FOURTH SERIES, Vol. I. 1904,—5,—6.

PROCEEDINGS

OF THE

BRISTOL NATURALISTS' SOCIETY.

EDITED BY THE HONORARY SECRETARY.

" *Rerum cognoscere causas.*"—VIRGIL.

BRISTOL:
PRINTED FOR THE SOCIETY.
MCMVII.

INDEX TO VOL. I (FOURTH SERIES).

Fourth SERIES, Vol. I., Part I. (issued for 1904). **Price 2s.**

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"Part of a Life History."

THE PRESIDENT'S ADDRESS.

JANUARY 28, 1904.

BY ARTHUR B. PROWSE, M.D., F.R.C.S.

I HAVE prepared the following summary of the past life of this Society in the hope that it may prove both interesting and instructive to many of the present members, and that the record may serve to rouse us, one and all, to take a more strenuous and practical interest in the aims and work contemplated by its originators.

The pleasure which always accompanies the acquirement of scientific knowledge is purer and more lasting than that derived in many other more widely-popular ways: and this is one great reason why we should strive to do more, ourselves, by personal observation and study, and also do our best to interest others in the work. I quote here from an early "Report of the Council": "A Society cannot live on the inheritance of the past; its existence depends on the self-consciousness of present active powers rather than on the credit of past achievements." And again, "A Society changes its complexion more rapidly than an individual; decay begins as soon as present activity fails, and its decay is followed by oblivion, even before it officially dissolves. Every society that pursues purely scientific aims, and that is dependent solely on voluntary effort, has of necessity a critical constitution and an uncertain vitality, and therefore is in constant need of extended and sustained support from its whole body as well as from individual members."

This was said at a time when the Society numbered about 240 members, after a few years of steady increase from the original membership, and when the record of past work was good, and the promise for the future hopeful. It is, surely, not inappropriate to quote this now, for though our numbers are fewer, the volume of good, honest work in recent years has not been inconsiderable, and should serve to stimulate a far larger proportion of the members to become active workers for the good of all.

Early in 1862 the late Frederic Adolph Leipner, who had adopted our historic old city as his home in 1854, and who from childhood had been a true lover of Nature and Natural Science, took steps to carry into effect his conviction that there was *need* of a Society which should concentrate and stimulate the scientific life of our city. In a few weeks he and six other gentlemen formed themselves into a "Provisional Committee," which proceeded to sound the scientific mind of Bristol upon the question of the proposed Society. The response was very encouraging, for 168 gentlemen signified their willingness to join. The Provisional Committee consisted of Mr. Stephen Barton, Dr. John Beddoe, Mr. William J. Fedden, Dr. Henry Edward Fripp, Mr. Charles T. Hudson, and Mr. William Walter Stoddart, with Mr. F. A. Leipner as the Hon. Secretary.

Invitations to an inaugural meeting were sent to the 168 gentlemen who had replied favourably to the original letter, and on Thursday, May 8, 1862, 79 gentlemen met, under the Presidency of Rev. Canon Guthrie, in the theatre of the "Bristol Philosophical Institution" in

Park Street. From the statement, prepared by the Provisional Committee, and read at this meeting, I will now quote a few paragraphs: "The present movement would appear to be the most opportune for a brief statement of the principles and plan of action by which the provisional committee were guided in their attempt to form and model this Society. For though their principles and plans are necessarily to be found embodied in the rules about to be proposed for adoption, yet a less formal statement of them will doubtless facilitate that mutual understanding and unity of purpose so necessary to the prosperous commencement and successful working of the Society. Moreover, as several Societies are already in operation and in connexion with the Philosophical Institution, it may not appear out of place to explain briefly the aim and character of this our Naturalists' Society, and to show that it is distinct alike in plan, purpose, and proposed organization from any of the other Societies at present existing here."

"And, *firstly*, we claim for this Society a wider sphere of operation than that which any single subject or department of science could fill. Our aim and object is to include *every branch of Science that finds culture amongst us*, and every worker resident in the neighbourhood as our associate, or—if too far from our locality to be an associate—as our correspondent. Too long has our city been denied the reputation of being a centre of science for the West of England, and the need is urgent that the valuable but scattered labours of those amongst us who are engaged in Scientific occupations should be concentrated and displayed in aggregate form and strength, and that our public should reap the full harvest, and not be content with an occasional gleaning."

"We desire to stand upon the largest possible basis, to combine the efforts of many observers, to unite in one body all who are willing to work hand in hand, to strengthen, to animate each individual with the confidence and power derived from association of numbers, and the sympathy of fellow-labourers in one extended Scheme." I need not quote more, for the above sufficiently explains the aim of the promoters.

The Chairman—Rev. Canon Guthrie—" then gave an animated exposition of the manifest advantages to be derived from such an association, which received the cordial assent and concurrence of all the members present."

The Rules proposed, sixteen in number, were then discussed one by one ; and it was moved by Mr. J. W. Morris, seconded by Mr. Augustin Prichard, and unanimously resolved " that the Rules and Regulations now read be adopted as those of the Bristol Naturalists' Society." The following officers were then appointed, on the proposal of the Rev. William James, seconded by Dr. Beddoe : *President*, Mr. William Sanders ; *Vice-Presidents*, Rev. Canon Guthrie and Dr. Alfred Day ; *Hon. Treasurer*, Mr. William Walter Stoddart ; *Hon. Secretary*, Herr Adolph Leipner. It is pleasant to note the cordiality with which the infant Society was welcomed by its elder brother, the Philosophical Institution, the Committee of which, in reply to an application, passed the following resolution : " That this Committee has heard with real pleasure of the formation of the said Society for the promotion of the study of Natural History, and that the rooms of the Institution be placed at its disposal, during pleasure, under the direction of the Lecture Committee " ; and in sending this decision the Hon. Sec. of the Institution, Dr. Alfred Day, wrote that " the term ' during pleasure ' and the limitation conveyed in the last sentence, are merely adopted for the purpose of preventing any such application of the permission as would conflict with the necessary ordinary business of the Institution, and not with any idea of arbitrary interference with the free and unfettered action of your Society, which the Committee would desire to support to the utmost."

Mr. William Sanders, F.R.S., F.G.S., was re-elected PRESIDENT, year by year, and remained in office until his death in November, 1875. His successor, Dr. Henry Edward Fripp, was elected in May, 1876, and continued his services until March, 1880, when his death took place. At the annual meeting in May, 1880, the recommendation of the Council that "No member shall be eligible for the office of President or Vice-President for more than three consecutive years" was adopted, and Dr. George Forster Burder was elected. In May, 1883, Dr. John Beddoe, F.R.S., succeeded him, and was followed by Professor (now Sir) William Ramsay, Ph.D., F.R.S., 1884 to 1886; Rev. Thomas Hincks, F.R.S., 1887 to 1889; Professor C. Lloyd Morgan, F.R.S., LL.D., F.G.S., 1890 to 1892; and Professor Adolph Leipner, F.Z.S., 1893. His lamented death, in March, 1894, made a vacancy, which was filled by Professor Sydney Young, D.Sc., F.R.S., 1894 to 1896. Since then the holders of the office have been Mr. Samuel Henry Swayne, M.R.C.S., 1897 and 1898; Professor C. Lloyd Morgan, again, 1899 and 1900; and Arthur B. Prowse, M.D., F.R.C.S., 1901 to 1903.

Of VICE-PRESIDENTS there have been, during the forty-one years, twenty-five. There was, for many years, no limitation as to the number of consecutive re-elections, and some of the earlier holders of the office served for many years in succession. In May, 1880, the rule, above referred to, limited the period to three years consecutively, and since 1885 the rule has been that the term of office for Vice-Presidents shall not exceed two years consecutively. This rule has, however, been inadvertently broken in two or three instances.

The Hon. Treasurers have been six in number. William Walter Stoddart, F.G.S., F.C.S., acted for the first thirteen years of the Society's life; Walter Derham, M.A., LL.M., F.G.S., for six years; Thomas W. Jacques for six also; Arthur B. Prowse, M.D., F.R.C.S., for fourteen; Thompson Strickland for one; while our present Hon. Treasurer has nearly completed two years. It is instructive to find from the records of the Society that the difficulty in obtaining subscriptions from some members has been by no means confined to recent years. At the date of the second annual meeting, May 5, 1864, more than half the members were in arrears; and though the proportion does not seem to have been so great subsequently (probably because a paid *collector* was soon found to be a necessity), yet from time to time in the annual Reports references occur to this apparently perennial difficulty.

The subscription was at first five shillings annually, but in November, 1866, it was enacted that in future the sum should be seven shillings and sixpence. This was necessary to meet the increased cost of printing the *Proceedings* in a fuller and more suitable form. Hitherto the printing had been the annual Reports and lists of members, etc., together with off-prints of the accounts of meetings sent to the daily papers by the Hon. Reporting Secretary (William Lant Carpenter, B.A., B.Sc.), obtained by arrangement from the Editors, and sent to the members of the Society. In May, 1874, the annual subscription was increased to ten shillings, so that it might be possible to issue still better *Proceedings*. The sum payable for Life-Membership was also now raised from £4 4*s*. to £5.

The early publications were at first issued rather irregularly. In 1866 the account of meetings was first published in pamphlet form. January to April appeared under one cover, and the other parts issued were, one each for May and June, one for July, August and September together, and one each for October, November, and December; total, seven parts. In 1867 there were eleven monthly parts, September only being omitted. In 1868 there were nine parts, June and August being omitted, and September and October issued together. From 1869 to 1872, inclusive, two parts were brought out yearly—one for January to May, and a second for May to December. From 1873 and onwards there has been one part issued for each year, and three of these parts form one volume.

It should be noted that, although the sessional and financial years of the Society (until 1895) began in May and ended the following April, yet the *Proceedings* of the Society were published for the calendar years, commencing in January and ending in December. As time went on, however, the custom of including the *work of one year* in the *volume or part issued for that year* was unwisely departed from on several occasions, and the consequence was that unnecessary confusion was caused. It is much to be desired that in future the original simpler and more accurate plan will be adhered to. The Session and the financial year now coincide with the calendar year, the change having been made in the Thirty-third Annual Report, which is for the twenty months, May, 1894, to December, 1895, and which includes two balance sheets, one for the twelve months May, 1894, to April, 1895, and the other for May to December, 1895.

The Honorary Secretaries have been four in number. Frederic Adolph Leipner, F.Z.S., acted from 1862 to 1893 (May), when he became President. H. Percy Leonard succeeded him, 1893 to 1896 (January). Then for a year the Secretarial duties were shared by a committee of three, consisting of Henry J. Charbonnier, Sidney H. Reynolds, M.A., F.G.S., and Charles King Rudge, M.R.C.S.

Theodore Fisher, M.D., M.R.C.P., became Secretary 1897 (January), and resigned at the annual meeting on January 25, 1900. Since then our present Hon. Sec., Professor Sidney H. Reynolds has worthily filled the post; and has found, like his predecessors, that it is a hard matter sometimes to persuade members to provide pabulum in the form of papers, for the monthly meetings to assimilate. There are references, from time to time, in the Minutes of the Society's meetings and in the annual Reports, to the scarcity of what may be termed "Working Members," and in this association I would again refer to the quotation I gave just now from the annual Report read on May 5, 1866.

The "REPORTING SECRETARIES" have been sixteen in number. Only two served for as long a period as five years, and these were Edward Bernard Tawney, F.G.S., F.Z.S., 1873 to 1878, and Mary Katharine Moore, 1896 to 1901. Our first lady-officer was a great success, and it is amusing to read in the Minutes of the Society that in October, 1863, the hazardous experiment of admitting ladies at all—and then merely as visitors—to the meetings was made! The record runs thus: "That the Council should be empowered to invite the attendance of ladies whenever the subjects of the evening are likely to be of a nature to interest a female audience." In March, 1868, a further concession was granted by the creation of a class of "Lady Associates," but it was not until October, 1872, that the gentler sex obtained full enfranchisement, and had the right to membership.

The HONORARY LIBRARIANS have numbered five. From 1865 to 1879 the wonderful zeal of the late Professor Adolph Leipner enabled him to fulfil the duties of this office, as well as the onerous work of Hon. Secretary. Oliver Giles succeeded him, but resigned in 1883. Then again for a year Professor Leipner acted. From 1884 to

1890 Professor Lloyd Morgan filled the post, and for the last thirteen years Dr. C. K. Rudge has been in office. For the past twenty years Mr. H. J. Charbonnier has been SUB-LIBRARIAN. In December, 1864, it was decided to commence a Library by the aid of voluntary donations and subscriptions, and a year later the "nucleus" of the Library was shown at the forty-third meeting of the Society. The first list of books, including fourteen works, was printed in the Report read May 3, 1866. The next list printed at the end of the Report, read on May 7, 1868, shows thirty-two works. At the end of the session 1871–2 the number had risen to eighty-six, and included Sowerby's *English Botany;* but a footnote states that the ninth volume of the work was missing. Unfortunately, it is still absent (Jan., 1904). In the next two Reports a supplementary list of works added during the year is appended to the full list. In 1875,–6, and –7 the recently-added volumes alone are mentioned, and during the next four years no list at all seems to have been issued. But in the twentieth annual Report (May, 1882) it is stated that a "*Catalogue*" had been printed and circulated. There is, unfortunately, no copy of this preserved in the Library.

In 1888 a new Catalogue was printed, and it records some hundreds of books and pamphlets, the list occupying forty pages. Since 1888 the number of books has so largely increased that another catalogue is urgently needed.

Until 1871 the books were deposited at the "Philosophical Institution," Park Street. Then, until 1884, the books were housed at Professor Leipner's. Subsequently space was found for them in University College, but at the end of 1890 it was found necessary to increase the accommodation, so a room was rented from the "Literary and Philosophic Club" in Berkeley Square, which it was hoped would be used by the members also as a Reading Room. This, however, has been so to a very limited extent.

The EXECUTIVE (or COUNCIL) of the Society consisted at first of the officers alone—the President, two Vice-Presidents, the Secretary, and the Treasurer; but in May, 1863, it was decided to add to them six elected members, of whom two should retire annually. At the same meeting, too, the office of "Reporting (or Editing) Secretary" was instituted, and Mr. William Lant Carpenter, who had been acting as reporter for four months, was elected. In May, 1864, the number of elected members of Council was increased to nine, of whom three were to retire annually. In 1875 the officers of each "Section" (President and Secretary) were made *ex-officio* members of the Council. Since 1884, when the Rules were modified considerably, the regulation as to the annual retirement of three of the elected members has been omitted, and past Presidents were added to the Council.

The RULES adopted in 1862 were printed in the inaugural statement, together with a list of members, and another of "Corresponding" members. They numbered sixteen until 1874, and were printed in 1863,–4,–8,–9, 1870,–1, and –4. In April, 1873, an *addendum* to Rule ix. was decided on, providing for a Life-Membership, if desired, on payment of £4 4*s*. In 1875 the sixteen Rules were expanded into sixty-seven "LAWS," and these were printed. In 1884 a revised list was again issued. In 1895, after another revision, the number was sixty-one, and the "LAWS" at present in force number sixty, and are being printed now (1904).

In October, 1864, four SECTIONS of the Society were inaugurated—*Botanical*, *Entomological*, *Geological*, and a combined "*Chemical and Photographic*": and in March, 1865, a *Zoological* Section was added. The first lasted until 1890, when it made way for a *Biological* section, which, however, never flourished ; so in 1896 the *Botanical* was revived, and is still in existence, though very lethargic. The *Entomological* and *Geological* sections have survived until the present time, the latter being in a splendidly vigorous condition. The *Chemical and Photographic* lived only three years, but a *Chemical and Physical* section came into being in January, 1878, and has only just expired. It was for many years a very active member of the family. The *Zoological* section became moribund in 1875, but did not officially pass into oblivion until two years later. In October, 1886, a *Microscopical* section was instituted, but it came to an untimely end in 1890. In January, 1887, an *Engineering* section started, with a " flourish of trumpets," but it was abolished in 1893. The tenth and last on the list, the *Ornithological* section, was formed in October, 1896, and, having completed the work of cataloguing the local birds, it voluntarily dissolved in 1900.

The place of meeting was in the " Bristol Philosophical Institution " until March 2, 1871. On May 4 of that year the Society met for the first time in the " Bristol Museum and Library," and it continued to meet there until November, 1883. On December 6, 1883, the meeting was held in " University College," and within its hospitable walls we have met ever since.

The hour for the General Meetings was at first 7.30 ; but from October 1873 onwards it has been 8 p.m. In the early days of the Society, too, the time for closing the meetings seems to have been rigidly adhered to, and there are many entries in the Minutes as to Papers being postponed, or discussions cut short at 9.30, by reason of the " lateness of the hour."

Members were at first of two classes, *Ordinary* (or subscribing) and *Corresponding*, the latter being " Honorary," though it was not until 1878 that they were called *Honorary*. During the forty-one years they have numbered forty-six, including seventeen who had previously been *Ordinary* members. In 1868 ladies were first entered on the rolls as *Associates*, but in 1872 this title was dropped, and ladies joined as *Ordinary* members. In 1882 a class of *Associates* was instituted for members of both sexes, who should pay half the ordinary subscription, and this has continued until now. In 1895 it was resolved to form a third class—*Sectional* Members, who were to pay 2*s*. 6*d*. to the general funds, i.e. only one quarter of the full subscription; but after five years' trial it was found necessary to abolish this class, which had not proved satisfactory, either in numbers or in paying even the small subscription required.

The Society began with a membership of 168. In 1865 this had risen to 240. Two years later it was only two less; but there seems to have been some jealousy of the Society in the district, and a letter found its way into one of the local papers on April 29, 1867, announcing the intended dissolution of the Society. The Council promptly investigated the matter, and discovered that Mr. Leipner's handwriting and signature had been copied and forged, and an old letter of his also made use of, in order to impose upon the Editor of the paper. A letter from the Council was inserted the following day, speaking of the hoax as "childish, weak, and wicked": "weak, because such a statement was calculated to put even fresh energy into the officers of the Society; and wicked, because the author was endeavouring to diminish the usefulness of a Society which had already done a good deal of useful work, and would doubtless accomplish much more." Two years after this the membership was only 176. In 1876 the numbers had fallen to 158, but in 1887 they had risen to 251. Then began another period of depression, and towards the end of 1900 there were only 139. Since then there has been a slow but steady improvement.

During the forty-one years there have been about 900 members, but of these only about one-sixth have contributed anything to the Society's business in the way of papers or exhibits. There have been 428 papers read at general meetings, and one half of these have appeared in the *Proceedings*, either in full or in abstract. Of papers read at sectional meetings, 179 have also been printed, more or less fully. The subjects of the papers have been very varied, as might have been expected from the broad basis wisely laid by the founders of the Society. Among them are such as can be classed under the following branches of knowledge: Anatomy (*Human*), Archæology, Astronomy, Botany, Chemistry, Cosmography, Electricity, Engineering, Entomology, Epidemiology, Ethnology, Folklore and Superstition, Geology, Histology, Magnetism, Mental Science, Meteorology, Microscopy, Ornithology, Philology, Photography, Physics, Physiology, Sanitary and Social Science, Technology, and Zoology. With the exception of three of these—Human Anatomy, Histology, and Photography—all are represented in the printed *Proceedings* of our Society. During recent years a wish has been expressed by some members that we should restrict our work mainly, if not entirely, to "Natural History" pure and simple; but it will be an evil day for the Society if its members permit this. Our membership is, even now, far smaller than it should be in so populous a centre, and any narrowing of the base upon which we stand can but produce a condition of unstable equilibrium, which will end in disaster.

The Carboniferous Limestone of Burrington Combe.

By T. F. SIBLY, B.Sc.

Contents.

I. *INTRODUCTION.*

THE Burrington Combe Section has been described by Professor C. Lloyd Morgan, LL D., F.R.S., etc., in a paper entitled, " Mendip Notes ".[1] This paper is accompanied by a map and section. Professor Lloyd Morgan recorded the occurrence of the " Bryozoa Bed " near the base of the Carboniferous Limestone series, and suggested a broad division of the series here exposed into Lower Transition Beds, Lower Limestone and Upper Limestone. He further called attention to the absence of the topmost beds of the Carboniferous Limestone from the section.

