks and views therein contained, on the subject of Water Supply generally.

First, in respect to altitude, it is well known that the extreme elevation of the Cotteswolds is only 1100 feet above the sea; and the average yearly rainfall on them is, as may be expected, not great, being but 28 inches, as stated by Mr. BRAVENDER in his paper, and by myself in the evidence taken before the Commission for inquiring into the best means of preventing the Pollution of Rivers. It may be interesting to the Cotteswold Club to have a return of the rain as registered at Thames Head, and I therefore append a copy of the record, as made under my direction at that place, from January 1859, to December 1866, viz.:—

	1859	1860	1861	1862	1863	1864	1865	1866
	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
JANUARY	1·50	2·61	1·40	2·70	2·94	1·78	2·41	3·75
FEBRUARY	1·54	2·02	2·74	0·46	0·55	1·60	2·17	3·41
MARCH	2·57	2·46	2·35	4·80	1·08	3·00	1·11	1·11
APRIL	2·61	1·52	0·76	2·47	1·13	1·06	1·09	2·20
MAY	1·41	3·69	1·16	3·78	1·06	1·06	1·86	0·72
JUNE	3·37	6·13	2·22	2·70	3·54	1·42	0·97	3·21
JULY	1·40	1·61	3·77	1·90	0·44	0·94	4·90	2·67
AUGUST...	2·56	3·99	0·52	1·76	2·95	1·20	3·93	3·60
SEPTEMBER	3·05	3·08	2·73	3·39	2·96	2·81	nil	5·81
OCTOBER	2·72	1·89	1·47	3·96	3·57	2·03	5·24	2·37
NOVEMBER	2·39	2·77	4·26	0·69	2·19	2·16	3·15	1·59
DECEMBER	2·74	3·05	1·75	1·65	1·39	2·91	1·56	2·71
Average, 28·17	27·86	34·82	25·13	30·26	23·80	21·97	28·39	33·15

Now with reference to the schemes which have been promoted, the first by Mr. Bateman, for supplying London with water from enormous storage reservoirs formed on the flanks of the mountain ranges of Cader Idris and Plynlimmon, in North Wales; as well as that of Messrs. Hemans and Hassard, who propose for their gathering-grounds the mountain ranges of Westmoreland and Cumberland, adjoining the lakes of Haweswater, Ullswater, and Thirlmere.

It must be remembered that both schemes start with a much larger rainfall than any on the Cotteswolds. Mr. Bateman says:—"A summit, ridge, or line of watershed, of irregular height, and direction extending from north to south, is crossed and broken by several parallel ranges of mountains extending from south-west to north-east, the intervening valleys on the west side of this irregular summit being quite open to the westerly winds. The valleys on this side, walled in as they are by mountains rising at their peaks to 2500 and 2900 feet in height, and so, raising their heads above the general level of the rain-clouds, form, as it were, so many funnels, up which the the clouds are driven over the low passes at the summit line of watershed into the valleys on the east, where, sheltered from the wind, they discharge the bulk of their watery contents," and he concludes by saying, "From all these observations and from many others which might be brought to bear upon the subject, we shall be quite justified in assuming 45 inches as the annual net produce of two or three successive dry years upon the drainage ground from which I propose to collect water for the supply of London; but in order to be within perfectly safe limits I base my calculations on 36 inches only, being but 10 per cent. more than the observed results at the Manchester Waterworks, and probably only half the gross amount of rain."

Messrs. Hemans and Hassard say, in their published report, the area from which water is herein proposed to be collected, extends over 177 square miles, the altitudes varying from 500 to 3,200 feet above the sea. These, however, are the extremes, the mean altitude will probably be 1300 or 1400 feet above the sea level. They publish a variety of returns of rainfall from

Mr. G. Symons, "British Rainfall"* and other returns, and conclude their observations thus: "In estimating for the supply of London and the intermediate towns, the water producing capabilities of the district, we take it to avoid question at somewhat less than its minimum, viz.: at 80 inches. In a precipitous hill and rocky district, such as this, the loss from evaporation and absorption will be small, probably not more than 12 inches. We take it, however, at 14 inches, leaving 66 inches as the minimum depth of available rain during a continuous period of dry seasons."