In a forthcoming paper[2] entitled " The Palæontological

[1] *Proc. Bristol Nat. Soc.* New Series, vol. vi. (1888–91), p. 179.
[2] *Q.J.G.S.*, vol. lxi., part 2.

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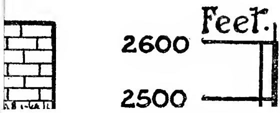
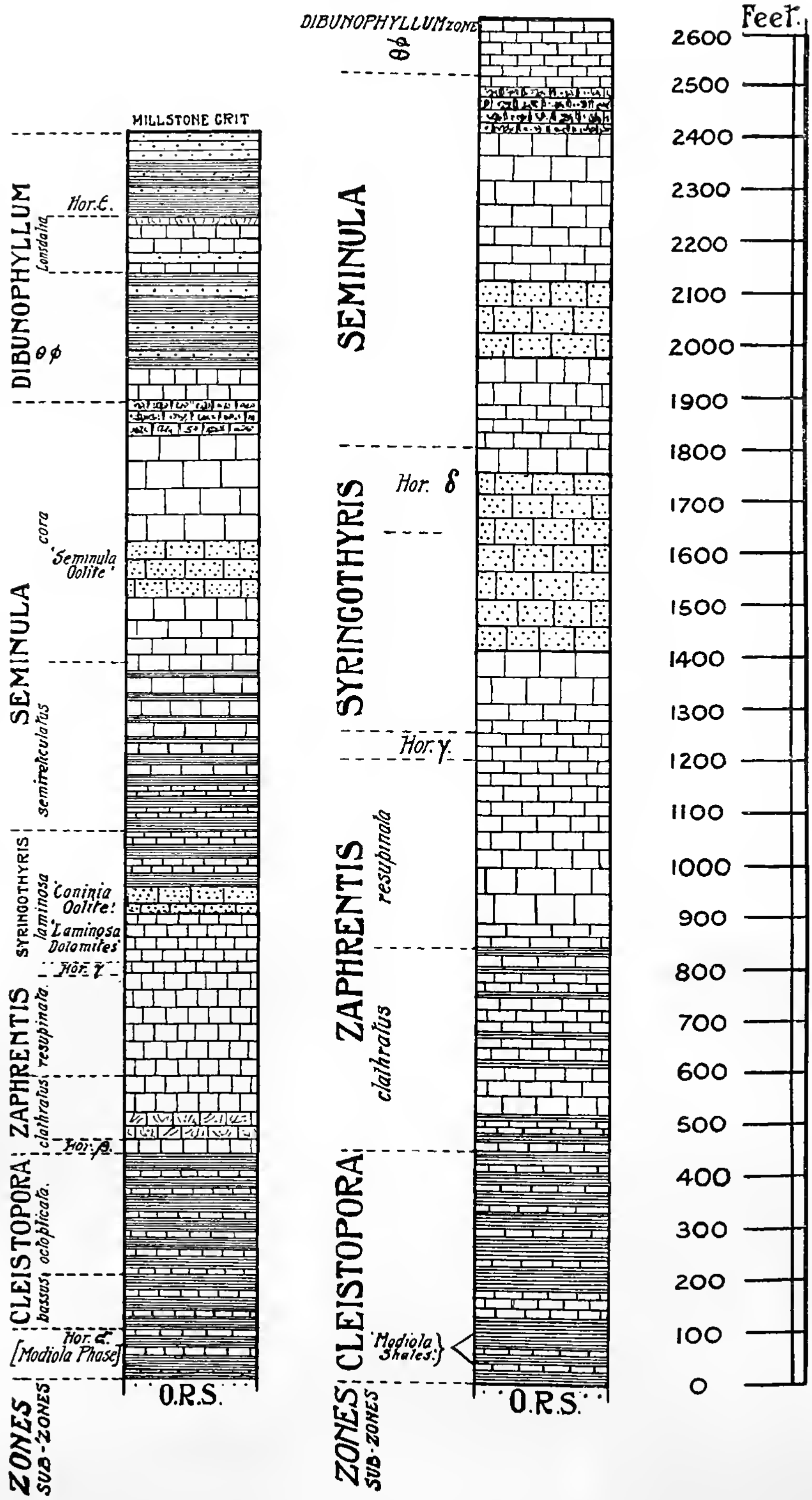


VERTICAL SECTIONS
Showing the Thickness and Lithology of the ZONES *and* SUB-ZONES *in the* CARBONIFEROUS LIMESTONE *of the* AVON GORGE *and* BURRINGTON COMBE



AVON SECTION
(After A. Vaughan)

BURRINGTON SECTION

Sequence in the Carboniferous Limestone of the Bristol Area," read before the Geological Society on June 8, 1904, Dr. Arthur Vaughan, B.A., D.Sc., F.G.S., has suggested a system of palæontological zones for the Carboniferous Limestone of the Bristol Area, based entirely on the sequence of corals and brachiopods. In this paper Dr. Vaughan gives a brief list of the main features of the Burrington sequence for comparison with the Bristol sequence.

I am at present engaged on the examination of the Carboniferous Limestone of the whole Mendip Area, with a view to establishing a zonal system for this development. The lines which I am following in this investigation are essentially similar to those followed by Dr. Vaughan in his examination of the Bristol Area.

Such an undertaking is best commenced by an examination of the best section to be found in the area : this section may then form a basis for correlation during the subsequent work.

Burrington Combe affords the most complete section to be found in the Mendips, the total thickness of Carboniferous Limestone exposed being about 2,600 feet : this series extends from the top of the Old Red Sandstone into the Lower Dibunophyllum Zone, and is thicker than the whole Carboniferous Limestone series as displayed in the Avon Gorge. The top beds of the Carboniferous Limestone are, at Burrington, covered up by Triassic deposits.

The present paper contains the results of a detailed examination of this section. This examination has demonstrated beyond doubt that the faunal sequence at Burrington is, on the whole, remarkably close to that in the Bristol Area. Accordingly, the greater part of the zonal system adopted by Dr. Vaughan for the Bristol sequence has been adhered to in this paper ; alterations being made only when striking differences in the facies at certain levels have called for them.

The Burrington Section shows, from the level at which marine limestones first predominate to the top, an unbroken series of fossiliferous limestones. It is, therefore, very suitable as a type section.

In this paper the section is treated zonally. Under each zone are given :—

(1) A brief description of exposure and of lithological characters.
(2) Lists of the corals and brachiopods occurring in the zone.
(3) Special faunal characters.
(4) A comparison with the equivalent part of the Bristol sequence.

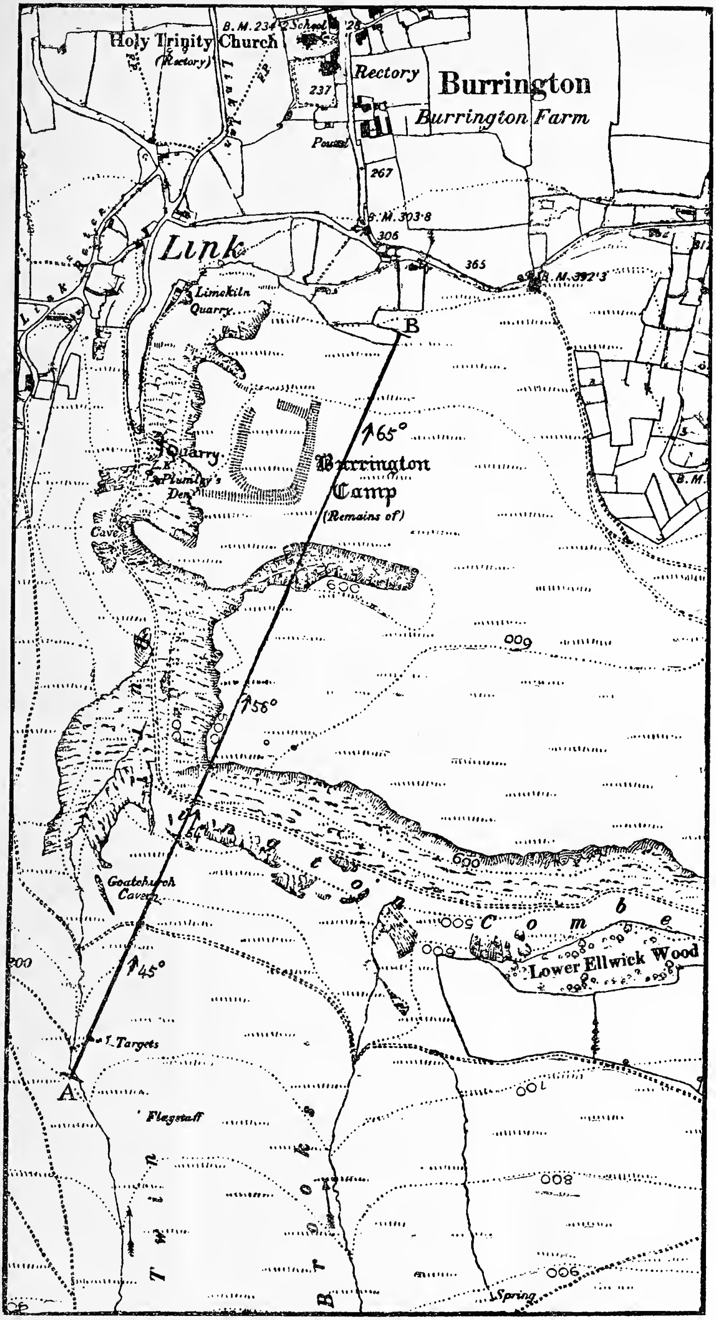
The paper is accompanied by a map, a horizontal section and a vertical section. The two former may prove useful to any one examining the section. With the latter I have given a vertical section of the Avon sequence, taken from Dr. Vaughan's paper, by kind permission of the author and of the Council of the Geological Society. These vertical sections are useful for reference during comparisons, and show the lithological sequence in each case.

In all places throughout the paper where reference is made to the Bristol Area, the information was obtained from Dr. Vaughan's paper.

In the faunal lists I have followed exactly the system of specific naming adopted by Dr. Vaughan in his work. Each specific name is used in the same sense in which it is employed in his paper.

I am under a very deep obligation to Dr. Vaughan ; in general, for the great encouragement which he has given me in undertaking this work, and for his continual advice ; in particular, for much assistance in the examination of the section and for invaluable help in the palæontological work. For all this I offer him my sincere thanks.

I am indebted to Professor S. H. Reynolds, M.A., F.G.S., for his kind assistance ; and to Mr. F. P. Burt for very valuable help in the field.



MAP OF BURRINGTON COMBE.

Scale 6 inches = 1 mile.

(AB is in the line of section, along the direction of dip.)

II. *DETAILED ACCOUNT OF THE BURRINGTON SECTION.*

A. Cleistopora Zone (including Modiola Shales).

Lithological characters.

This zone includes the whole of the thick series of shales and limestones which lies between the top of the Old Red Sandstone and the base of the Zaphrentis Zone.

[As is explained in the sequel, a separation of the lower part of this series as a Modiola Zone would not agree with the evidence. The whole series is, therefore, included in the Cleistopora Zone.]

Exposure.

The beds are exposed in the ravines, formed by the "Twin Streams," which furrow the north slope of Black-down and open out into the Combe. They are best examined in the east ravine.

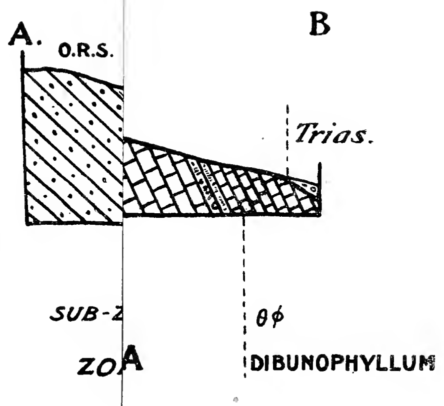
Coral fauna. None as yet recorded.

Brachiopod fauna.

Cliothyris Royssii (vars.)
Eumetria sp.
Cliothyris glabristria.
Camarotoechia mitcheldeansis.
Spirifer aff. *clathratus,* and var.
Syringothyris aff. *cuspidata.*
Spiriferina octoplicata.
Orthotetes aff. *crenistria.*
Rhipidomella aff. *Michelini.*
Productus cf. *bassus.*
Productus cf. *Martini.*
Chonetes cf. *hardrensis.*
Chonetes '*Buchiana*' [Dav.]

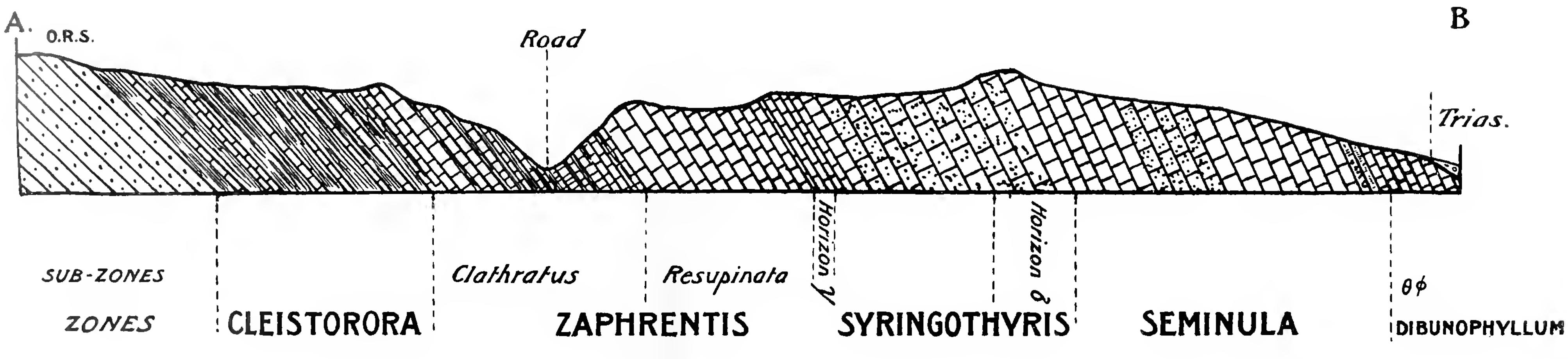
Special faunal characters.

In the lower part of the zone, the shales contain *Modiola*


A.
B
O.R.S.
Trias.
SUB-Z
θφ
ZOA
DIBUNOPHYLLUM

THE BURRINGTON SECTION

Horizontal Section, along the line AB on map
Natural Scale :- 12 inches = 1 mile. 1 inch = 440 feet.



sp. and abundant Ostracods. Brachiopods, which are comparatively rare, include *Eumetria* sp., *Chonetes* cf. *hardrensis*, *Camarotoechia mitcheldeanensis* and *Orthotetes* aff. *crenistria*.

In the lowest series of thin limestones, *Cliothyris Royssii* var., and *Chonetes* cf. *hardrensis* are abundant, and are associated with *Orthotetes* aff. *crenistria*, *Spirifer* aff. *clathratus* and *Camarotœchia mitcheldeanensis*.

The "Bryozoa Bed," about 150 feet above the top of the Old Red Sandstone, consists of red limestones crowded with *Rhabdomeson* sp., and containing *Spirifer* aff. *clathratus*, *Orthotetes* aff. *crenistria* and *Chonetes* cf. *hardrensis*.

Chonetes '*Buchiana*' and *Productus* cf. *bassus* have only been found in the middle part of the zone.

Orthotetes aff. *crenistria* and *Chonetes* cf. *hardrensis* are abundant at various levels throughout the zone.

Spiriferina octoplicata is apparently rare: only two specimens have been recorded, from the middle and upper parts of the zone respectively.

Rhipidomella aff. *Michelini* first appears in the upper part of the zone, and increases in abundance as we approach the Zaphrentis Zone.

Spirifer aff. *clathratus* and var. are comparatively rare in the lowest limestones; become commoner as we ascend; and are extremely common at the top of the zone.

Syringothyris aff. *cuspidata*, *Cliothyris glabristria* and *Productus* cf. *Martini* appear near the top of the zone.

Remarks and comparison with the Bristol Area.

The exposure of the beds is unsatisfactory throughout the zone, particularly in the upper and middle parts. The passage into the Zaphrentis Zone is not exposed at all, and the fossils recorded from this level were obtained by excavating on the hillside. The knowledge of the special faunal characters of the various parts of this zone is, therefore, incomplete, and comparison with other areas is rendered difficult.

The 'Modiola Shales' resemble the shales in the Modiola Zone of the Avon Section in lithological and palæontological characters. These shales cannot, however, be separated as a distinct zone at Burrington. They alternate with limestones which contain many fossils, some in abundance, characteristic of the Cleistopora, fauna. Each series of these shales represents the prevalence of a 'Modiola-Ostracod' phase. The limestones, which from the base of the zone contain a more or less characteristic Cleistopora fauna, indicate the gradual establishment of the bathymetric conditions which prevailed during the formation of the Carboniferous Limestone.

The 'Bryozoa Bed' exactly reproduces the lithological and palæontological characters of the corresponding bed in the Avon Section.

Special faunal characters: comparison with the Avon Section.

(i) Resemblances.

Cliothyris Royssii is common at two levels only, (1) in limestones near the base of the zone, (2) in the highest beds of the zone. This agrees with its abundance at two levels, in the Modiola Zone and at Horizon β respectively, in the Avon Section.

A *Productus* of the type of *P. bassus* occurs in limestones a little above the Bryozoa Bed. This agrees with the occurrence of *Productus bassus* in the bassus sub-zone of the Avon Section.

Chonetes '*Buchiana*' is abundant in that part of the series which is equivalent to the bassus sub-zone of the Avon Section.

Chonetes cf. *hardrensis* is abundant at various levels throughout the series above the Bryozoa Bed; especially at the top of the zone.

Spirifer aff. *clathratus* and var. increase in abundance as we approach the top of the zone, and are very abundant at that level.

Orthotetes aff. *crenistria* abounds at numerous levels throughout the series.

Rhipidomella aff. *Michelini* is not uncommon in the upper part of the series, and increases in abundance towards the top.

Camarotoechia mitcheldeanensis occurs throughout the series.

Cliothyris glabristria and *Productus* cf. *Martini* are first recorded from the top of the zone.

The same species of *Eumetria* which occurs in the Modiola Zone of the Avon Section has been recorded in the lower part of the zone.

(ii) Differences.

No specimen of *Cleistopora* has been recorded (in the absence of weathered surfaces this is not surprising).

Spiriferina octoplicata is apparently rare throughout the series. In the Avon Section it is rare in the bassus sub-zone, but is highly characteristic of the octoplicata sub-zone, and attains a maximum at the top of this sub-zone. The failure to record it in any abundance at Burrington may quite likely be due to the absence of weathered surfaces.

No specimen of *Leptaena* has been found. In the Avon Section, *Leptaena* occurs in the Modiola Zone and is abundant in the Cleistopora Zone.

Orthotetes aff. *crenistria* and *Spirifer* aff. *clathratus* are not uncommon in the lowest limestones. In the Avon Section, these forms are rare in the Modiola Zone.

Chonetes cf. *hardrensis* is abundant in the lowest limestones. In the Avon Section, it is not recorded with certainty from the Modiola Zone.

Syringothyris aff. *cuspidata* has only been recorded from the top of this zone. In the Avon Section it enters at the top of the bassus sub-zone.

NOTE.—Considering the poor exposure of this zone at Burrington, the failure to find many of the above fossils cannot be said to prove more than their non-abundance.

B. ZAPHRENTIS ZONE

Lithological characters.

This zone includes the series of limestones (with subsidiary shales) from the first appearance of *Zaphrentis* to Horizon γ. The limestones are very encrinital. The lower part of the zone is shaly and is cut through by the upper part of the Combe, above the bend.

Exposure.

The east ravine cuts through the lower part of the clathratus sub-zone before opening into the Combe. In the west ravine, from Goatchurch Cavern to the Combe, the whole of the clathratus sub-zone is rather poorly exposed. The massive limestones occurring just above the top of the clathratus sub-zone form the fine escarpment which towers above the road, on its north side, in the upper part of the Combe

The upper part of the resupinata sub-zone is poorly exposed on the slopes below the bend.