Much, therefore, as we cherish our Cotteswolds, the birthplace of the Silver Thames, and fully as we appreciate the description of our friend, Mr. Hull, when he says: "The Cotteswold Hills may be called emphatically the land of rivers and fountains of waters. From the bases of their Mural Cliffs, from the sides and heads of their dells and valleys, copious streams gush forth of the clearest water, supplied by the underground reservoirs, which remain unexhausted long after the surface of the ground is parched." It must be admitted that these rivers and fountains of waters, of which he speaks, do not attain the force and volume which characterize occasionally the early sources of the Severn in North Wales, or of those streams which descend from the mountains to supply the lakes of Cumberland and Westmoreland. The available rainfall of the Upper Thames district, or the waters which, (as I understand Mr. Bravender to mean,) become effluent down the surface-drainage channels, being taken by him at 9 inches per annum, each square mile of the district, produces $5280 \times 5280 \times \cdot 75 \times 6 \cdot 23 = 130{,}261{,}724$ gallons in the year, and in this way a drainage area of 272 square miles would produce water enough in the year to supply nearly 100,000,000 gallons per diem.

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* Of which, as an example, the Seathwaite Gauge, 422 feet above the sea, recorded:—

	Inches		Inches
1860	142·20	1863	173·84
1861	182·58	1864	134·67
1862	170·03	1865	117·49

But without the interposition of very large storeage reservoirs to make the flow uniform, the effect could not be produced, and the settlement of the question of supply remains as distant as ever. For instance, 272 square miles of drainage is attained by the Thames and its tributaries, just below Lechlade, and here the minimum summer flow of the Thames is under 20,000,000 gallons per diem, or but one-fifth of the required quantity. Again, the minimum summer flow at Hampton, being the result of 3676 miles of drainage area (see the published Report of the Commissioners for Preventing the Pollution of Rivers) is but 362,000,000 gallons per diem, being at the rate of 26,700,000 gallons per 272 square miles, and little more than one-fifth of the required quantity, and at Castle Eaton only a few miles above Lechlade, Mr. Bravender found the most insignificant quantity of water passing down the river in the summer of 1864.

Besides this, any scheme of supply involving the abstraction of *the whole* surface waters, having regard to riparian and other interests, would be imperfect or impossible, and it would be necessary that the reservoirs should be large enough, not only to provide for the main supply to the metropolis, but also to maintain the *dry weather* stream during periods of drought. Now I know not where such extensive reservoirs could be formed, either in the valley of the Thames, or of its early tributaries, and it should be also observed that the elevation of the Thames at Lechlade being but 234 feet above the sea, is insufficient for services in London by gravitation only.

On the subject of storeage, Mr. Bateman takes his usual bold comprehensive view, and I think he establishes the facility of the construction of his proposed reservoirs in the district which he selects. His gathering grounds would cover 204 square miles, and his reservoirs would hold 35,000,000,000 gallons, and would supply London with nearly 200,000,000 gallons per diem, after deducting compensation to the rivers affected, at the rate of one-fourth of the assumed rainfall for 140 days of drought.

Messrs. Hemans and Hassard having regard to prospective increase in the requirements of London and some supply along their line of conduit, contemplate supplying 250,000,000 gallons per diem. Their gathering ground would extend over 177 miles, and the storeage capacity afforded by the lakes Haweswater, Ullswater, and Thirlmere, with some auxiliary reservoirs, which they propose would even somewhat exceed the storeage proposed by Mr. Bateman.

The length of aqueduct for the North Wales scheme would be 183 miles, and that from Westmoreland and Cumberland 240 miles.

Mr. Bateman's total estimate is £10,850,000, of which the aqueducts and syphons, to cross valleys, take 6,410,000.

Messrs. Hemans and Hassard's total estimate is £12,200,000, of which the aqueduct, including a tunnel eight miles in length, takes £8,475,000.

I consider very serious objections arise in the case of both schemes to the long length of open aqueducts which are proposed.

The cost of covering them would be so great as to render such a construction of them almost impracticable. The water practically would have deteriorated from its native purity in its passage before reaching the Metropolis, and thus the chief argument of the promoters arising from the excellent and unexceptionable quality of the water at the source of supply would be lost.