The limestones forming Horizon γ stand out prominently on the slopes, and are well exposed on both sides of the road, about 200 yards below the bend.

Coral fauna.

Zaphrentis aff. *Phillipsi.*
Zaphrentis aff. *cornucopiae.*
Caninia cylindrica.
Amplexus cf. *coralloides.*

Michelinia cf. *favosa.*
Syringopora θ.

Brachiopod fauna.
Cliothyris Royssii (mut. β).
Cliothyris glabristria.
Spirifer aff. *clathratus* and var.
Reticularia aff. *lineata.*
Martinia glabra., var. *linguifera.*
Syringothyris aff. *cuspidata.*
Syringothyris cuspidata.
Syringothyris aff. *laminosa.*
Leptaena analoga.
Orthotetes aff. *crenistria.*
Rhipidomella aff. *Michelini.*
Schizophoria resupinata.
Chonetes cf. *hardrensis* } and intermediate
Chonetes aff. *papilionacea* } mutations.
Chonetes papilionacea.
Productus cf. *Martini* } and intermediate
Productus semireticulatus } mutations.
Productus pustulosus.
Productus aff. *Cora.*

The base of this zone has been fixed at the point where *Zaphrentis* is first recorded.

In the Bristol Area, as typified by the Avon Section, the base of this zone is characterized by the co-occurrence of *Zaphrentis* and *Spiriferina octoplicata*, and thus exhibits a well-marked overlap of the Cleistopora and Zaphrentis faunas = Horizon β.

At Burrington, however, *Spiriferina octoplicata* is rare throughout the Cleistopora Zone and has not been found in association with *Zaphrentis*. Horizon β cannot, therefore, be distinguished; and accordingly all beds below the level at which *Zaphrentis* first appears are included in the Cleistopora Zone. The top beds of the Cleistopora Zone, however, contain nearly all the brachiopods characteristic of Horizon β; and the failure to distinguish this horizon is very probably due to the absence of satisfactory exposures.

SUBDIVISIONS.

(i) Clathratus sub-zone.

Special faunal characters.

Brachiopods.

Cliothyris Royssii (mut β) is not uncommon at the base of the sub-zone.

Cliothyris glabristria occurs throughout and gradually increases in abundance.

Spirifer aff. *clathratus* and var. are extremely abundant throughout this sub-zone.

Syringothyris aff. *cuspidata, Leptaena analoga* and *Productus* cf. *Martini* are abundant in the lower part of the sub-zone.

Orthetetes aff. *crenistria* is abundant throughout.

Chonetes cf. *hardrensis* reaches a maximum near the base of this sub-zone, where it is extremely abundant; it continues abundantly throughout; and near the top it is for the first time associated with a mutation towards *Chonetes* aff. *papilionacea.*

Rhipidomella aff. *Michelini* occurs throughout and reaches a maximum at the top of the sub-zone.

Reticularia aff. *lineata* is not infrequent.

A single interesting *Productus* of the type of *P. Cora* has been found in this sub-zone.

Corals.

Zaphrentis aff. *Phillipsi* enters at the base of the sub-zone and immediately becomes fairly common.

Michelinia cf. *favosa* enters at the base and gradually increases in abundance.

(ii) Resupinata sub-zone.

Special faunal characters—

Brachiopods.

Cliothyris glabristria attains its maximum and is associated, though rarely, with *Schizophoria resupinata.*

Spirifer aff. *clathratus* and var., though less abundant than in the clathratus sub-zone, are very common throughout.

Syringothyris cuspidata, in the typical form characteristic of the Syringothyris Zone, occurs at the top of this sub-zone.

Syringothyris aff. *laminosa* enters at the base, and is abundant at a certain level.

Chonetes cf. *hardrensis* is common at various levels throughout this sub-zone, and is associated with *Chonetes* aff. *papilionacea* in the upper part. *Chonetes papilionacea* enters, and is very common in the upper part of the sub-zone.

Productus cf. *Martini* is replaced by a larger form closely allied to *Productus semireticulatus.*

Rhipidomella aff. *Michelini* occurs, but has passed its maximum.

Orthetetes aff. *crenistria* occurs abundantly throughout.

Corals.

Zaphrentis aff. *Phillipsi* and *Zaphrentis* aff. *cornucopiae* become abundant at the top of the sub-zone.

Caninia cylindrica enters in the lower part of the sub-zone and rapidly becomes abundant.

Amplexus cf. *coralloides* appears early in the sub-zone and soon attains a maximum. At its maximum it is abundant.

Michelinia cf. *favosa* attains its maximum, being very abundant at certain levels.

Syringopora θ occurs in abundance.

NOTE.—Owing to the very unsatisfactory exposure of the upper half of this sub-zone, little is known concerning the relative abundance of various fossils in the beds underlying Horizon γ. The maxima of *Zaphrentis* aff. *Phillipsi, Zaphrentis* aff. *cornucopiae, Syringopora θ, Cliothyris glabristria* and *Schizophoria resupinata* are not, therefore, capable of accurate determination.

(iii) Horizon γ.

Since the corals and brachiopods characteristic of both the Zaphrentis and Syringothyris Zones co-occur here in abundance, this level forms a well-marked horizon of faunal overlap. The beds are extremely fossiliferous and are, from the collector's point of view, the most interesting in the section. Further, this level is remarkable for the association of *Caninia cylindrica,* in great abundance, with an abundant brachiopod fauna which, in the Bristol area, characterises the lower resupinata sub-zone. These features are clearly brought out by the following list of :—

Special faunal characters.

Brachiopods.

Cliothyris glabristria occurs, but is uncommon.

Spirifer aff. *clathratus* and var. are still abundant.

Syringothyris cuspidata, in the typical form characteristic of the succeeding zone, is common.

Schizophoria resupinata occurs commonly.

Leptaena analoga occurs here, but has not been recorded from any higher level.

Chonetes cf. *hardrensis* and *Chonetes* aff. *papilionacea* occur commonly.

Orthotetes aff. *crenistria* and *Chonetes papilionacea* are abundant.

Productus semireticulatus in its typical form occurs not uncommonly at this horizon.

Productus pustulosus has been found at this level only.

Corals.

Caninia cylindrica attains its maximum, and is extremely abundant.

Zaphrentis aff. *Phillipsi* and *Zaphrentis* aff. *cornucopiae* are abundant.

Comparison with the Bristol Area.

The general faunal assemblage agrees almost exactly with that in the same zone of the Bristol development. The enumeration of the resemblances would therefore amount to a repetition of the greater part of the above lists, and I shall consequently only discuss the more important points of difference.

As is explained above, Horizon β cannot be distinguished at Burrington, owing to the failure to find *Zaphrentis* and *Spiriferina octoplicata* occurring together.[1] In the Bristol Area this horizon is very well marked.

The further division of the zone into (i) Clathratus sub-zone, (ii) Resupinata sub-zone, (iii) Horizon γ, which is so well established for the Bristol Area, agrees well with the change of the main faunal assemblage at Burrington. The following points of difference between the ranges and abundance of certain forms, at Burrington and in the Bristol Area respectively, should, however, be noted :—

(i) Clathratus sub-zone.

At Burrington—

Michelinia occurs at the base of the sub-zone.

In the Bristol Area—

Michelinia has not been recorded below the resupinata sub-zone.

(ii) Resupinata sub-zone.

At Burrington—

Michelinia attains a maximum and is common throughout.

Amplexus is abundant in the middle of the sub-zone and reaches a maximum at this level.

[1] It has, however, been pointed out that the failure to recognize Horizon β at Burrington may be due to the absence of satisfactory exposures at this level.

Caninia cylindrica appears in the middle of the sub-zone and immediately becomes common.

Spirifer aff. *clathratus* and var. are abundant throughout.

Syringothyris cuspidata in its typical form is not common below Horizon γ, but attains its maximum in the Syringothyris Zone.

Schizophoria resupinata is apparently uncommon in the main sub-zone, but is common at Horizon γ.

In the Bristol Area—

Michelinia only begins to be important in the upper part of this sub-zone.

Amplexus characterizes the upper part of this sub-zone, and attains a maximum just below Horizon γ.

Caninia cylindrica is common at Horizon γ only.

Spirifer aff. *clathratus* and var. are greatly diminished in numbers.

The typical form of *Syringothyris cuspidata* is abundant just below Horizon γ, and here attains its maximum.

Schizophoria resupinata is only common at the base of this sub-zone.

(iii) Horizon γ.

At Burrington, *Caninia cylindrica* and *Zaphrentis* spp. are associated with *Spirifer* aff. *clathratus* and var. (abundant), *Schizophoria resupinata* (common), *Cliothyris glabristria* and *Leptaena analoga*.

In the Bristol Area, these brachiopods are either absent or very rare at Horizon γ.

The above lists bring out very clearly the fact that we have at Burrington, as compared with the Bristol Area, a relative acceleration of the coral fauna on the brachiopod fauna in this part of the series. The main faunal assemblage is the same in both areas; but slight differences between the special faunal characters of the various parts of the zone, in the two areas, have been demonstrated, as was to be expected.

C. Syringothyris Zone.

Lithological characters.

Massive limestones mainly oolitic.

Exposure.

The whole of this zone, from Horizon γ, about 200 yards below the bend, to the top of Horizon δ, at Plumley's Den, is well exposed on the right hand side of the road as we descend the Combe. The lower and upper beds have been quarried back to some little distance from the road. The top beds of the main zone (just below Horizon δ) stand out prominently into the Combe, and cause a bend in the road; at this point a Cave runs into the hill.

Coral fauna (omitting Horizon γ).

Zaphrentis aff. *cornucopiae.*
Caninia cylindrica.
Cyathophyllum ϕ.
Michelinia cf. *megastoma.*
Syringopora spp.
Clisiophyllid.

Brachiopod fauna (omitting Horizon γ)

Spirifer aff. *clathratus* and var.
Syringothyris cuspidata.
Syringothyris aff. *laminosa.*
Spiriferina cf. *laminosa.*
Reticularia aff. *lineata.*
Athyris cf. *expansa.*
Seminula ambigua.
Seminula aff. *ficoidea*

'Athyris' cf. *gregaria.*
Rhipidomella aff. *Michelini.*
Orthotetes aff. *crenistria.*
Productus semireticulatus (mutations).
Productus aff. *Cora* (mut. C.)
Productus θ.
Chonetes cf. *hardrensis.*
Chonetes aff. *papilionacea.*
Chonetes cf. *comoides.*
Chonetes papilionacea.

Subdivisions.

(i) Horizon γ.

Already described in detail. This may also be regarded as the base of the main Syringothyris Zone.

(ii) The Main Syringothyris Zone.

This includes all the beds from Horizon γ to the corner immediately beyond the Cave.

Special faunal characters.

Brachiopods.

Spirifer aff. *clathratus* and var. are not uncommon just above Horizon γ. They occur throughout the zone, but become more rare in the higher beds, and have not been recorded above the top of the main zone.

Syringothyris cuspidata in the typical form attains a maximum and is everywhere common.

Syringothyris aff. *laminosa* occurs throughout the zone but is never abundant.

Reticularia aff. *lineata* occurs at a particular level near the top of the zone.

Seminula ambigua is abundant at the top of the zone, just below Horizon δ, and is associated with *'Athyris'* cf. *gregaria.*

Orthotetes aff. *crenistria* occurs abundantly throughout.

Productus semireticulatus, in the typical form, occurs in this zone. In the higher part of the zone the mut. *concinnus* is abundant, attaining a maximum just below Horizon δ.

Productus aff. *Cora* (mut. C.) is not uncommon at the top of the zone.

Chonetes cf. *hardrensis* occurs in the lower beds, but has yielded its predominance to *Chonetes papilionacea*, and dies out early in the zone.

Chonetes papilionacea, which is abundant throughout the zone, crowds certain beds, and is at some levels associated with *Chonetes* cf. *comoides* in abundance.

Rhipidomella aff. *Michelini* occurs rarely in the upper part of the zone.

Corals.

Caninia cylindrica, though never abundant, occurs throughout, and dies out at Horizon δ.

Zaphrentis aff. *cornucopiæ* has been recorded from the middle of the zone.

Cyathophyllum ϕ first appears in the upper part of the main zone, but is not common below Horizon δ.

A Clisiophyllid has been found in the middle of this zone. The early occurrence of a member of this important group is very interesting; particularly so because a similar specimen has been obtained by Dr. A. Vaughan from the same level in the Carboniferous Limestone of the Tenby district.

Michelinia cf. *megastoma* is common throughout the zone, but has not been recorded at Horizon δ.

(iii) Horizon δ.

This includes the beds extending from the corner below the cave to Plumley's Den.

Special faunal characters.

Brachiopods.

Syringothyris cuspidata still occurs, but dies out at the top of the horizon.

Syringothyris aff. *laminosa* is recorded from this level, and not from any higher point.

Spiriferina cf. *laminosa* occurs here, and has not been recorded from any other level.

Athyris cf. *expansa* is not uncommon.

Seminula aff. *ambigua* is associated with the first examples of *Seminula* aff. *ficoidea*.

Orthotetes aff. *crenistria* is abundant in the lower part of the horizon, but becomes distinctly less common towards the top, and is rare in the succeeding beds.

Productus semireticulatus mut. *concinnus*, is not uncommon, but has not been recorded above this horizon.

Productus θ enters, and is abundant at the top of the horizon.

Chonetes papilionacea is abundant.

Corals.

Cyathophyllum ϕ becomes abundant in the middle of this horizon; declines in abundance towards the top, and has not been recorded from any higher level.

Caninia cylindrica occurs rarely at the base of the horizon.

The bryozoan '*Chaetetes*' *tumidus* is highly characteristic of this horizon.

This horizon is well defined as the top of the Syringothyris Zone, for it clearly exhibits the decline and disappearance of the characteristic corals and brachiopods of the zone. It does not, however, possess the characters of a satisfactory horizon of faunal overlap. The separation of the Syringothyris and Seminula Zones is apparently sharp. *Syringothyris*, Semireticulate *Producti* and Zaphrentid corals have not been found above this level.

Orthotetes loses its predominance, and is rare above the top of the horizon. Very few forms characteristic of the Seminula Zone occur below the top of this horizon, and these are distinctly rare, e.g., *Seminula* aff. *ficoidea* only occurs rarely, and no *Lithostrotion* has been recorded. *Seminula* aff. *ficoidea* and *Lithostrotion* first occur in any abundance at a considerable vertical distance above the top of Horizon δ. *Chonetes papilionacea* is abundant at repeated levels throughout the Syringothyris and Seminula Zones, and its occurrence both at and above Horizon δ is, therefore, no evidence of a faunal overlap.[1]

In the division of the Carboniferous Limestone into two great stages, a lower or Tournaisian and an upper or Viséan, the line of separation must be drawn at the top of Horizon δ, and is, as the above remarks show, clearly defined in this section. This horizon is, therefore, an extremely important one; further work in the Mendip Area will doubtless add greatly to our knowledge of its characters.

Comparison with the Bristol Area.

The development of this part of the sequence at Burrington differs greatly from that in the Bristol Area.

At Burrington we have an unbroken series of massive limestones extending upwards from Horizon γ to the base of the Seminula Zone, and containing abundant corals and brachiopods throughout. This series may be very satisfactorily designated the Syringothyris Zone. *Syringothyris cuspidata*, in the typical form, occurs commonly throughout and attains a maximum in this zone. Moreover, this form is not common below Horizon γ, and dies out at Horizon δ. At the base of the zone, Horizon γ forms a well-marked horizon of overlap between the Zaphrentis and Syringothyris faunas. Horizon δ, on the

[1] *Vide* footnote, p. 35.

other hand, marks the top of the Syringothyris Zone very clearly, but does not form a good horizon of faunal overlap, the separation of the Syringothyris and Seminula faunas being apparently sharp. In the Bristol Area, Dr. Vaughan has adopted *Syringothyris* aff. *laminosa* as a sub-zonal index for that part of the zone lying between Horizon γ and Horizon δ. At Burrington, however, since *Syringothyris* aff. *laminosa* is never common in this zone, though it occurs throughout, and since it attains a maximum in the Zaphrentis Zone, I do not propose to use it as an index. All that part of the zone lying between Horizon γ and Horizon δ is, therefore, referred to as the Main Syringothyris Zone.

The characters of this zone throughout the Bristol Area are so widely different from those of the Burrington series that a detailed comparison would necessarily be of great length ; more especially so because, in the Bristol Area itself, the lithological and palæontological characters of the zone vary from point to point. I shall, therefore, confine myself to a few broad comparisons, taking the Avon Section as a type, and only referring to other parts of the Bristol Area when it is necessary to bring out special features.

The lithological characters of the zone are widely different from those of the same zone at Burrington. In the Avon Section we have, in ascending order from Horizon γ—

(1) Limestones appreciably dolomitic.
(2) A thick band of oolite—the Caninia or Gully Oolite.
(3) Shales with thick beds of pure dolomite and subsidiary beds of oolite.
(4) Massive limestones with thin shale partings

(1), (2) and part of (3) form the laminosa sub-zone. The remainder of (3) with (4) forms the lower part of the Seminula Zone, i.e. the semireticulatus sub-zone. The lower part of the laminosa sub-zone, i.e. the series from Horizon γ to the base of the oolite, agrees well in faunal characters with the base of the main Syringothyris Zone at Burrington. The only point calling for notice is the greater abundance of *Syringothyris cuspidata* at Burrington.

In the Caninia Oolite and the succeeding shales and dolomites there is apparently a remarkable palæon'ological break. *Orthotetes*, *Syringopora* and *Michelinia* occur occasionally in the oolite, but are distinctly rare.

As the Carboniferous Limestone is traced from the Avon towards Clevedon, this break is found to be partially filled in by the development of fossiliferous limestones (the "Bellerophon Beds") in the shale series, about 150 feet above the base of the oolite (cf. Failand and Tickenham). These limestones reproduce exactly the palæontological characters of Horizon δ as developed at Burrington, but they occur at a lower level in the sequence than does Horizon δ at Burrington.

In the Avon Section, fossiliferous beds are found again as we approach the top of (3), and in (4) we find a typical Seminula fauna, i.e. very abundant *Seminula ficoidea* and *Lithostrotion*. These forms are, however, associated with *Productus semireticulatus*, *Syringothyris* aff. *laminosa*, *Caninia cylindrica* (mut. S_1), and *Cyathophyllum* ϕ.

There is, therefore, a wide overlap of the Syringothyris and Seminula faunas in the Bristol Area, rendering a subdivision of the Seminula Zone necessary; whereas at Burrington, where the separation of the Tournaisian and Viséan faunas is apparently sharp, no subdivision of the Seminula Zone is justifiable.[1]

[1] I have recently found, in the Weston-super-Mare district, where the development is, in the main, very similar to that at Burrington, a small but distinct development of the semireticulatus sub-zone at the base of the Seminula Zone. Since the exposure of the base of the Seminula Zone, as defined in this paper, is very poor, it is quite possible that some such development at Burrington has not been revealed. Further-work in the Mendips will doubtless settle this important question.

D. Seminula Zone.

This zone includes all that part of the section lying between the top of Horizon δ, at Plumley's Den, and the middle of the limekiln quarry.

Lithological characters.

Chiefly massive limestones, oolitic in parts; with concretionary limestones near the top, and very compact limestones at the top of the zone.

Exposure.

The basal beds are poorly exposed between Plumley's Den and the quarry at the side of the road. Beyond this quarry, on the grassy slope at the side of the lane leading to the limekiln quarry, the beds are poorly exposed at intervals. The top beds of the zone are exposed in the limekiln quarry.

Coral fauna.

Lithostrotion Martini and vars.
Cyathophyllum Murchisoni.
'*Clisiophyllum*' (*Carcinophyllum*) θ.
(?) *Dibunophyllum* θ.
Syringopora spp.

Brachiopod fauna.

Seminula ficoidea and vars.
Athyris aff. *planosulcata* (?)
Orthotetes aff. *crenistria.*
Productus θ.
Productus aff. *Cora* (muts.)
Productus hemisphericus.
Chonetes papilionacea.

No subdivision of this zone is justifiable. The lower part of the zone differs from the upper only in the presence of *Productus* θ, in the absence of Clisiophyllids and in its less fossiliferous character, i.e. *Lithostrotion*, *Seminula* and *Productus* aff. *Cora* are not so abundant in the lower part of the zone as in the upper part.

Special faunal characters.

Lithostrotion, *Productus* aff. *Cora* (mut. S_2), *Seminula ficoidea* and *Chonetes papilionacea* occur throughout, and abound at certain levels throughout the upper three-quarters of the zone.

Productus aff. *Cora* (mut. D_1) and *Productus hemisphericus* are common in the upper part of the zone.

Productus θ occurs at the base.

Orthotetes and *Cyathophyllum* are rare.

'*Clisiophyllum*' (*Carcinophyllum*) θ is not uncommon in the upper part of the zone; *Dibunophyllum* θ has also been doubtfully recorded here.

Comparison with the Bristol Area.

If we except the wide overlap of the Syringothyris and Seminula faunas, which is so characteristic a feature of the Lower Seminula Zone in the Bristol Area, the main faunal characters of this zone at Burrington and in the Bristol Area are very similar. A detailed comparison is, therefore, unnecessary. One striking difference should be noted. In the Avon Section, *Lithostrotion* and *Seminula* are extremely abundant throughout the lower part of the zone; at Burrington, however, these forms attain their maxima in the upper part of the zone, and are not abundant in the lower part.

E. Dibunophyllum Zone.

θ ϕ Sub-zone.

The base of this sub-zone, consisting of compact limestones with thin shale partings, is exposed in the limekiln quarry.

Coral fauna.

Lithostrotion Martini and mutation.
Cyathophyllum Murchisoni.
Dibunophyllum θ.
Koninckophyllid *Cyathophyllum.*
Alveolites septosa.
Syringopora cf. *ramulosa.*

Brachiopod fauna.

Orthotetes aff. *crenistria.*
Productus aff. *Cora* (muts.)
Productus '*giganteus.*'
Productus cf. *costatus* (?).
Chonetes papilionacea.

Productus '*giganteus*' and *Orthotetes* aff. *crenistria* in a characteristic mutation are abundant.

The interesting coral recorded as Koninckophyllid *Cyathophyllum* is the form described by Dr. A. Vaughan in "Carboniferous Corals and Brachiopods,"[1] and occurs at the same level in the Avon Section.

Comparison with the Bristol Area.

The fauna of this horizon at Burrington exactly resembles that of the same level in the Bristol Area

III. *SUMMARY.*

Having given a detailed account of the palæontological sequence in the Burrington Section, and compared each zone with its equivalent in the Bristol development, I shall now summarise the main features of the section, taking each zone in turn.

A. Cleistopora Zone.

In this zone is included the thick series of shales (with subsidiary limestones) extending from the top of the Old

[1] *Proc. Bristol Nat. Soc.* New Series, vol. x., part 2, p. 119.

Red Sandstone to the level at which *Zaphrentis* is first recorded. Shales predominate in the lower part of the zone, but more and more limestone occurs as we ascend the series. Limestones containing characteristic Cleistopora fossils occur very near the base, and in ascending the zone we find the gradual establishment of the Cleistopora fauna.

No subdivision of this zone is justifiable on the evidence obtained. The exposure of the upper two-thirds of the zone is very unsatisfactory, and our knowledge of the faunal characters of this part is therefore very limited, but the following outstanding features are important :—

(i) In the lower part of the zone, 'Modiola-Ostracod' shales alternate with thin limestones which contain characteristic fossils of the zone.
(ii) In the middle of the zone, *Chonetes* '*Buchiana*' is abundant, and *Productus* cf. *bassus* occurs occasionally.
(iii) The upper part of the zone is marked by the increasing abundance of certain forms, and the entrance of others; all these forms persist into the Lower Zaphrentis Zone, where the majority attain their maxima.

B. Zaphrentis Zone.

This zone, which is very finely developed, having a total thickness of 800 feet, exhibits the maximum development of the Tournaisian fauna. The lower part of the zone consists mainly of thin-bedded limestones with thin shale partings ; the upper half is formed chiefly of massive limestones. Horizon γ consists of thin-bedded limestones. Nodular chert occurs in the massive limestones near the middle of the zone. The basal beds are poorly exposed, and in the failure to recognize Horizon β the lower limit of the zone has been fixed at the level where *Zaphrentis* is first recorded.

The main clathratus sub-zone is finely displayed and shows all its characteristic faunal features.

The base of the resupinata sub-zone is well displayed, but the succeeding beds are not well exposed until Horizon γ is reached. The most striking features of the resupinata sub-zone, by comparison with the Bristol development, are the entrance of *Caninia*, *Michelinia* and *Amplexus* in abundance and the persistence of *Spirifer* aff. *clathratus* and var. as abundant forms.

Horizon γ is finely developed. The beds are extremely fossiliferous and exhibit the following striking features :—

(1) An extraordinary abundance of *Caninia cylindrica*.
(2) The by no means uncommon occurrence of several brachiopods, which in the Bristol Area are characteristic of the lower resupinata beds and absent or very rare at this horizon.
(3) A well-marked overlap of the Zaphrentis and Syringothyris faunas.

C. Syringothyris Zone.

Between the top of the Zaphrentis Zone and the base of the Seminula Zone there is a thick series of massive limestones, mainly oolitic. This series is fossiliferous throughout and is well defined as the Syringothyris Zone.

At the base, Horizon γ exhibits a clear faunal overlap.

Throughout the main zone we see the gradual decline of the Tournaisian fauna, though *Syringothyris cuspidata*, which attains a maximum, and *Productus semireticulatus* (muts.) are very characteristic throughout.

At the top of the zone, Horizon δ, which forms a well-marked faunal level and marks the end of the Tournaisian facies, is well developed.

A few Viséan forms enter near the top of this zone, but on the whole the separation of the Tournaisian and Viséan facies is sharp : the line of separation must be drawn at the top of Horizon δ.

D. Seminula Zone.

This zone consists of limestones which are sometimes thin-bedded, but chiefly massive. In the middle of the zone the limestones are oolitic and near the top they are concretionary. The top beds are very compact in texture.

No subdivision of this zone is necessary.

The establishment of a typical Viséan fauna is exhibited. The lower beds are distinctly less fossiliferous than the upper; in fact a true Seminula facies is first found at a considerable vertical distance above the top of Horizon δ. The main zone shows all the characteristic faunal features of the upper Seminula Zone as developed in the Bristol Area. The topmost beds are relatively unfossiliferous.

E. Dibunophyllum Zone.

Only the basal beds of the $\theta\ \phi$ sub-zone, consisting of thin bedded limestones with thin shale partings, are satisfactorily exposed. Their faunal characters are exactly similar to those of the corresponding level in the Bristol sequence.

In conclusion, I may draw special attention to the two most important features of the Burrington sequence as compared with the sequence in the Bristol Area.

(1) The absence of shallow water conditions in Syringothyris time, as indicated by the absence of dolomites, which are so characteristic of the whole Bristol Area to the north.

(2) Absence of any considerable overlap of the Tournaisian and Viséan faunas, a feature which characterizes the lower Seminula Zone (= semireticulatus subzone of Vaughan) in the Bristol area.

The Carboniferous Limestone of South-West Gower.

By WILLIAM BRENDON GUBBIN, M.D., C.M.

THE somewhat striking differences, both in rock structure and in the nature of their organic remains, between the Carboniferous Limestone series in the northern and southern areas of Britain, have hitherto offered an insurmountable barrier to the establishment of any correlation between their respective zones; but the recent attempt by Dr. Vaughan to establish a series of zones founded upon the Coral and Brachiopod sequence seems likely to achieve better success than that of any previous geologist.

In the small area of S.W. Gower a remarkably interesting series of Carboniferous Limestone occurs, rich in fossils, and exhibiting very accurately the successive zones which Dr. Vaughan has mapped out for the Bristol area.

The scenery of this district is of the kind so commonly seen in Carboniferous Limestone regions, a somewhat monotonous plateau, scarred by sharply-cut gorges. The coast line from Oxwich on the east to Rhosilly on the west of the Peninsula extends in bold rugged cliffs, forming some of the grandest coast scenery in Wales.

Two small ranges of low rounded hills, of Old Red Sandstone formation, cut off the limestone of the southern area of Gower from the rather more extensive mass lying to the northward. No good sections are to be found inland, nor have we present in the cliffs any such continuous section as is afforded by the Avon Gorge ; save some of the top beds, however, which have been removed by denudation, almost the entire series from Millstone Grit to Old Red Sandstone can be made out by following the coast line, where a series of curves and faults brings bed after bed into view.

At Oxwich Bay a series of black shales occur, with vast colonies of *Lithostrotion* ; one of these shale beds ic seen on the cliff, but the greater part are buried under a huge sand-bank, and can only be seen in fragments at very low tide. The whole cliff from Oxwich round the headland to Porteynon is so dislocated and shattered by faults that it would be tedious and misleading to attempt to trace out the various horizons in this locality. At Porteynon Bay, however, a vast synclinal curve occurs in the beds, the top of the curve being occupied by Dolomitic Conglomerate (1) of Triassic Age, the original thickness of which cannot be stated, as the bulk of it has been eroded. This conglomerate rests unconformably on the Carboniferous Limestone series, which had undergone extensive denudation before the Triassic deposits were laid down.

The successive zones may now be referred to in order, the notation adopted being that of Dr. Vaughan for the Avon Section.

DIBUNOPHYLLUM ZONE.

Sub-zone D_2.

The highest beds of the *Dibunophyllum* zone, that are found at Porteynon Bay, consist of a series of red shales, (2)[1] with seams of yellow and purple sandstones, the entire thickness of which is about 40 ft. Below this, and conformable to it, a limestone bed (3)[2] is reached, 250 ft. in thickness, with bands of chert, lenticules of calcareous sandstone, and veins of calcite. Through the greater part of this, fossils are few in number, save in a few pockets containing badly preserved specimens of *Lithostrotion* and *Productus ;* but towards the base fine examples of *Productus*, cf. *giganteus*, *Lithostrotion Portlocki*, *L. junceum*, *L. irregulare*, and *L. Martini* (mut.) occur.

Sub-zone D_1.

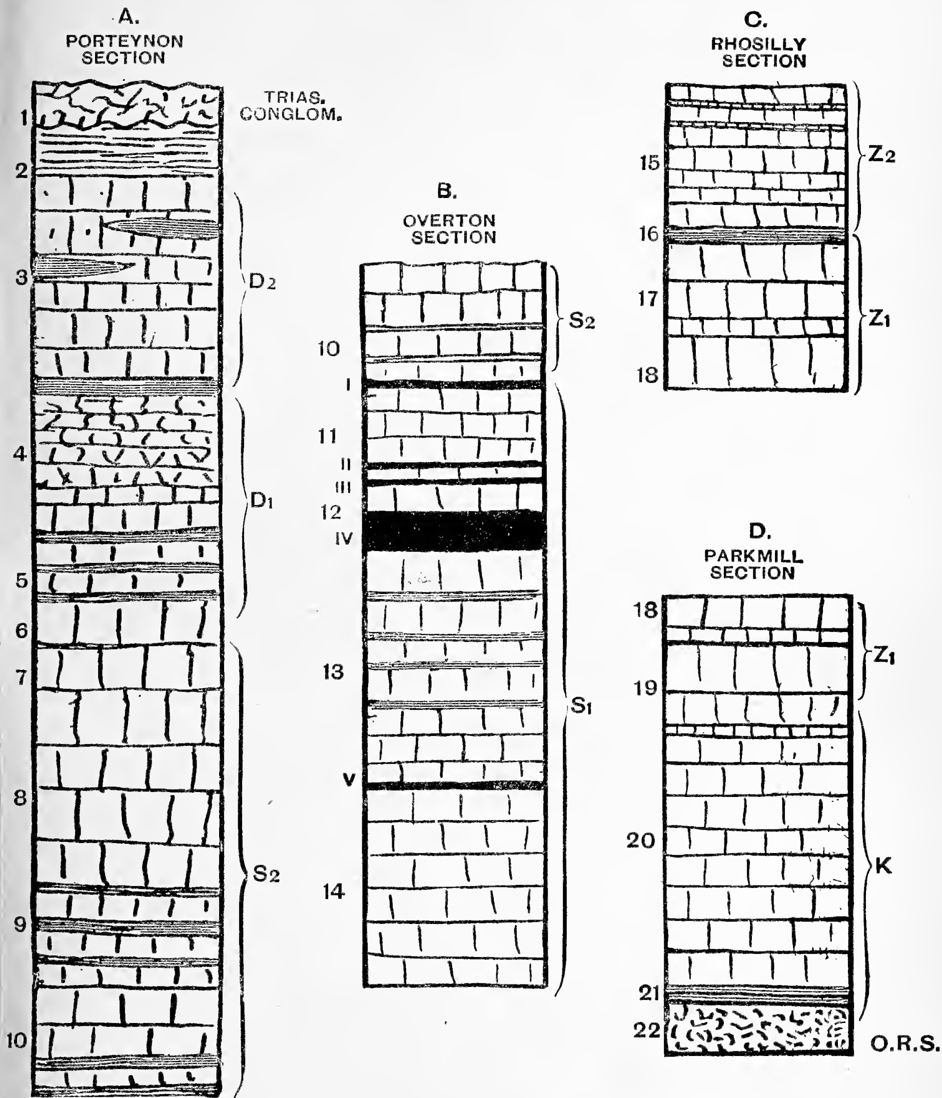
This commences with a series, 60 feet in thickness, of loose rubbly limestone,(4)[3] lying immediately below the coral bed just described. It appears to be absolutely unfossiliferous, and is followed by 30 feet of alternating bands of compact limestone and bright red shale. (5) These are very rich in fossils, particularly corals : *Cyathophyllum Murchisoni* is abundant, and *Dibunophyllum* θ, *Campophyllum* sp , *Syringopora* sp., *Lithostrotion Martini*, *Productus* '*giganteus*,' and *Productus hemisphericus* are also found commonly. The Bryozoa, which are such a characteristic feature in the shale beds, at a much lower horizon (S_1), do not appear in these, which are the basement beds of sub-zone D_1.

SEMINULA ZONE.

Sub-zone S_2.

The upper beds of the succeeding sub-zone (S_2) are well exposed on Porteynon Head, and in the Overton Gorge, a mile to the northward, and consist of the

[1] *Vide* Section A on page 45.
[2] *Ibid.*
[3] *Ibid.*


A.
PORTEYNON SECTION
TRIAS. CONGLOM.
1
2
3
4
5
6
7
8
9
10
D2
D1
S2
B.
OVERTON SECTION
10
I
11
II
III
12
IV
13
V
14
S2
S1
C.
RHOSILLY SECTION
15
16
17
18
Z2
Z1
D.
PARKMILL SECTION
18
19
20
21
22
Z1
K
O.R.S.

following series : a grey limestone, 30 feet in thickness, (6) with *Productus* '*giganteus*' at the top only ; but crowded with *Lithostrotion Martini* and *Syringopora* sp. ; a blue limestone, (7) 25 feet thick, in which *Productus* aff. *Cora* appears, with a vein containing *Seminula ambigua* (mut. S_2) and *Seminula* aff. *ficoidea.*

The rock now gradually becomes oolitic, (8) and *Productus* aff. *Cora* is the characteristic fossil; *Lithostrotion Martini* and *Syringopora* are still fairly common, and a few specimens of *Carcinophyllum* θ occur. Corals, however, are not nearly so abundant as in the upper beds.

Towards the base *Athyris planosulcata, Productus fimbriatus* and *Seminula* occur, with occasional masses of *Alveolites.*

The oolitic character of the limestone is maintained through about 200 feet of rock, save where it is broken by bands of black calcareous sandstone. (9) Three of these black bands appear, each from 3–4 feet in thickness, and contain the same fossils as the limestone. The oolitic rock ceases abruptly, and gives place to beds of blue and grey limestone, (10) the first 70 feet of which contain merely a few specimens of *Lithostrotion Martini* and *Syringopora. Productus* aff. *Cora,* as far as I can determine, does not extend below the oolitic series. The succeeding 30 feet of limestone are interstratified with bands of black sandstone similar to those of the oolitic bed. The fossils are broken and badly preserved, and consist of *Lithostrotion Martini* and *Productus* (sp.), with *Lithostrotion affine* sparingly in the lowest layer. At Porteynon Head this bed, which is the last of sub-zone S_2, is at the base of the cliff, between high and low water mark.

Sub-zone S_1.

A huge fault, running north and south, brings the underlying beds into view on the cliff at Overton, where a fine section occurs, yielding vast numbers of organic remains, very varied in character. The most interesting feature presented is five distinct Gastropod layers, the highest of which may be taken as the top of sub-zone S_1. Of the Gastropods I can only as yet refer to genera; several of them are, I believe, new species, and some possibly peculiar to the district. In the highest of these gastropod beds (I), which is two feet in thickness, are found *Bellerophon* sp., *Loxonema* sp., *Dentalium* (*priscum ?*), and *Platyschisma* sp. Forty-eight feet of limestone (II),[1] yielding *Lithostrotion affine* and a few specimens of *Bellerophon*, separate Gastropod Beds (I) and (II), which latter (II), 5 feet in thickness, contains the same species as (I), but in greater numbers, *Dentalium* being especially common. Bed (III) lies 2 feet below this and is a thin layer, with apparently no other species than those found in the two higher beds. Below this third bed are 15 feet of limestone (12), in which a few scattered examples of *Bellerophon* sp. *Lithostrotion affine* and *Syringopora* are the only fossils. Bed IV, the thickest of the series, measuring 25 feet, yields in abundance *Loxonema*, *Platyschisma*, *Euomphalus*, *Murchisonia*, *Pleurotomaria*, *Natica ? Naticopsis*, *Bellerophon*, and *Dentalium*, with *Orthoceras laterale*, *Orthoceras* sp., *Nautilus*, and *Modiola ?* In the last 12 feet of this interesting layer the shells are nearly all in fragments, with a few perfect specimens of *Platyschisma* and *Loxonema*.

The succeeding bed, 6 feet in thickness, contains merely the persistent *Lithrostrotion affine*, and rests on a base 5 feet thick, crowded with broken crinoid stems, few traces of which occur in any of the previous layers. Beneath this we have about 90 feet of alternating limestones and bright red shales (13), the latter usually only a few inches thick, and showing on their surfaces a matted mass of *Lithostrotion affine*, *L. Martini*, *Syringopora* sp., and crinoid stems,

[1] *Vide* Section B, on page 45.

interspersed with Bryozoa. Spines of *Productus semireticulatus* are numerous, but I found no specimens of the entire shell.

The Brachiopods are represented, however, by a gigantic *Productus*, one specimen of which measured 15 inches across the hinge line.

The other fossils collected from this sub-zone were *Conocardium* sp., *Conocardium*, cf. *aliforme*, *Orthotetes crenistria* (mut. S.), *Seminula ficoidea*, *Spiriferina* cf. *laminosa*, *Chonetes papilionacea*, *Chonetes* cf. *hardrensis* (rare), *Rhipidomella* aff. *Michelini*, the Corals *Caninia cylindrica* (mut. S_1), the Bryozoa *Glauconome gracilis*, and *Heterotrypa tumida*, and the Trilobite *Phillipsia pustulosa*.

Chonetes cf. *hardrensis* and *Rhipidomella* aff. *Michelini* occur only at the base of the series.

The last Gastropod Bed (V) occurs 50 feet below the lowest shale. *Loxonema* and *Platyschisma* are still common, but *Dentalium* was not found ; *Bellerophon*, on the contrary, rare in Gastropod Bed (I), grows more and more abundant as one passes downward to Bed (V.).

I have described these Gastropod Beds in detail, as they are persistent through the entire breadth of the Gower Peninsula, and crop out near Parkmill on the East Coast, with precisely the same characteristics as are seen at Overton.

The last bed of *Sub-zone* S_1 consists of over 150 feet of hard blue limestone (14), with vast numbers of broken crinoid stems and scattered colonies of *Syringopora* and *Lithostrotion Martini* and a few specimens of *Bellerophon*. The exact thickness of this last bed cannot be stated, as it passes down below low water mark.