No doubt if the Cotteswolds could afford anything like such a supply as the district chosen by Mr. Bateman, their proximity to the Metropolis (one half the distance which his aqueduct is proposed to traverse) would afford a sufficient reason for their selection as a very suitable gathering ground, and I do not think any serious objection could be taken against the quality of the Waters of the Cotteswolds by reason of their hardness, which is not of a permanent character, and is reduced by boiling. Such an extensive supply as that contemplated by Mr. Bateman, the Cotteswolds, however, do not afford, neither do I think that Mr. Bravender has shewn we may safely depend upon them even for the more limited supply of 100,000,000 gallons per diem.

That rain waters which have fallen on our Cotteswold Hills are no doubt lost in large quantities for any useful purpose; that these may be recovered and turned advantageously to the purpose of water supply; and that such waters in connection with the existing supply to the Metropolis will be sufficient for all purposes, present and future, is my decided opinion.

We must not forget the steps taken by present legislation for rescuing the Thames from pollutions, and that river will hereafter be under conservancy in this respect, as strict as could be designed for the security of any aqueduct constructed for the purpose of supply alone.

It is in conclusion my opinion that the supply afforded by the river unpolluted will meet all the requirements of the inhabitants who live upon its banks.

Supposed Permian Beds at Portskewet. *By* ROBERT ETHERIDGE, ESQ., F.R.S.E., F.G.S., H.M. Geological Survey of Great Britain.

IT will be remembered, that at the third meeting of the Cotteswold Club, on the 17th July, at Stanton, a short notice by J. JONES, Esq., was communicated to the members, drawing their attention to the report and general belief, that at the New Passage, or at the Portskewet junction of the South Wales and Bristol Railway, the Permian beds were exhibited, and in a somewhat remarkable manner and condition. It was also stated that organic remains of that age had been found, and that numerously so. To test this belief, and if possible to definitely settle the question, your President, Sir WILLIAM GUISE, and myself, on our return from the meeting of the club at Southerndown and Dunraven, spent some time in examining the beds and strata in question.

I now briefly[1] lay before the club the result of that investigation, reserving for a future paper or notice in the Proceedings of the Club any longer account of the physical structure and correlation of the beds supposed to be Permian.

The beds exposed in the cliffs overhanging the Severn at the New Passage, and also in the railway cutting at Portskewet Station, belong decidedly to the Keuper (the New Red Marls;) but whether higher in the series than the place of the Gypseous Marls, is not clear, owing to the indefinite conditions of their physical structure, to their similarity throughout in detached sections, and to the absence of the Gypsum bands. I am, however, disposed to believe that the Yellow Magnesian Marls that cap the Red series (*i.e.* locally) are the equivalents of the

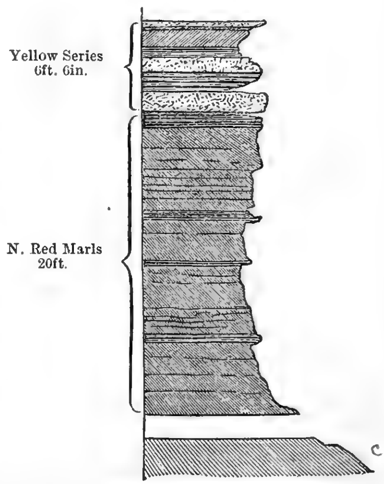
[1] A longer notice on further enquiry will be given.

Gypseous series in other localities, (*example*, Aust and Westbury,) or they may even be the representatives of the Rhætic beds, under different physical conditions, and in an unfossiliferous state. It is these Red and Yellow Marls that have been, or appear to have been, mistaken for the Permian beds—chiefly, perhaps, from their colour and Magnesian Marl-like condition, but more particularly from the mistake which has evidently arisen through fossils having been collected from the yellowish Limestones below them, but which fossils unmistakeably belong to the Carboniferous Limestone.