The upper beds of *Sub-zone* S_1 are palæontologically the most interesting in the Gower series. In the number and variety of their fossils they exceed any of the other beds, and the 90 foot layer of limestone and shale is the only one in which I came upon any trace of the waning order of Trilobites. Of the four genera known to exist in the Carboniferous Limestone, viz. *Phillipsia*, *Brachymetopus*, *Cyphaspis*, and *Griffithides*, thus far I have discovered only the first in the Gower Limestone.

In this *Sub-zone* S_1 evidence of upheaval and shallow water conditions is, I believe, discoverable (*vide* note).

From Overton to within half a mile of Worm's Head, a distance of about 5 miles, the beds extend without displacement, and, as in other limestone districts, are pierced by caves, which at Paviland, not far from Rhosilly, have yielded a rich harvest of Pleistocene mammalian relics.

Near the Worm's Head a fault occurs, and lower beds are thrust up. Unfortunately, however, the *Syringothyris Zone* (Zone C with horizon γ), of Dr. Vaughan, is buried under turf and débris, so that no opportunity of examining it occurs, and it is impossible to determine whether the sequence between S_1 and Z_2 is continuous.

ZAPHRENTIS ZONE.

Sub-zone Z_2.

Just below the coastguard look-out at Worm's Head, where a sharp anticlinal curve appears, beds referred to *Sub-zone* Z_2 crop out on the shore, composed of a series of flags, about 100 feet in thickness, with two thin but well marked veins of chert near the top (15).[1] Almost the only fossils in the whole of this series appear to be *Syringothyris* aff. *laminosa*, *Productus* aff. *semireticulatus*, and possibly *Conocardium*.

Syringothyris is thickly scattered over the surfaces of some of the flags, and good specimens can be procured weathered out.

[1] *Vide* Section C, on page 45.

At the north-east angle of Rhosilly Bay and immediately below the village, the Carboniferous Limestone rises sharply up over the Old Red Sandstone; but the junction of the two is hidden by an enormous mass of detritus.

Sub-zone Z_1.

The flags just referred to are seen here to overlie about 10 feet of unfossiliferous dark shale (16), under which a blue limestone is reached, packed with broken crinoid stems (17); a few fragments of calices were procured but too broken up to permit their being identified. In this bed Bryozoa are somewhat common, *Glauconome* sp. being the chief form. The only coral met with was *Zaphrentis* aff. *Phillipsi* (rare). Under this layer was a stratum of 20 feet (18), very rich in *Orthotetes crenistria*, *Productus* cf. *Martini*, *Spirifer* aff. *clathratus*, *Leptaena analoga*, *Chonetes* cf. *hardrensis*, which typify *Sub-zone* Z_1. *Chonetes* cf. *hardrensis* is the characteristic fossil of this bed, and in places the limestone seems almost entirely built up of it.

Gastropods occur at this horizon in a bed only a few inches thick, but they are not comparable in variety nor in abundance with those found in the bed of *Sub-zone* S_1.

The chief genera are *Bellerophon* and *Naticopsis*, and with these is associated an elongated slender *Orthoceras*.

These beds are the last which can be traced in the Rhosilly section, the underlying beds, however, are to be found on the banks of a little stream entering the sea at Parkmill,[1] on the east side of the Gower Peninsula. Though somewhat obscured by sandhills, the highly fossiliferous *Chonetes* bed, so noticeable a feature at Rhosilly, can be easily made out. About 14 feet of dense unfossiliferous limestone (19) divide it from a thin seam (19), with numerous but badly preserved specimens of *Spirifer* aff. *clathratus*. No trace of any organism occurs in the next

[1] *Vide* Section D on page 45.

bed (19), (15 feet), after which a layer yielding *Chonetes* cf. *hardrensis*, *Spirifer* aff. *clathratus*, *Rhynchonella* sp., and *Productus* cf. *Martini* is reached, which appears to be the limit of Z_1.

CLEISTOPORA ZONE.

Sub-zones K_1 *and* K_2.

Zone K, which is the last horizon of the Carboniferous Limestone, here comprises about 200 feet of red, grey, and black flags (20) ; but owing to their being almost devoid of fossils, the Sub-zones 1 and 2 cannot be differentiated in the South-West Gower series. At one spot only, towards the upper part of these flags, a grey limestone was found, containing a few specimens of *Eumetria* cf. *carbonaria*, and *Spiriferina octoplicata*. Below these limestone flags lies a bed of brown shale, from 4–6 feet thick (21), which in turn overlies the Old Red Sandstone, represented by a reddish Quartz conglomerate (22). The shale bed is presumably conformable to the Old Red Sandstone, but as the actual exposure here is a very small one and somewhat obscured by weathering, this cannot at present be definitely decided.

The palate bed, so prominent a feature in *Sub-zone* K_1 of the Avon Section, does not occur here, nor did I detect any teeth in *Sub-zone* Z_2, but as these are not very plentiful even in the Bristol limestone, a more extended search may possibly discover them at Rhosilly.

The thickness of the four zones described amounts to 1,500 feet, whilst that of the *Syringothyris* zone may be roughly estimated at nearly 300 feet more. Thus the entire thickness of the Carboniferous Limestone in South-West Gower must be about 1,800 feet.

NOTE.—In *Sub-zone* S_1 at Overton a vein of quartz sand consolidated into irregular crusts, exhibits precisely the same appearance as a recent layer on the surface of the cliffs formed from blown sand cemented by carbonate of lime. The vein of Carboniferous age is composed of rounded grains and rests on a somewhat irregular surface of limestone, and is suggestive of a brief period of elevation above sea level. A broken shell bed just below the sand vein points to a shallow water condition.

Note on the BRACHIOPODS and CORALS, collected by Dr. Brendon Gubbin, from the CARBONIFEROUS LIMESTONE of SOUTH-WEST GOWER, and the ZONES which they indicate.

By ARTHUR VAUGHAN, B.A., D.SC., F.G.S.

IN the following faunal lists the relative position of the fossils and their association are stated on Dr. Gubbin's authority, checked by the rough test of similarity or dissimilarity of matrix.

Explanations of the Zonal terms and symbols, as well as notes on the denotation of the fossil names, are given in my paper on the "Palæontological Sequence in the Carboniferous Limestone of the Bristol Area" (*Q.J.G.S.* vol. lxi.).

CLEISTOPORA ZONE, K_1 AND K_2.

Fully developed near Parkmill.

Fauna.—The number of specimens is small. *Spiriferina octoplicata* is apparently not uncommon in the upper part of the zone, where it is associated with an early Z_1 fauna. *Eumetria* cf. *carbonaria*, and *Modiola lata* occur (in association with *Camarotœchia mitcheldeanensis*) near the base of the zone; the fact that these two forms have only been found elsewhere in the lowest beds of the Carboniferous Limestone, where that formation lies conformably upon the Upper Old Red Sandstone, would suggest the same conformity in the Gower Peninsula.

ZAPHRENTIS ZONE, Z_1 AND Z_2.

Z_1 has a typical development at Rhosilly.

Fauna—

Zaphrentis aff. *Phillipsi* (rare).
Productus cf. *Martini.*
Chonetes cf. *hardrensis.*
Orthotetes crenistria.
Spirifer aff. *clathratus.*
Leptena analoga.

Z_2 is only suggested by the special forms of the few fossils found in the beds above the preceding sub-zone at Worm's Head, viz.—

Productus aff. *semireticulatus.*
Syringothyris aff. *laminosa.*
(?) *Conocardium alaeformis.*

HORIZON γ AND SYRINGOTHYRIS ZONE ; γ, C_1 AND C_2.

It is extremely unfortunate that Dr. Gubbin was unable to collect from these beds. It is consequently unknown whether the series is continuous between Z_2 and S_1, and also whether there is any distinct evidence of shallow water conditions in West Gower at the epoch when the neighbouring areas were subject to great physiographical disturbance.

HORIZON δ AND THE LOWER SEMINULA ZONE δ AND S .

Exceedingly well exhibited in the Overton Section.

Fauna—

Seminula ficoidea	Indicate the
Giganteid *Producti*	establishment
Chonetes papilionacea	of the
Lithostrotion Martini and vars.	Viséan fauna.

Productus semireticulatus (mut. S_1) | Indicate the survival of the Tournaisian fauna.
Orthotetes crenistria (mut. S.)
Spiriferina cf. *laminosa*
Caninia cylindrica (mut. S_1)
Chonetes cf. *hardrensis* | Occur near the base.
Rhipidomella aff. *Michelini*

A new species of the *punctatus* group of *Producti* is apparently very common at Overton; this species has already been found by Mr. T. F. Sibly in C_2 at Weston. *Heterophyllia* sp. is the first record of this genus from South Wales or South-West England. Gastropods and Bryozoans are abundant, and Trilobites are not uncommon; the species appear to be the same as those found in the Avon Section, Bristol, but the Gastropods are certainly more numerous. Among the Bryozoans, *Heterotrypa tumida* is very characteristic, as it is in the Avon Section.

UPPER SEMINULA ZONE, S_2.

Forming the upper part of the Overton Section and the lower part of the Porteynon Section.

Fauna—

Productus aff. *Cora* (mut. $S._2$) (abundant).
Productus hemisphericus (abundant).
Seminula ambigua (mut. $S._2$).
Seminula aff. *ficoidea*.
Athyris sp (cf. *glabristria*).
Athyris planosulcata | occur near base.
Alveolites sp.
Syringopora cf. *distans*.
Lithostrotion Martini.
Lithrostrotion affine.
Carcinophyllum θ.

NOTE.—*Seminula ambigua*, mut., and *Carcinophyllum* θ occur in the upper part of the sub-zone as they do elsewhere.

Athyris sp. is a form that occurs in S_2 at Lydstep (near Tenby), Burrington and Weston.

DIBUNOPHYLLUM ZONE D_1 AND D_2.

D_1 is characteristically developed in the Porteynon Section.

Fauna—

- *Productus* '*giganteus*.'
- *Productus hemisphericus*.
- *Syringopora* cf. *ramulosa*, *Syr*. cf. *geniculata* and *Syr*. sp.
- *Cyathophyllum Murchisoni* (abundant).
- *Lithostrotion Martini*.
- *Campophyllum* sp.
- *Dibunophyllum* θ (common).

D_2 forms the upper part of the Porteynon Section

Fauna—

- *Productus* sp.
- *Lithostrotion Portlocki*.
- *Lith. irregulare* and var. (abundant).
- *Lith. junceum* (common).
- *Lith. Martini* (Koninckophyllid, mut.), (common).

HORIZON ϵ.

This horizon is not represented by any of the fossils in Dr. Gubbin's collection; the highest beds he mentions contain abundant *Lith. irregulare*, and must be referred to D_2.

On a Cranium and other Human Bones from Kingston Bagprize, near Abingdon.

By JOHN BEDDOE, M.D., LL.D., F.R.S.

THIS skull belonged to one of several bodies which were recently discovered at a depth of about three feet in the earth during some excavations made by Mr. Guy Graham, occupier of the land. Kingston Bagprize lies about five miles to the west of Abingdon, and between two and three miles south of the Thames ; the land belongs to Mr. J. Noble C. Pope, to whose kindness I am indebted for the opportunity of seeing and examining the bones. Mr. Graham informs me that the bodies discovered, of which there were several, lay east and west, with the feet to the east ; they were in the natural earth, without any appearance of cist, coffin, or other receptacle. Mr. Graham thinks that the buriers dug down till they struck the rock. An iron bridle bit, and some fragments of fine dark-red pottery, most likely belonging to a drinking cup, accompanied this body ; among the bones sent me I recognized the mandible of a sheep, and there may have been other unhuman bones.

Both the skull and the long bones sent to me were badly fractured, but otherwise in not bad condition, so that I was able to reconstruct the skull, two humeri and two radii, and an ulna ; unfortunately, no femur or tibia could be restored, which fact renders the determination of the probable stature less easy than it might have been.

The following are my measurements :—

Cranium—*Lengths.* Glab.-max. 188 mm. Fronto-inial, 184. Glab. in., 184. Ophryo-max. 185. Face-lengths, 70 and 119. From Opisthion to lambda, 105.

Breadths. Frontal minim. 97. Steph. 114. Prè-auric. 110. Maximum, 138. Mastoid (prominent point of curve), 127. Asterial, 110. Bigonial, 87. Breadth Index, 73·4.

Height. Basio-bregmatic, 138. Ear-height, 120 ; this is somewhat doubtful : I cannot be sure of it. Height Index 73·4.

Circumf. horiz., 522. Sagittal. : Naso-inial, 130 + 112 + 74 = 317. Sub-occip., 53. Foramen, 36 (× 29). Basio-nasial, 102. Total, 508. Transverse, supra-auric, to centre of meatus over bregma 332. Total, 467.

Nasal Length, 53·8. Breadth, 25. Index, 46·5, leptorrhine.
Orbital Breadth, 38. Height, 31. Index, 81·6, microseme.
Palatal Length, 55. Breadth, 34.
Mandible. Depth of chin, 32. Length of Base, 83 ; of Ramus, 78.

				Stature by Manouvrier.	By Pearson.
Humerus	..	Right	330	1657	1661
	..	Left	326	1646	1650
Ulna	..		271	1696	
Radius	..	Right	247	1666	1661
		Left	244	1657	1651
Hum. + Rad.					1654·6
Means, about				1664·4	165·5
			=inches	65·53	65·16

Capacity, by Manouvrier's method, 1505 c.c., or perhaps less.
Welcker's 3 methods, C 1481, D 1495 × 1495, Mean 1490·3.
Pelletier's 1490
Beddoe's 1490
Pearson's . . . . . 1455, perhaps more.

I have used 115 × 2 as the divisor for Manouvrier's plan ; but I suspect that the master himself would have used a larger one, the skull being dolichokephalic, and the glabella rather prominent. 116 × 2 would give a quotient of 1492 c.c., when reduced to Flower's standard.

For Pearson's plan I have measured the ear-height at 120; but having no special apparatus for the purpose, and not being confident of accuracy in this difficult bit of mensuration, I put down the figure 1455 with some doubt. As all the other methods agree almost exactly, I think we may safely put the capacity at 1490 c.c., on Flower's standard, which is a very fair magnitude.

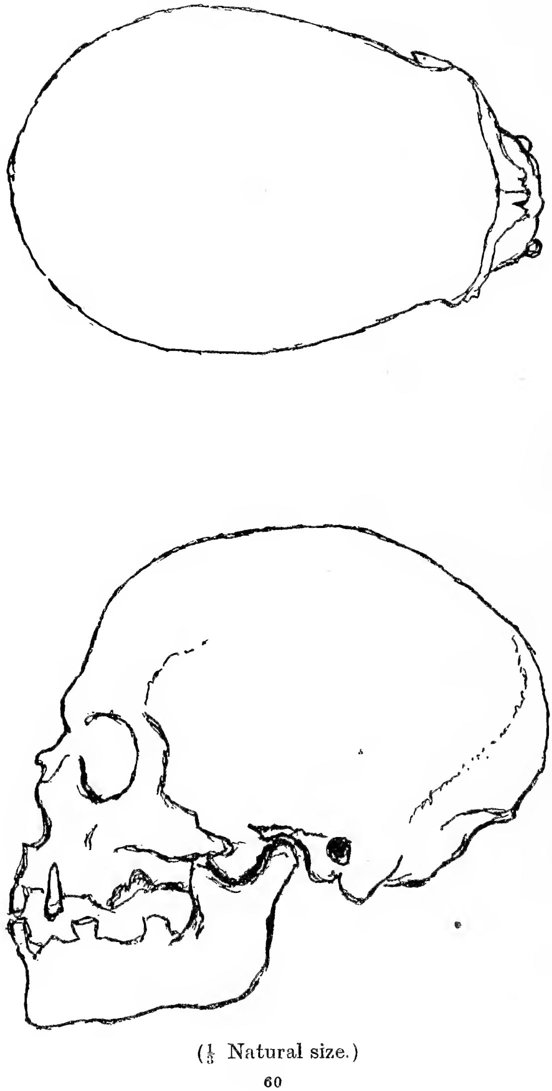
The vertical aspect of the cranium is a very regular, long oval; the lateral aspect shows moderate post-parietal flattening and capsulation, or *absätzung*; it shows also a prominent glabella, a prominent, probably aquiline nose, and a slight degree of prognathism. The whole aspect reminds me of the Sion type, considerably lengthened; the Sion type of His and Rutimeyer was probably true Helvetian; but Ranke thinks it predominates in the modern Franconians.

Other points to be taken into account are: The presence of iron in the form of a bridle-bit—that might indicate the late Keltic or any later period; the parallel position of the bodies, reminding one of the Rowgrave or late Pagan-Teutonic period; the orientated position, perhaps early Christian; the pottery, which I cannot date, though some expert may yet do so.

My own diagnosis, or rather conjecture, is that we have here the remains of a Saxon of the earliest Christian period, that is, of the former half of the seventh century, and that he was of mixed blood, his mother or grandmother having been a British or Welsh woman more or less of the ancient "bronze type." He was of rather sturdy build, but his stature was probably not more than 1660 millimeters, or say five feet five inches and a half.

NOTE.—The Bagprize skull was found at Kingston hill farm, Bagprize, about six miles from Abingdon in Berkshire.—H. BOLTON.

CRANIUM FROM KINGSTON BAGPRIZE.



($\frac{1}{3}$ Natural size.)

Report on Two Skulls Found at Great Depths at Bristol Dockgate and at Avonmouth Dock.

By JOHN BEDDOE, M.D., LL.D., F.R.S.

I SHALL confine my remarks pretty much to what may be inferred from inspection and mensuration of these skulls ; the geological surroundings and the question of the respective ages I will leave to the more competent hands of Mr. Bolton.

The two are in several respects strongly contrasted. The Bristol one is masculine, very small, extremely thick and heavy ; the Avonmouth one feminine apparently, large, capacious, extremely thin and light. The former is mesatikephalic, the latter hyperbrachykephalic. The former is absolutely perfect, with the exception of the maxilla ; the latter wants also the facial bones, but the brain-case is sufficiently well preserved to admit of mensuration.

MEASUREMENTS.

	Dockgate Skull.	*Avonmouth Skull.*
Length, glab.-max.	173	172
Fronto-inial	166	161
Glab.-inial	167	162
Ophryo-max.	166	167
Facial (nas.-alv.)	63	—

MEASUREMENTS.

	Dockgate Skull.	*Avonmouth Skull.*
Breadth, frontal min.	86	98
Stephanic	104	120
Zygomatic	126	—
Supra-auricular	106	118
Maximum	135	148
Mastoid	114	131
Asterial	102	106
Height, basio-bregmatic	122	127
basio-max.	122	130
Ear-height, marginal	109	114·3
central	104	119·5
Circumference, horiz.	489	505
Sagittal, frontal	123	124
parietal	123	122
occipital, sup.	67	64
inf.	42	46
Foramen	30	35
Basio-nasial	88 alv. 83	94
Total	473	485
Transverse, medio-auric	299	328
Total	410	464
Nasal measures	45, 26	—
Orbital measures	33, 29	—
Index, of breath	78·03	86·04
,, of height	70·52	73·84
,, Nasal	46·6	—
,, Orbital	87·8	—
,, Facial	50	—

Weight of Dockgate skull (without mandible), 41 ounces avoirdupois ; of Avonmouth skull (wanting also the facial bones, ethmoid, central sphenoid, and small portions of the frontal and occipital), 14 ounces.

The Dockgate man, from the evidence of the teeth, and from the open condition of the sutures, appears to have been a young adult. In the norma verticalis the form is rather sphenoid or pentagonal than oval, and the zygomata are conspicuous ; the occipital aspect shows nothing markworthy ; the lateral shows prominent brow ridges, an enormous glabella, and a forehead arched, but rather narrow, low and receding, and a tolerably regularly curved outline, until we arrive at a very large inion, strongly hooked downwards.

In the face the cheek-bones are broad and prominent, the orbits high but square, the nose platyrrhine and probably concave ; and there is slight alveolar prognathism.

The breadth index is mesatikephalic, but if reckoned by the ophryal length, as Flower would have done, it would be brachykephalic ; and indeed, its general contour and aspect seem to me those of a man of the bronze race, or at least of that type. I have not seen any of the bones said to have been found with this skull, nor can I give any opinion of the age of the silt or gravel-bed in which it was found.

Though the external measurements of this skull are not remarkably small, its internal capacity is so, owing to the unusual thickness and weight of the cranial bones. The computed capacity is certainly greater than the true one by every plan of estimation.

Thus Welcker's Table D would give 1,268 c.c. ; Pearson and Lee, 1,266 ; Beddoe, 1,264 ; Pelletier, 1,220 ; Welcker's Table C, 1,216 ; Manouvrier, 1,197. The last certainly comes nearest the truth. But by actual gauging, with peas, on Welcker's plan, I got only 1,002, figures near the border of imbecility. I am by no means an expert gauger, and the truth may probably be a little larger than this, but I should guess it at less than 1,100.

In the case of the Avonmouth skull there is little evidence as to the age of the owner ; but as the sagittal and sphenoidal sutures are obliterated, I should think he or she was of considerable age. The sex is doubtful—I should say feminine, chiefly on the ground of the extreme thinness of the bones, and the almost complete absence of apparent muscular attachments. The glabella and brow-ridges are, however, rather prominent, and the size and capacity are rather large for a woman. The smooth almost spherical form, and the flatness of the foraminal region, raise some suspicion of hydrokephalus. The general form approximates that of a sphere whereof two portions have been cut off by sectors ; in the occipital aspect this appearance is very striking ; the vertical aspect is very broadly ovo-elliptic ; the index, if calculated in the usual way, is 86, but if on the ophryal length, is not less than 88·6. The zygomata are gone, and were probably very feeble, and not visible in the norma verticalis.

I am told that the geological evidence for considerable antiquity is stronger in this case than in that of the other skull. So far as the form enables one to form an opinion, I am disposed to see in this one also a specimen of the "bronze" race or type. I prefer the term "Bronze" to that of Goydelic, or to any term which ties us down to an unproved, however probable, historical theory.

It may, however, be worth while to note how often it has happened that in prehistoric finds of presumably very early date a single extreme brachykephal has been found associated with pronounced dolichokephals.

The capacity of this skull is, as aforesaid, large for a female specimen. It cannot be ascertained by actual measurement. By various methods of estimation it comes out as follows—

	Pearson & Lee.	C. Welcker.	Do., D.	Pelletier.	Manouvrier.	Beddoe.
If male .	1386	1391	1419	1392	1408	1452
If female .	1370	?	?	1450	1447	1500

In this case I have no doubt that my own method gives the most satisfactory, as it does the largest, result. The spheroidal compact form, the smooth exterior, the thinness of the bones, all tend unduly to reduce the bases of computation.

Note as to the occurrence of the skulls, by Herbert Bolton, F.R.S.E., curator of the Bristol Museum :—

The Avonmouth skull was found at a depth of 24½ feet below Ordnance Datum, and 46 feet below the surface. The deposi consists of a layer of mud and sand loam containing pockets of peat, and the bones and skulls of oxen and sheep.

The Bristol Skull was found in an excavation for the foundation of a tobacco warehouse near the new Ashton Swing Bridge. It occurred at a depth of about 40 feet in river silt, and was accompanied by a large series of bones of oxen, mediæval pottery, etc.

Reports of Meetings.

GENERAL.

THE usual eight monthly meetings were held during the year 1904, the forty-first in the history of the Society. Dr. A. B. Prowse, the retiring President, selected the subject of the " Life History " of the Bristol Naturalists' Society for his address at the Annual Meeting on January 28. The subjects brought before the Society at the General Meetings were as follows :—

Feb. 11.—Mr. G. C. Griffiths, on " The Migration of Lepidoptera."

Mar. 3.—Miss I. M. Roper, on " Flowers of Mendip."

Apr. 7.—Mr. H. J. Charbonnier, on " The Birds of our Woodlands," and Dr. A. B. Prowse, on " The So-called Vegetable Caterpillar."

May 5.—Mr. R. Phillips, on " Wanderings in the Bush and Jungle of Northern Queensland," and Mr. H. Bolton, F.R.S.E., " On Some Abnormally Marked Lion Cubs " and " On the Occurrence of a Shell Bearing Gravel at Dumball Island."

Oct. 6.—Mr. H. J. Charbonnier, on " Local Diptera."

Nov. 3.—Mr. O. C. M. Davis, on " Fermentation," and Dr. J. Beddoe, M.D., LL.D., F.R.S., on " A Cranium and other Human Bones from Kingston Bagprize, near Abingdon," and Report on Two Skulls found at great depth at Bristol Dockgate and at Avonmouth Dock.

Dec. 1. Mr. C. A. Wood, on "Beside a Gloucestershire Stream."

The following specimens were exhibited on January 28: A flowering branch of *Eucalyptus globulus*, by Dr. A. B. Prowse; Feb. 11, a parlour palm (*Aspidistra lurida*) in flower, by Dr. A. B. Prowse, and a tail of the Lyre Bird, by Dr. A. C. Fryer; May 5, a nest of the trap-door spider, by Dr. A. B. Prowse; Oct. 6, a sage whose bracts during flowering showed a crimson colour, and a white-flowered Herb Robert, whose colour had remained constant for fifteen generations, by Dr. A. B. Prowse; also specimens of *Helianthemum polifolium*, *Scilla autumnalis* and *Primula scotica*, by Mr. C. A. Wood.

BOTANICAL SECTION.

THE year 1904 is memorable in the annals of Bristol Botany for the discovery, within a few miles of the city, of a new British grass—a species well known in France and Central Europe, but which has remained unidentified in this country until a few months ago. Particulars must be reserved for the present, as the discoverer has not yet published the details of this remarkable find.

Almost as surprising to west-country botanists was the news that *Aster linosyris* is not yet extinct with us, as had been feared. No living specimen had been seen in Somersetshire for close on half a century, so that the report of about 100 good plants still existing in the Bristol district is most cheering.

Barbarea intermedia has been added to the local flora from both West Gloucester and North Somerset. The writer has examples gathered near Fishponds, Nailsea and Portishead. The plant is not a conspicuous weed, and seems to occur only in small quantities ; it may therefore be readily overlooked. Still, the characters that distinguish it from *B. vulgaris* and *B. præcox*—between which species it is intermediate—are well marked and sufficient. The leaves are all pinnatifid ; the flowers are smaller and of a deeper yellow than with the congeners ; the pods short, thick, crowded, erect, with short conical points. The original description by Boreau (Flore du Centre de la France) is to be preferred to those given in works on British Botany. Although rare in Britain, I expect to hear that this new member has been detected in other localities.

There will have been remarked in Swete's *Flora Bristoliensis* a paragraph relating to the occurrence of *Trifolium resupinatum* in a meadow east of Shirehampton, where it was gathered by a Mr. Drummond many years ago, and whence it speedily disappeared. The circumstance received more attention than it deserved in several publications. For this clover has no claim to be considered a British plant. It is an alien, and is only found in this country as an introduction with corn, seed, or foreign forage. As such, a plant or two from time to time has been noted about Bristol, at St. Philip's, Conham, and Portishead Dock. But during the past summer a very unusual quantity appeared upon our Downs. Mr. C. Wall drew my attention to at least nine patches growing among the turf, one of them a long way from any path, the others close to a roadside. This was a curious invasion, and it will be interesting to see if the plants survive our winter or be reproduced. About the same time Mr. Wall discovered *Sclerochloa loliacea* near the Severn Passages, thus making a new record for the county of Gloucester. This grass was known in the district previously only from Weston-super-Mare and Burnham.

One of our rarest plants—the *Vaccinium oxycoccus*—hitherto found very sparingly in one bog on Blackdown, has been noticed by Miss Roper in a second locality near Priddy. The delicate prostrate stems, creeping among Sphagnum, are always difficult to find.

Three new-comers, not before recorded in this neighbourhood, have appeared in some abundance on waste ground in St. Philip's, viz. *Galium Vaillantii*, *Centaurea calcitrapa* and *Apera interrupta*. From the nature of the ground, these cannot be expected to endure long at the same spot; but the causes that introduced them will remain in operation, and therefore it is quite likely that they will reappear at intervals in the vicinity of our docks and railways.

JAMES W. WHITE, F.L.S.,
Hon. Sec.

GEOLOGICAL SECTION.

THE Section commenced the year with fifty members and ended with fifty-seven, six having resigned during the year. Professor S. H. Reynolds, M.A., F.G.S., was re-elected President, and Mr. B. A. Baker Hon. Sec.

There have been nine Meetings of the Section, at which the following papers were read :—

Feb. 4.—"Notes on the Geology of the Volcanic Eifel," by Miss F. MacIver.

Feb. 18.—"The Rhætic Bone Beds," by W. H. Wickes.

Mar. 17.—"The Mesozoic Rocks of Northern Ireland," by Prof. Grenville A. J. Cole, of Dublin.

April 28.—"Notes on the Carboniferous of the Avon Gorge," by Dr. A. Vaughan, B.A., F.G.S.

May 19.—"Notes on the Geology of Shropshire, with special reference to the Church Stretton district," by Prof. S. H. Reynolds, M.A., F.G.S.

June 16.—" The Carboniferous Limestone of Burrington Combe," by T. F. Sibly, B.Sc.

Oct. 20.—" Notes on the Volcanic District of Auvergne," by Prof. S. H. Reynolds, M.A., F.G.S.

Nov. 17.—" The Relations between the Carboniferous Limestone, Yoredale and Pendleside Series," by Dr. A. Vaughan, B.A., F.G.S.

Dec. 22.—" The Fauna and Flora of the British Coal Measures," by Herbert Bolton, F.R.S.E.

The average attendance was twenty-two at each meeting.

The Financial Report shows a total receipt of £8 16*s*. 4*d*., including the balance of £2 13*s*. 10*d*. brought forward from last year, and a total expenditure of £7 6*s*., leaving a balance of £1 10*s*. 4*d*. to be carried forward to 1905. The Section has made a donation of £2 to the parent Society, towards the expense of printing the *Proceedings*. There still remain sixteen subscriptions unpaid, one subscription remaining unpaid from the previous year. This Report shows that the Section continues to progress, but there still remains room for a great increase of members. There are several most interesting Reprints of Geological Papers to be had from the Hon. Librarian, at a small cost.

B. A. BAKER,
Hon. Secretary.

ENTOMOLOGICAL SECTION.

JANUARY 15.—Annual Meeting. Mr. R. M. Prideaux communicated a paper on " First Appearances of a few Species of Diurni in the years 1893 and 1903." The average date in the cases of the twenty-two species recorded was thirty-seven days later in 1903 than in 1893, no doubt arising from the climatic conditions existing in these years.

Mr. H. J. Charbonnier exhibited a large number of specimens and coloured drawings of galls made by insects of various orders: the habits of the gall-makers were described, with interesting remarks upon parasitism and other facts connected with their life histories. Mr. Charbonnier also showed a specimen of the leaf insect *Phyllium scythe*, with illustrations of its ova, which resembled seeds, an instance of probable protective value.

Feb. 25.—Dr. C. King Rudge exhibited a vellum-bound book, dated 1678, which had been attacked by bookworms, and the habits of the beetle *Anobium paniceum*, Linn., were described.

A specimen of the large water bug *Belostoma grandis* was also shown.

Mr. G. C. Griffiths exhibited, amongst others, the following rare species of Lepidoptera: *Shœnbergia paradisea*, Staud., from New Guinea; *Eurycus cressida*, bred at Clifton, from Brisbane pupa; *Luehdorfia puziloi*, from Japan; *P. imperator*, *poeta*, and *Thibetanus*, all from Thibet; *Papilio pilumnus*, Mexico; *P. Texana*, Texas; and *P. Troilus*, from Delaware.

Mar. 15.—Mr. H. J. Charbonnier exhibited eighty-nine British species of *Syrphidœ*, and explained many points in their economy; also by a geological chart showing that these were amongst the most recent of insects occurring in the Miocene period.

Mr. G. C. Griffiths exhibited for comparison British and Canadian examples of *Oporabia dilatata*, *Scotosia undulata*, and others.

Dr. C. King Rudge produced living specimens, representing six species, of *Entomostraca*, reared from river mud from Gihon, Jerusalem; the specimens had survived after having been in the mud dry for four or five years.

Oct. 18.—Mr. G. C. Griffiths reported having continued his researches upon the frenulum in Lepidoptera, in an examination of the *Pterophori*, or plume moths, a number of which were shown. The President also exhibited numbers of species of Lepidoptera, principally of the genus *Colias,* when a discussion took place regarding the cause of the predominant colours—yellow and orange—in this genus.

Mr. H. J. Charbonnier read notes communicated by Mr. C. J. Watkins, of Painswick, upon certain species of Lepidoptera observed there in 1904.

Nov. 15.—Dr. C. King Rudge exhibited a specimen of a Mole cricket (? sp.), taken on board ship off the coast of Java.

Mr. G. C. Griffiths exhibited numerous specimens of *Satyrinæ,* including ♂ and ♀; *Zethera thermœa,* Hew., from Luzon, Philippines; and *Pierella Hymettia,* Stdgr., from Ecuador.

Mr. H. J. Charbonnier showed coloured prints of the eggs of the Guillemot, and watercolour drawings, done life-size by himself, of Guillemot, Dunlin, Ringed Plover, Water-rail, Corncrake, Quail, Woodcock, and Peewit.

The Secretary exhibited ♂ and ♀ specimens of *Nyssia lapponaria,* from Rannoch; also a box of Hymenoptera and Diptera captured near Crantock, North Cornwall.

CHARLES BARTLETT,
Hon. Secretary.

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FOURTH SERIES. VOL. I. PART II.

PREFACE.

The excellent series of photographs, which form the most attractive feature of this paper, were all taken by Prof. S. H. Reynolds, M.A., F.G.S., who has devoted much time and trouble to the satisfactory illustration of the Avon Sequence.

The cost of publication of the plates has been most generously defrayed by a large number of geologist-friends.

To them, and to Prof. Reynolds, are due the thanks, not only of myself, but of all those who are interested in the study of the Carboniferous Limestone.

In the hope of making the text worthy of the illustrations, of the kindness of the contributors, and of the grand section with which it deals, I have carefully revised my earlier work and have included the results of later research.

A. V.

Clifton, *May*, 1906.

The Carboniferous Limestone Series (Avonian) of the Avon Gorge.

By Arthur Vaughan, B.A., D.Sc., F.G.S.

Contents.

I. Introduction.

This paper is intended to serve as a geological guide to the grand section of Carboniferous Rocks which is exposed in the Avon Gorge. It is hoped that a visitor who is interested in the geology of the Gorge will, without further aid than this manual, be able to recognize the various phenomena to which attention is drawn, and to test the interpretations which are here suggested.

The technical knowledge which is postulated is of the most elementary kind, for I deem it more useful to attempt to arouse the interest of the student than to set out a concise disquisition for the delectation of the Carboniferous-specialist.

With this end in view, I have appended elementary definitions of the generic names which recur most frequently in the text; the section devoted to this purpose is intended for the use of the student only, since its necessary incompleteness will render it unsatisfying to the specialist.

Again, since the paper deals mainly with the establishment and analysis of the faunal succession, it has been necessary to introduce a brief statement of the biological principles upon which the zoning of the Lower Carboniferous Rocks has been carried out, and also to point out certain fundamental phenomena which characterize faunal variation.

Lastly, since this manual is confessedly a compilation, I have seen no reason for nicely allotting the credit for each fact, and for each law, to its first discoverer.

History

It would be a laborious, if not an unprofitable, task to collect all the references which have been made by earlier writers to the rocks and scenery of the Avon Gorge. I shall consequently content myself with references to the work of those few geologists who have examined the section systematically, and with the purpose of some definite line of research.

Nearly a century ago, in a paper entitled 'On the Limestone Beds on the River Avon, near Bristol,'[1] George Cumberland gave a minute description of each bed in the Avon Section and, although the old-time terminology sounds strange, it is not difficult to recognize certain of the best known horizons from the writer's descriptions.

Some sixty years later,[2] W. W. Stoddart undertook a detailed examination of the Carboniferous Limestone Series of the Avon, with the view of compiling an exhaustive record of the fossils found in each bed. An analysis of Stoddart's paper, in so far only as it deals with Corals and Brachiopods, will be found, set forth at considerable length, in my paper on the Bristol Sequence.[3]

[1] Geol. Trans. (1811 and 1818).
[2] Proc. Bristol Nat. Soc. n.s. vol. i. (1875), p. 313.
[3] Quart. Journ. Geol. Soc. (1905), vol. lxi. p. 200

In 1885,[1] Prof. C. Lloyd Morgan, LL.D., F.R.S., F.G.S., published an extremely suggestive account of the Avon Gorge in which he pointed out the broad principles which have governed the formation of the Gorge itself and of its tributary depressions. The magnitude of the Great Fault and its extension on the Leigh Woods side of the river are also discussed in the same paper. The present communication will, it is hoped, serve as a necessary complement to the work of Prof. Lloyd Morgan by filling in detail, where he has already firmly sketched the broad outline.

Mr. E. B. Wethered, F.G.S.,[2] has dealt with the micro-structure of the rocks which form the Avon Sequence and has classified the local development of the Lower Carboniferous Rocks into broad lithological divisions.

From 1902 to 1905, I was engaged upon the detailed examinations of the Carboniferous Limestone sequence in the Bristol Area, with the special object of determining the faunal sequence and of setting out a series of life-zones. The results of this investigation are described in my paper, 'The Palæontological Sequence in the Carboniferous Limestone of the Bristol Area,' to which reference has already been made. In this paper, the Avon Section is described in considerable detail and is adopted as the type-section for the Avonian of the South-Western Province.

Fossil Notation The following definitions explain the precise meaning which is to be attached to the conventional symbols employed in the designation of fossils throughout this paper.

A species is a form so completely described that the characters of two individuals, both of which are correctly referred to the same species, can only differ in degree of expression; furthermore, all the individuals which constitute a species must

[1] 'Subaerial Denudation and the Avon Gorge.' Proc. Bristol Nat. Soc. n.s. vol. iv. p. 171.

[2] 'On Insoluble Residues obtained from the Carboniferous Limestone Series at Clifton.' Quart. Journ. Geol. Soc. vol. xliv. (1888), p. 186.

be continuously connected in time. (An individual in which all the characters of a certain species are reproduced, but which came into existence long after that species had died out, cannot be correctly assigned to the same species.)

The whole assemblage, which is composed of the ancestors, descendants and collateral relatives of a given species, constitutes the gens of that species and is denoted by prefixing 'aff.' to the specific name. Thus, *Productus* aff. *semireticulatus* denotes *any* member of the gens of which *Prod. semireticulatus* (Martin) is a well-known member.

In the case of a long-lived gens, an early member usually differs sufficiently from a late one to constitute a new species. All such time-variants of a given gens are here referred to as mutations of the gens and the time at which a given mutation flourished is indicated by the addition of a zonal or subzonal symbol to the abbreviation 'mut.' Thus, *Spirifer* aff. *bisulcatus*, mut. C. implies a species which existed at the time indicated by the zonal symbol C. (v.i.) and which is a member of the gens containing *Spirifer bisulcatus*, J. de C. Sow.

A homœomorph is a form which strongly resembles the species with which it is compared, although it is presumably not a member of the same gens. Homœomorphy is indicated by inserting 'cf.' before the specific name of the form with which comparison is made. Thus, *Orthothetes* cf. *crenistria* bears a strong resemblance to '*Spirifera*' *crenistria*, Phillips (as typified by the specimen preserved in the Gilbertson Collection), but the two species are presumably not members of the same gens since Phillip's species appears to be a *Derbya*, whereas the form which is here denoted by *Orthothetes* cf. *crenistria* is a true *Orthothetes*.

The Theory of Zoning Stratigraphical Zones are subdivisions which succeed each other always in a definite order; they may be defined by the occurrence of a particular rock-type ('Lithozones'), or by some faunal particularity ('Biozones').

Lithozones, by their very nature, can only determine horizons within a very limited area and must always be employed with great caution.

For example the *laminosa*-dolomites, the *Caninia*-oolite and the *Caninia*-shales and dolomites succeed one another in ascending order throughout the Bristol Area, but their relative thicknesses vary considerably from point to point and the sequence cannot be recognized in the Mendip Area, which lies only a short distance to the south.