The mistake seems to have occurred from the (local) absence of the Red beds (below the Yellow) at the Railway Station, and the immediate superposition of the Upper Yellow Sandy Marls upon the yellowish coloured Carboniferous Limestone, and a want of care in discriminating between the two, although perfectly nonconformable one to the other. Long ago it was stated by Mr. Eassie that he had collected from these Yellow Marls (?) numerous fossils, called Permian. This fact he long ago mentioned to Mr. Jones, myself, and lately to Mr. Bristow, of the Geological Survey, who visited the section this summer, and collected a few fossils (Terebratulæ.) Mr. Bristow seems also to have failed to detect the exact position of the fossils, or the nature of the Marls and Sandstones, with relation to the Carboniferous Limestone upon which they rest. The latter gentleman forwarded to me several specimens of Terebratulæ, which at first sight strongly resembled *T. sufflata*, from the Permian beds of Northumberland, &c., or dwarfed varieties of the well-known *T. hastata*, from the Carboniferous Limestone. These were submitted to Mr. Davidson, who would not decide as to their exact species for the want of better specimens, although he at once admitted that they had close affinity with, and strongly resembled, the Carboniferous *hastata*. These doubts determined me to visit the section, and examine into its physical structure, as well as fossil contents. The result was that the so-called Permian fossils do not come from the Yellow Marly Magnesian Sandstones, but are from Red and Yellow beds of Carboniferous Limestone age, which exist immediately below the so-called Permian, and which cannot be mistaken for anything else; and it is, or was, from one particular bed only in the Limestone (* in section) that the Terebratulæ were obtained.

The accompanying section will show the position of the Yellow Marly Sandstone, with relation to the Carboniferous Limestones below, and thus, I hope, clear up the doubts, both as to position and age.

SECTION 1.—Showing the position of the Yellow Marly Sandstone with relation to the Carboniferous Limestone.



SECTION 2.—Section exposed on the banks of the Severn, at New Passage. The Carboniferous beds assumed below.

The above section, like many others covered by the Bunter and Keuper Marls, exhibits their Red and Yellow beds horizontally covering the older rocks below, here denuded into basin-like hollows, the portion in places resting upon Limestone, in others the Red, as at A and B; and thus, when seen at different localities with either one or the other exposed, tend to mislead, or cause different readings of the same series. Such is the case at the New Passage, where, immediately on the river, no Carboniferous Limestone is exposed, and the Red and Yellow Marls are nearly 30 feet thick. (See Sect. 2.) In the hollow in the above section, (1) (at **,) nearly the same thickness occurs, but the Limestones below are plainly determinable. It is the Yellow Marly Sandstone that seems to have misled most observers; and to it they have referred the Permian, or the Permian rock to it. Up to the present time, however, no fossils seem to have been found which can be assigned to the Permian deposits. Only one species of Brachiopoda has been obtained, which is either a small variety of *T. hastata,* or an elongated form of *T. sacculus.* It resembles *T. sufflata,* from the Permian beds of Durham, and was at first believed to be that shell.

The chief interest attached to this question, with relation to New Passage and Portskewet sections, arises and arose out of doubt as to the long looked for and expected Permian beds being deposited over some, if not many, parts of the Bristol Coal Field where Magnesian Conglomerates in places abound, and also along the southern flanks of the Welsh Coal Field; and the very abnormal conditions of those same beds, overlying the Carboniferous Limestone in Glamorganshire generally, especially in the Bridgend, Sutton, Ewenny, and Ogmore districts, added to the interest attached to the somewhat uncertain conditions under which the Sutton Stone and Lower Lias generally were deposited along and upon, or against, the southern outcrop of the Basin, or indeed the Bristol Channel altogether; and it is yet expected and believed that if the Permian beds are found anywhere in the West of England, they would occupy the basin of the Severn. The statement, then, that the Permian series existed and had been found at Portskewet induced Sir William Guise and myself to devote some hours to the investigation of the question at issue, and to carefully examine the site and sections at the New Passage, as we were both anxious that the Club should inform itself through one or more of its members if such really existed, feeling that this came within its geographical area on the one hand, and its privilege to determine such questions on the other, and moreover that it rested with them to solve the problem, as one or two of its members had raised the question.

I reserve to myself any extension of this question, and will gladly extend these notes on communicating with Mr. Eassie and others who have visited the localities in question; and if worthy of place in the Proceedings of the Club, will also communicate newer matter.

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