On the other hand, a sequence of biozones may be of world-wide application and, however ill-chosen, must always express some portion of the truth, seeing that the definition of a biozone must always be the record of part of the fauna which existed during a definite interval of relative time.

It is, however, easy to understand how a series of biozones, defined by the successive faunas of a particular locality, may appear to fail when applied to a more extended area.

For, let us suppose that three successive zones at a certain locality indicate oscillatory succession of conditions, as expressed by the ascending sequence :—

A, containing a normal shallow-water fauna ;

B, containing a normal fauna of moderate depth ;

C, containing a normal shallow-water fauna.

The faunas of A and C will be essentially similar, and that of B markedly different, since the life-assemblage at different bathymetric levels is distinct.

If, now, the fauna of C, while presenting the same broad generic facies, differs from that of A in the introduction of new species in place of old ones, it will be perfectly legitimate to select the faunas of A and C as defining two successive biozones. In so doing, we implicitly adopt shallow-water conditions as our standard conditions for purposes of zoning and consequently the complete series of biozones must express the successive shallow-water faunas throughout the whole interval which is to be zoned.

The fauna of B would be very incorrectly set down as constituting a zonal assemblage intermediate between those of A and C, for it is impossible to discover, either how early in the zone of A the fauna of B became established, or how late it persisted into that of C. Hence B must be regarded as an interruption of the zonal sequence.

Any such interruption of a zonal sequence, by deposits formed under conditions distinct from the standard conditions which have been selected for the purpose of zoning, is termed a 'Phase.'

In the South-Western Province the standard conditions must be chosen to be those which, under normal circumstances, existed at moderate depth, for these are the conditions which prevailed during the greater part of Avonian time throughout the Province. Two 'phases' are co-extensive with the Province;—the *Modiola* Phase of the *Cleistopora*-Zone characterized by shallow-water conditions, and the S_2-Phase of the *Seminula*-Zone, which was deposited in shallow water containing an excess of carbonate of lime.

Certain phases are purely local within the Province and the most important of these is the dolomite-phase of the *Syringothyris*-Zone which is characterized by abnormal shallow-water conditions. Since however this phase is undeveloped in part of the area (for example, in the Mendips) the faunal succession under standard conditions can be satisfactorily filled in.

In the Bristol Area, the Brachiopods and Corals are the only two classes which are sufficiently abundant throughout the sequence to render a system of zones, founded upon their faunal variation, both reliable and useful.

It has been found advisable to study the variations of at least two classes, in order that the zones constructed from Coral-variation may be checked by the simultaneous Brachiopod-variation. For if, at each of two distant points within the Bristol Area, two time-scales be graduated in terms of the variation-incidents which are exhibited by the Corals and Brachiopods separately, it is found that the same variation-incident, which is marked on both Brachiopod-scales, does not occupy exactly the same position with reference to the graduations of the two coral scales at the two localities. (In fact, in passing from south to north, the entrances of the coral gentes occur later and later, as measured over a considerable segment of the Brachiopod-scale, whereas the *sequence* of variation-incidents, which form the graduations, remains constant for both the Brachiopod and Coral scales.)

This irrationality of two time-scales, constructed from the variations of two different classes, represents a relative acceleration of the one class upon the other and its existence puts a definite limit to the smallness of useful zonal divisions ; for the size of a zone or subzone must necessarily be large when compared with the error which may be introduced by relative acceleration.

We have now to tabulate the successive species or mutations of each gens of the two classes we have selected and to express the relative times at which each mutation was dominant.

It has been pointed out by several observers that a species, during its period of dominance, retains its distinctive characters without appreciable change and that transitional forms connecting it to other species are relatively scarce.

This general principle is strikingly exemplified in the variation of a gens. Each new mutation arrives almost unannounced and is usually never more abundant than at the time of its first establishment. (Careful search usually results in the detection of a few early forerunners of each mutation and, in a small number of cases, the maximum development of a species does not take place until some time after its first establishment.)

Each gens may be conveniently represented graphically by a line upon which stations are marked which represent the maxima of successive mutations, and the distance between two stations is measured proportional to the actual thickness of strata in the Avon Section which intervenes between the maxima of the two mutations. (Where a station cannot be fixed from the occurrence of a mutation in the Avon Section itself, its position must be approximately fixed by correlation.) This method is of more practical use than the attempt to plot accurate time-intervals by reducing the thicknesses of various deposits, by estimation, to one uniform rock-type.

A Range-diagram is now constructed by plotting all the gens-lines parallel to one another, and at arbitrary distance apart, in such a manner that any transverse line which cuts all the parallels at right angles is an isochrone, and the aggregate of the mutations which lie upon it represents the faunal assemblage of a particular instant of zonal-time.

The Range-diagram is the complete expression of the faunal succession and, upon it, every system of zoning must be founded.

It is not, however, an entirely simple matter to draw up a series of zones from the mere inspection of a Range-diagram.

Theoretically, any one of the long gens lines upon which several stations are marked would serve as a time-scale, but the longer the life of a gens, the greater is its stability and, consequently, the greater are the distances between successive mutations and the smaller the actual difference between them (in other words, a long-lived gens has a low variation-gradient). *Orthothetes* cf. *crenistria* affords an excellent example of the practical difficulty in employing this method.

Again, a long-lived gens is usually dominant only during a limited part of its existence and is relatively unimportant during the remainder of its life.

The practical stratigrapher naturally desires to fix his zonal position by the aid of fossils which are at once easily found and easily recognized (in fact by a system of 'spot-zoning') and this method leads to absolutely accurate results, so long as it is only relied upon within a small area. There are, however, several weighty objections to this method, if its intrinsic limitations are not fully appreciated.

(1) It usually happens that the various species of a gens, or of closely allied gentes, are not all dominant *throughout* a large area, but that an earlier species is dominant in one part and rare in another, whereas a later species may be rare in the first locality and dominant in the second. Hence, the field worker,

who is not specially trained to the appreciation of variational differences, may confuse the later for the earlier variant if he pass immediately from the first locality to the second.

The case of *Zaphrentis* aff. *Phillipsi* which characterizes Z, and *Zaphrentis* aff. *Enniskilleni* which marks the upper part of D, may be cited as an excellent example.

(2) A particular area may, during a certain period, have been subject to peculiar conditions and consequently exhibit a peculiar faunal assemblage. If a dominant fossil of such an assemblage be selected as a zonal fossil, it will probably be of value only in areas which were subject to the same conditions during the same period, and the absence of the fossil will not denote the absence of deposits of that particular age in areas which do not exhibit the special conditions.

(3) If a species which exhibits very exaggerated characters be selected as a zonal fossil, there is a danger of confusing the local extinction of a mutation of a gens with the total and general extinction of the gens itself.

Extinction is frequently accompanied by the development of excrescences, such as spines and exaggerated ornament in the Brachiopods, roots and the excessive development of vesicles in the Corals, and these striking moribund characters almost completely conceal the less pronounced mutational differences upon which we rely for fixing zonal positions. If, then, a gens becomes extinct in a particular area, owing to the incoming of unfavourable conditions, the individuals which stayed on in the area until it became uninhabitable may exhibit the same moribund characters which are to be seen in the last stages of the gens itself at a much later time.

For example, the temporary extinction of the gens of *Productus semireticulatus* at the top of S_1, in the Bristol Area, is signalized, in the last representatives, by the extraordinary development of spines and marginal accretions.

On the other hand, the structural complexity or specialization which heralds the general extinction of a group affords an extremely valuable measurement of time-intervals; for, in such cases, the variation-gradient is abnormally large and appreciable variation takes place in small intervals of time. Among the Corals, the Clisiophyllid group exhibits this rapid variation in the most striking manner and the degree of specialization affords a valuable guide to zonal position.

There is one other natural law which assists very materially in the determination of time-level.

At any one period, there is a general tendency among the gentes of the different genera of the same class to adopt some particular character which is possessed by the particular group of that class which is dominant at the time.

For example in *Dibunophyllum*-time, (1) the *Cyathophylla* and the Lithostrotions adopt, more or less completely, a Clisiophyllidan type of structure.

(2) *Productus* aff. *giganteus* and *Chonetes* aff. *comoides* become closely assimilated.

In the working of this law, genera lose their distinctness and their artificiality is often strikingly displayed.

Characters which are common to several genera at the same time may be termed time-traits, and the general law itself may be entitled convergence or coeval assimilation.

To sum up:—

A natural system of zonal indices must be based upon the variation of the gens, those gentes being best adapted for our purpose whose variation-gradients are large.

In practice, dominant species must be relied upon for purposes of zoning and, consequently, we are frequently forced to change from one gens-line to another.

The presence of a zonal fossil suggests a zone, but does not fix it; for it is, by nature, impossible to select a series of indices which shall be exactly conterminous.

In fine, the zonal index merely connotes the whole faunal assemblage which is the ultimate expression of a biozone.

The Zonal System The faunal assemblages which characterize the successive zones and subzones in the Carboniferous Limestone Series of the South-Western Province will be sufficiently understood from the fossil lists which are given under each division in the descriptive portion of this paper, and the zonal and subzonal indices are set forth in the same place. It is only necessary, here, to draw attention to the implication of certain new terms which are employed in the zonal scheme.

Avonian denotes the whole interval of time during which the Carboniferous Limestone Series of the South-Western Province was being laid down. It is divided into two main periods, the *Clevedonian* and the *Kidwellian*, which are characterized by essentially distinct faunas.

The Clevedonian is subdivided into three zones, namely the *Cleistopora*-Zone, the *Zaphrentis*-Zone and the *Syringothyris*-Zone.

The Kidwellian is divided into two zones, namely the *Seminula*-Zone and the *Dibunophyllum*-Zone.

Each zone is again divided into subzones, and, for local use only, into Phases.

The highest portion of one zone and the lowest portion of the next usually exhibit a mingling of the two faunas which are respectively characteristic of the two zones; such levels of faunal overlap are termed Horizons.

The use of a new term, Avonian, in place of the old and well-established Carboniferous Limestone, is a necessary outcome of the knowledge acquired by recent zonal work. A deposit is Lower Avonian, for example, because it contains a definite faunal assemblage; it is Lower Carboniferous Limestone, merely because it happens to occur at the base of a local series of limestones. For example, Dr. Wheelton Hind has recently shown[1]

[1] Abstracts of Proc. Geol. Soc. (1906), p. 88.

that the base of the 'Carboniferous Limestone' in the North Wales area is of Upper *Seminula* age and belongs, therefore, to a very much later date in the earth's history than the base of the Carboniferous Limestone in the Avon sequence.

The statement that a particular species occurs at a certain level in the 'Carboniferous Limestone' of one locality affords no clue to its position in the Carboniferous Limestone' of a second locality. On the other hand, the statement that a certain fossil occurs in a particular zone of the Avonian fixes its relative position for all localities.

Example of an Avonian Time-Scale

It will not, I hope, be wasted space to close this short outline of zonal method with a tabular summary of some of the more important incidents which marked the progress of Avonian time.

The particular incidents which I have elected to present are the times of *first establishment* of certain important genera and gentes of Corals and Brachiopods; but, to avoid overcrowding, I have selected only one Brachiopod-genus, namely, Productus.

An Avonian Time-scale, Graduated by the Entrances of well-known Corals and Producti.

Producti.	Zones, Sub-zones and Horizons.	Corals.
P. scabriculus and *P. costatus*	D_3	[*Cyathaxonia rushiana*] [1]
	ϵ	ZAPHRENTIS aff. ENNISKILLENI
P. longispinus	D_2	*Cyathophyllum regium*
Choneti-Productus		LONSDALIA and *Acrophyllum* *Aulophyllum*
	D_1	DIBUNOPHYLLUM and *Koninckophyllum*
P. aff. *giganteus*		*Lithostrotion irregulare* and *L. junceum* *Cyathophyllum Murchisoni*
P. corrugato-hemisphericus	S_2	
P. aff. *punctatus* and *P.* aff. *fimbriatus*		*Alveolites* *Carcinophyllum*
	S_1	
P. aff. *hemisphericus*		LITHOSTROTION
P. cf. *concinnus* *P.* aff. *pustulosus*	C	CYATHOPHYLLUM ϕ *Campophyllum*
	γ	
		CANINIA
	Z_2	
P. aff. *corrugatus*		*Zaphrentis* aff. *cornucopiæ*
	Z_1	*Michelinia*
P. aff. *semireticulatus*		
P. cf. *burlingtonensis*	β	ZAPHRENTIS aff. PHILLIPSI
	K_2	
P. bassus		
	K_1	*Cleistopora*

[1] Not yet recorded from the South-Western Province.

II. THE SECTION ON THE CLIFTON SIDE.

A. Topographical, Lithological, and Structural Characters.

Although there is no exposure south of the entrance to the Rocks Railway, we shall, for completeness, commence our traverse about 300 yards south of that point.

If we start from the 'General Draper' public-house, near the end of the Hotwell Road, we are at the junction of the Carboniferous Limestone Series with the Millstone Grit above; from this point, we shall have to cover a distance of a little more than 1½ miles downstream before we reach the junction of the Carboniferous Limestone Series with the Old Red Sandstone below.

Behind the 'General Draper' there was, formerly, a good exposure of the highest level in the Limestone Series (Horizon ϵ); this level is, however, no longer exposed on either side of the Avon.

The upper subzone (D_2) of the *Dibunophyllum*-Zone (D) is fronted by a row of houses and cannot be examined.

The lower subzone (D_1) is, in its higher portion, also concealed and lies behind the 'Colonnade'; its lower portion is, however, well exposed in the lofty vertical-face of rock which includes the entrance to the 'Rocks Railway' and the 'Hot Well.' The D_1 subzone extends northward to a point a little beyond the steps at the bottom of the 'Old Zig-zag' (a steep path which winds up the side of the gorge).

Between the 'General Draper' and this point, the whole of the *Dibunophyllum*-Zone is comprised.

Plate XI. We now enter the *Seminula*-Zone and the section rises to a height of more than 200 feet above us; we proceed under the Suspension Bridge and past the Hotwell Station, which lies at the foot of Observatory Hill, until we reach a fork in the road at the end of the Station wall. Following the upper branch (Bridge Valley Road) for a short distance, the massive grey *Seminula*-Limestone ceases abruptly where it abuts against a contorted mass of red rocks, and where the height of the section drops suddenly.

Plate X. The massive limestones which compose this portion of the sequence all belong to the Upper *Seminula*-Zone (S_2), whereas the red rocks against which they end belong to the upper part of D_2, and the S_2 limestone-mass is sharply separated from the subjacent D_2 beds by a reversed fault whose plane hades southward with the dip.

The under surface of the limestone is strongly slickensided, and the contortion in the soft D_2 rocks, due to the overthrust of the massive S_2 limestone, is finely shown, although it extends only a short distance north of the fault. The vertical displacement produced by the fault amounts to about 1,100 feet, calculated as follows :—The lowest portion of the limestone-mass is composed of '*Seminula*-Oolite,' a rock which we shall see again in the middle of the Great Quarry, and there is a perfectly continuous sequence from the '*Seminula*-Oolite' of the Great Quarry up to the D_2 beds immediately below the fault. Hence, knowing the average dip, and the horizontal distance from the '*Seminula*-Oolite' of the Great Quarry to the '*Seminula*-Oolite' just above the fault, the upthrow can be estimated.

Having noticed the crumpling of the soft D_2 beds by the overthrust of the great limestone-mass and also the smoothing of the under surface of the limestone, it is worth while to retrace our steps a few yards in order to study the effect of the overthrust upon the limestone-mass itself.

Above the northern end of the station-yard, the surfaces of the beds are sharply bent and smoothed, thus indicating the immense force behind the overthrust and marking how the limestone-mass was held back by friction at the fault plane, while the upper beds were sheared over the lower.

We must now return to the bottom of Bridge Valley Road and continue our walk downstream along the towing path.

From this point to the bottom of the Carboniferous Limestone Series, a distance of a little more than 1 mile, we continuously descend in the sequence, and whereas we have contented ourselves with a rather hurried examination of the rocks south of the fault, knowing that we should meet the same beds again north of the fault, we shall study the rest of the section more leisurely and shall pause at frequent intervals to consider what were the circumstances under which the beds were laid down.

The beds dip southward under one another at a uniform dip of nearly 30°, without a break in the succession, and the rocks can be examined, practically bed by bed.

The Avon section is probably the most complete section of the Carboniferous Limestone Series to be met with anywhere in the British Isles.

Dibunophyllum-Zone (D).

Upper subzone (D_2).

Plate IX.

The first exposure met with is a mural face at Round Point. The rocks are here massive and red stained ; the predominant rock-types are rubbly and encrinital limestones, but there are intercalated beds of pure grit and thin quartz-conglomerates. At the base of the series, just south of Point Villa, is a massive quartz conglomerate about 3 feet thick.

Such a variation in lithic structure indicates considerable movement of the sea floor, the total variation amounting to a change from clear water conditions, at a moderate depth, to the circumstances of an actual beach. We may also notice that the variation was oscillatory, for the same succession of rock types is repeated, as shown in the descending sequence[1] :—

Grit.
Limestone.
Quartz Conglomerate.
Grit.
Limestone.

Lower subzone (D_1).

The exposure at Round Point ends just south of Point Villa

[1] The sequence is best studied in the exposures at the side of Bridge Valley Road.

and our examination cannot be resumed, along the riverside, until we have passed the engine shed. From this point, the rocks of the subzone D_1 are exposed in low and discontinuous masses by the side of the towing path, as far as the level crossing which leads to the New Zig-zag (a steep path which winds its way up the side of the gorge, in a narrow depression of the surface of the Downs).

Plate VIII. The whole of this subzone can, however, be more satisfactorily examined along the side of the Hotwell-Avonmouth line which emerges from a short tunnel close to Point Villa, and runs along the side of the section to the end of the Carboniferous Limestone sequence.

The upper portion of the subzone, near the mouth of the tunnel, consists of shales, limestones and grits. The rock-characters indicate considerable variation of level, but of less amount than in the case of the D_2 beds.

The lower portion of the D_1 subzone can be examined by the side of the line, just south of the New Zig-zag level crossing; it consists of thick-bedded, fossiliferous limestones which, like most of the *Dibunophyllum* beds in the Bristol Area, are stained red. To the north of the New Zig-zag, the surface of the ground rises rapidly, on a dip slope, until it reaches a height of 200 feet above the towing path. The limestones forming this slope constitute the base of the *Dibunophyllum*-Zone; they are highly fossiliferous and can be examined by ascending the New Zig-zag Path and clambering up the slope on the left-hand side.

The rubbly limestones which recur so frequently throughout the *Dibunophyllum*-Zone may be studied either at ‘Round Point’ or in the exposures of the same beds along the Bridge Valley Road, between the large mass of Dolomitic Conglomerate, at the bend of the road, and the ‘Great Fault’ at its foot.

Examined in a clean cut face, the rock is seen to be made up of large numbers of rounded portions composed of comparatively pure limestone, separated by softer material which is usually very rich in iron; to this structure the face owes its 'mottled' appearance. The hard portions offer a relatively large resistance to weathering, and consequently the surface of the rock has become extremely irregular. Possibly the structure is, to a limited extent, concretionary, for, occasionally, the harder portions exhibit true 'shell-structure' near their surface; the greater number of these masses, however, seem to be due to the patchy accumulation of carbonate of lime, for the corallites of a large *Lithostrotion*-corallum can often be seen to pass from one hard portion to another.

The oolitic limestones which occur at various levels throughout the D series can usually be easily distinguished from the oolites which occur in lower zones. The oolite grains are larger and more scattered, and the rock has usually a red tint. (The deep red, coarse oolite which was formerly polished and sold as a characteristic Clifton rock was derived from beds in the D series.)

Seminula-Zone (S).

Upper subzone (S_2).

Plate VII. Returning to the railroad and resuming our walk northward along it, the lofty wall of *Seminula*-limestone lies at some little distance to the right of the line. The upper beds of the *Seminula*-Zone cannot be easily examined on this side of the river; we may, however, note in passing the thin capping of D_1 which we have already examined on the slope north of the New Zig-zag and, immediately beneath it, a band of thinner-bedded rock which constitutes the uppermost portion of S_2.

The rocks of this band are remarkable for a very peculiar structure, and they are here referred to as the 'Concretionary Beds.' (This term is used merely to describe the appearance of the rock, without definitely suggesting a particular mode of origin.) The 'Concretionary Beds' occur only at the very top of the *Seminula*-Zone, where, in certain parts of the Bristol Area (notably at Sodbury and near Westbury), they form a thick and extremely striking band. In the Avon Section, these beds can not be examined at the point which we have now reached, but they can be made out at the same level on the other side of the river and also in the repetition of the *Seminula*-Beds south of the 'Great Fault,' at a point which we have already passed, a few yards north of the bottom of the Old Zig-zag Path. The structure of these rocks is almost identical with that of 'Cotham or Landscape Marble,' but on a very much larger scale.

The upper surface of a typical bed consists of very numerous tall ridges, usually discontinuous, separated by equally deep narrow valleys. (This character is well shown on the right of the path which leads down, on the north side of Observatory Hill, from the Observatory to the Promenade.) A cross-fracture of the bed shows that these surface wrinkles are underlain by several thin layers in parallel undulations. Below this concretionary upper-portion comes the main thickness of the bed which consists of a very fine-grained, pale argillaceous limestone, mottled by black patches. In many cases these black patches can be seen to extend, as continuous pipes, from beneath the concretionary top-layer down to the under surface of the bed, and it is probable that most of the apparently-isolated patches are merely cross-sections of similar, continuous, but flexuous pipes. These pipes appear to be themselves concretionary and to be built up of thin layers which are convex upward. (Such pipes, bleached white by exposure, are well shown in the rock face just north of the Old Zig-zag, at the point already referred to.) The under surface of the bed is scored by sharp grooves in such a way that the bottom line of a cross section of the bed is notched at regular intervals. Beneath such a typical bed lies a thin black under-layer, which is almost entirely made up of small black nodules.

Compared with 'Landscape Marble,' the black under-layer represents the 'hedges and bushes,' the pipes correspond to the 'trees,' and the undulating upper-layer represents the 'sky.'

The origin of the peculiar structure described above has not yet been satisfactorily explained, although several theories have been advanced to account for it. It seems probable that such beds could only be laid down under water undisturbed by waves and charged with abundant carbonate of lime, and it seems a fair deduction from the remarkable character of the rock that the occurrence of these beds marks a datum level of absolute time, almost comparable in exactitude with that marked by a continuous lava sheet.

We will now proceed to the 'Great Quarry,' [1] where S_1 and the lower part of S_2 are splendidly exposed.

The highest beds, which come down to the floor of the quarry at its southern end, consist entirely of a fine white oolite, the '*Seminula*-Oolite.' This Oolite is seen as a conspicuous thick band in the face of the Quarry and, like the similar band lower down in the sequence, is characterized by the vertical joints which traverse its whole thickness, and by the weak development of bedding planes. (These characters are, however, much more striking in the *Caninia*-Oolite lower down and we shall consequently defer, for the present, an inquiry into their origin.)

The base of the Upper *Seminula*-Zone in the Great Quarry is marked by a good development of a very peculiar type of limestone which is here referred to as 'pisolite.'

This rock recurs at frequent intervals throughout the S_2 series and is, in the South-Western Province, confined to that subzone. It can be studied in the Avon Section at various levels, but nowhere is it so strikingly displayed as in the basal beds of the S_2 subzone, in the middle of the Great Quarry. (In the repetition of the S_2 series, south of the Fault, the 'pisolite' is well shown, at a higher level, a few yards south of the Suspension Bridge.) The rock has the aspect of a conglomerate or breccia in which the 'fragments' are of white limestone, cemented in a limestone matrix. When the 'fragments' are examined they are seen to have, in all cases, a concretionary structure, although this structure may only be evident in the outermost layers. The greater number of the 'fragments' are large concretions

[1] This quarry is now used as a Rifle Range by the Clifton College Volunteers.

which have been formed round shells and other organic débris; the rock may consequently be broadly described as a pisolite. In certain seams of *Seminula*, the majority of the shells are surrounded by concretionary crusts and, occasionally, comparatively large pieces of coral (such as *Syringopora*) are seen to be similarly included in a concretionary envelope. A great many of the 'fragments' are merely broken pieces of concretions and many complete concretions occur broken across, with the component parts displaced.

Lastly, it is important to notice that the S_2 series in which these pisolites occur contains numerous beds which are almost entirely built up of continuous coral masses (*Lithostrotion* and *Syringopora*).

A probable explanation of the origin of the pisolite appears to be the following:—The large coral masses which grew in clear shallow water near the shore line impeded the rapid removal of carbonate of lime, brought down from the land, and consequently the percentage of lime was necessarily maintained at a high level. Hence the shells and coral débris which accumulated on the floor were thickly coated with carbonate of lime. Many of the concretions were probably broken up almost as soon as formed, and the whole accumulation of débris, coated and uncoated, broken and unbroken, was rapidly cemented by the interstitial deposit of carbonate of lime.

Lower subzone (S_1).

Plate VI. All the beds below the 'pisolite' band, as far as the extreme north end of the quarry, belong to the Lower *Seminula*-Zone.

Thick limestones, mostly dark in colour but of very varying texture, build up the greater part of this subzone; they are separated by shales whose thickness increases more and more as we approach the end of the quarry.

One of the most striking of the limestone-types is termed 'China stone'; this rock has a perfect conchoidal fracture and is as compact in texture as a hone; a fresh fracture is black, but, by weathering, the surface becomes coated with a thin white skin. This peculiar type is found at various levels throughout the *Seminula*-Zone of the South-Western Province but I have not yet met with it outside that zone.

Another noteworthy feature of the beds near the north end of the quarry is the fact that they are, in several places, stained black by petroleum; one such large patch can be seen in the quarry-face, just above the slope on which stand the rifle-butts.

Syringothyris-Zone (C).

Plate V. Leaving the Great Quarry at its extreme corner and returning to the railroad, the beds immediately below are exposed in a low cutting by the side of the line. Here, shales predominate, but thick beds of pure dolomite are intercalated at frequent intervals and there are one or two beds of oolitic limestone.

Plate IV. The cutting ends in the striking white oolite of the 'Gully Quarry.' The upper part of this quarry consists of a thick band of pure white oolitic-limestone in which bedding planes are very inconspicuous, but in which vertical joints, traversing the whole thickness of the band, present a striking feature. The highest beds of the quarry consist of shaley, thin-bedded limestones which form a striking cap to the massive band of oolite beneath.

The oolitic band rests upon a series of limestones which are rich in carbonate of magnesia; this series has been termed the '*laminosa*-dolomites' on account of the chemical composition of its beds and their zonal position.

If we examine the two slopes of the broad depression known as the 'Gully,' we shall find that, at the bottom of the Gully, the Oolite lies wholly on the south side, whereas the northern slope is a dip slope in the '*laminosa*-dolomites.' Near the top of the Gully, however, there is a fine exposure of the white Oolite on the northern side, and the screes from this crag extend for a considerable distance along the floor of the Gully.

The massive white Oolite forms so striking a feature in the scenery of the Gully that its local title, 'Gully Oolite,' is well deserved. Since, however, it is essential to emphasize the zonal position of any particular rock-type, in order to distinguish it from the same rock-type occurring at a different level, I have named this Oolite the '*Caninia*-Oolite.' (Compare the terms '*laminosa*-dolomite,' '*Seminula*-Oolite.')

We now enter the Black Rock Quarry by scrambling through into it from the bottom of the Gully Path (keeping along the right-hand side of the fence which bounds the railroad).

[The limestone-massif which bounds the Gully on the north is known as the 'Black Rock'; the top of this mass is flat and forms the plateau of the Durdham Downs, its river edge is known as the 'Sea Wall' and, from this edge, there is a precipitous descent into the 'Black Rock Quarry.' To the south of the massif lies the Gully, and to the north lies the lower ground of the 'Lower Limestone Shales.']

The thick bed which underlies the north slope of the Gully can be examined between the Gully and the Black Rock Quarry. It is a dull, yellowish-brown dolomitic limestone and forms the base of the '*laminosa*-dolomites'; as seen in the face of the quarry, it forms a conspicuous cap, distinct in colour and texture from the pure limestones beneath.

With this bed we reach the bottom of the *Syringothyris*-Zone which we have been examining ever since we left the Great Quarry.

Reviewing the whole zone, it is clear that the circumstances of deposit were peculiar and comparatively local.

Judging by similar deposits of recent age, the *Caninia*-Oolite indicates perfectly clear and shallow water conditions such as are associated with the growth of coral reefs. Further, deposition must have been sufficiently continuous to prevent the formation of well marked bedding planes and consequently, when the mass consolidated, the cross joints traversed the whole mass.

The dolomites point to the same conditions, for it is probable that the dolomitization which affects recent coral masses is initiated at the surface of the mass, and therefore, practically at sea-level.

The conclusions thus arrived at, as to shallow water conditions during *Syringothyris*-time, are confirmed by an examination of the strata of the same age in other parts of the South-Western Province :—

At Weston-super-Mare, the rocks of this age contain inter-bedded lava and ash, of such a nature as to indicate shallow water and proximity to land. Farther west at Pendine, north of Tenby, there is a gap in the succession and the *Syringothyris*-Zone is absent, indicating that, locally, the sea floor emerged and became land during this period.

Zaphrentis-Zone (Z).

Plate III. All the beds in the Black Rock Quarry below the '*laminosa*-dolomites' belong to the *Zaphrentis*-Zone and are of essentially the same rock-type, namely a highly-fossiliferous, encrinital limestone. The divisions are consequently entirely palaeontological.

The uppermost part constitutes Horizon γ and the steep slope, just below the 'Cave,' may be taken as the dividing plane between the upper and lower subzones of the *Zaphrentis*-Zone (Z_1 and Z_2.)

The basal beds of the 'Black Rock' massif constitute Horizon β and are exposed in the small quarry north of the Black Rock Quarry. (This small quarry, here named Press' Quarry, is now closed and forms part of a private estate.)

The whole of the *Zaphrentis*-Zone, including Horizon γ at the top and Horizon β at the base, may be considered to have been deposited under standard conditions.

Cleistopora-Zone (K).

Upper subzone (K_2).

Plate I. Climbing up on to the railroad in front of Press' Quarry, we again resume our walk northward. The slope on the right hand side of the line is almost completely overgrown and consequently the rocks can only be examined in bare patches. It is not until we have passed the level crossing and reached the end of the low wall, which is there built up against the bottom of the slope, that a good section of the rocks is again exposed for examination. From the base of the Black Rock massif to this point, all the beds may be assigned to the upper subzone of the *Cleistopora*-Zone. They consist of thick shales, interbedded with thin-bedded, argillaceous limestones. The general type of sedimentation indicates muddy water of moderate depth, under standard conditions.

Lower subzone (K_1) [including the '*Modiola*-Phase.']

Plate II. If we now examine the section in the short cutting, north of the level crossing to which we have already referred, we are at once struck by the massive red beds which are termed the 'Bryozoa Beds.'

Resting on these beds, and extending southward as far as the end of the low wall mentioned above, are a series of thin-bedded limestones with shale partings. This portion of the sequence is the only part of K_1 which was deposited under standard conditions; the whole of the lower portion of K_1 consists of sediments accumulated under special conditions in extremely shallow water. The separation of K_1 into an upper and a lower division, characterized respectively by standard and special conditions, is much sharper in the Avon sequence than in any other part of the South-Western Province. The 'Bryozoa Beds' mark the junction of the two divisions and the 'Palate Bed,' which lies some 3 or 4 feet above the top of the 'Bryozoa Bed,' may be taken as the base of the normal development of K_1.

The 'Palate Bed' is a thin, very hard conglomeratic bed, full of coprolites and containing the teeth and spines of fish in considerable abundance. Like all 'bone beds,' the horizontal distribution of this bed is extremely patchy (at one point the bed is well developed, whereas at another, only a short distance away, it is practically absent); nevertheless, the bed occurs at widely separated points of the Bristol Area and always at approximately the same level (for example, a 'Palate Bed' of exactly the same type as the Avon bed occurs at practically the same level near Sodbury, 10 miles to the north). The very shallow water conditions under which this bed was formed are demonstrated alike by its conglomeratic characters and by the included mollusca.

The 'Bryozoa Bed,' which is here a massive red limestone about 8 feet thick, is the highest of the red beds which form so striking a feature in the two railway cuttings at this point. The rock is built up of vast numbers of small, *rounded* crinoid-fragments, which are cemented together by coarsely-crystalline calcite. It seems probable that the crinoid fragments were rounded by rolling in very shallow water and that the crystalline matrix has been produced, by solutional agency, at a time subsequent to the original cementation of the rock.

The '*Modiola*-Phase.'

The Bryozoa Bed and the rocks below it, down to the base of the Carboniferous Limestone Series, can be studied equally well in the cutting on either of the two Avonmouth lines which here run close together, one at a higher level than the other. (The lower line is the one we have been following all the way from Hotwell Station; the upper line emerges from the long tunnel under the Downs, at a short distance south of the Bryozoa Bed.) The following is a general description which applies to either cutting.

The Bryozoa Bed rests upon a massive red calcareous grit, about 10 feet thick.

Below this grit lie 20 feet of thin-bedded limestones, separated by highly fossiliferous shale partings, the fauna of the shales indicating shallow water conditions.

Descending in the sequence, we next come upon 30 feet of thick shales in which a few thick beds of limestone and calcareous grit are intercalated.

The section ends with 15 feet of thin slabby argillaceous-limestones, separated by shale partings. These beds exhibit very clearly their shallow water origin, both in their lithic characters and in their faunal contents. Several of the thin slabby limestones have undulating surfaces and exhibit sun cracks. Other beds are built up of angular fragments of thin shaley limestone cemented together in a fine-grained matrix. These beds were probably formed by the breaking up of thin limestone beds immediately after their deposition, and by the immediate cementation of the fragments.

The actual base of the Carboniferous Limestone Series cannot be definitely fixed for there is a complete passage down, from the calcareous series above, into the marls and sandstones which are regarded as constituting the uppermost portion of the Upper Old Red Sandstone.

In the lower cutting the junction is concealed by a wall, north of which the marls, sandstones and quartz-breccias of the Upper Old Red Sandstone are typically exhibited.

B. Palaeontological Characters.

We shall now turn back and study the fossils which are to be found at each successive level.

In this palaeontological survey our attention will be directed along two main lines of inquiry :-

(1) The possibility of making divisions which shall be based upon the occurrence of certain distinctive fossils ('Diagnosis').

(2) The registration and study of the important and abundant fossils which are associated at each level ('Fauna').

The Corals and Brachiopods are the only two groups which will be dealt with in detail, but attention will be drawn to the genera of other groups wherever they form an important constituent of the fauna.

Upper 'Old Red Sandstone.'

The green and red marls and grits, which immediately underlie the lowest beds of the Carboniferous Limestone, are almost entirely concealed on the Clifton side of the Avon, but, on the Leigh Woods side, these beds are well exposed for examination. They have there yielded, in considerable abundance, scales of a Rhizodont fish which is, most probably, a species of Strepsodus, a genus which has only been previously recorded from rocks of Carboniferous Age.[1]

CLEVEDONIAN OR LOWER AVONIAN.

Cleistopora-Zone : $K = \begin{cases} K_2 \\ K_1 \\ K_m. \end{cases}$

Zonal Index :—*Cleistopora* cf. *geometrica.*

Diagnosis:

The occurrence of *Cleistopora* and the absence of *Zaphrentis*.

Characteristic fossils:

Productus bassus, *Eumetria* aff. *carbonaria*, *Chonetes* cf. *Buchiana*, and *Spiriferina* cf. *octoplicata* are all abundant within the zone and are rare or absent above.

Lower Limit:

The *Modiola*-Phase constitutes the basal portion of the zone and presents a transitional stage between the conditions prevalent during the deposition of the uppermost Old Red Sandstone and the standard conditions which became established in the main portion of the *Cleistopora*-Zone.

Upper Limit:

The fauna of the uppermost beds of the zone only differs from that of the succeeding *Zaphrentis*-Zone in the presence of *Cleistopora* and the absence of *Zaphrentis*.

[1] I am indebted for this information to the kindness of Dr. Traquair, F.R.S., F.G.S., and Mr. E. T. Newton, F.R.S., F.G.S., to whom the specimens were submitted for identification.

Km = Phase of *Modiola lata.*

From the base of the Carboniferous series up to the 'Palate Bed,' the majority of the fossils are forms characteristic of shallow water, and very incomplete information can be obtained concerning the fauna which was then living in water of the depth which we have selected as our standard. This portion of the sequence, therefore, presents us with a special phase, and the change of fauna which takes place at its termination does not indicate the extinction of an earlier fauna and its replacement by a new, but merely introduces us to the life of a lower bathymetric-zone.

Diagnosis:

The abundance of shallow-water fossils (Modioliform lamellibranchs, Ostracods, *Spirorbis*, etc.), associated with Brachiopods which are characteristic of the Lower *Cleistopora*-Zone (*Athyris Royssii*, *Eumetria*, etc.).

Flora:

Plant fragments (common).

Fauna:

Spirorbis (?), Ostracods and Crinoid fragments.

Lamellibranchs of the genera *Modiola*, *Sanguinolites*, etc.

Gasteropods, especially small forms belonging to the genera *Murchisonia* and *Bellerophon*.

Bryozoa belonging to the genera *Rhabdomeson*, *Rhombopora* and *Fenestella*.

Fish scales (somewhat rare).

The Brachiopods include shallow water forms such as *Lingula*, '*Discina*,' together with a limited number of species which also belong to the fauna of standard depth :—

Athyris Royssii (abundant).

Eumetria sp.

Eumetroid Rhynchonellid.

Spiriferids (fragments, probably of both *Spirifer* and *Syringothyris*).

Chonetes cf. *hardrensis*.

Local detail:

Plate II. N.B.—The beds are dealt with in ascending order and the particular cutting which has yielded the best results is indicated at the side.

Lower Cutting.

(a) In the lowest 15 feet of the sequence, near the wall, thin slabs can be seen whose surface is covered with *Spirorbis* (?), small Gasteropods and Ostracods and with an occasional specimen of *Modiola*.

(b) The next 30 feet is very poor in fossils, but a thick bed, near the top, contains the small Eumetroid Rhynchonellid in some abundance. Resting upon this bed is a thick band of shale.

(c) The upper part of this shale-band, and the limestones and shales above (some 20 feet in thickness) are highly fossiliferous; all the shales yield abundant Ostracods and Modioliform Lamellibranchs (*Modiola lata* being extremely common), while the weathered surfaces of the limestones are covered with Bryozoa and with fragments of Brachiopods and Crinoids.

The lowest hard bed in this series is a black compact somewhat nodular limestone, rich in *Leperditia* (one of the largest forms in the Ostracod group).

Upper Cutting.

At the base of this series, *Athyris Roysii* is extremely abundant in the upper cutting. (This is a striking instance of the patchy distribution of individual forms). A large number of specimens of the shell should be collected, especially from the shales; when cleaned, the fringed expansions are often beautifully shown.

A little above the *Athyris Royssii* level, hunt should be made for a remarkable branching Bryozoan (*Rhombopora ?*) which, at first glance, resembles *Lithostrotion junceum*.

(d) The thick calcareous grit will scarcely repay examination.

The 'Bryozoa Bed' which caps the massive band of red rocks is best examined in a thin slice under the microscope. Bryozoa belonging to the genus *Rhabdomeson* are always to be seen, but they are relatively scarce in comparison with the great number of small rounded sections of crinoid fragments which constitute the main portion of the slide. These crinoid sections exhibit a finely reticulate structure suggestive of the transverse sections of dendroid Bryozoa, and it is to their great abundance that the rock owes its misnomer. [There are several beds in the upper part of the *Cleistopora*-Zone to which the title of Bryozoa Bed might be much more aptly applied.]

The index fossil, *Modiola lata*, is to be found throughout the *Modiola*-Phase, but it is most abundant in certain of the shales included in Division (c). The horizon at which it is most prolific is a shale bed in the Lower Cutting, 30 feet below the top of the 'Bryozoa Bed,' where it is associated with enormous numbers of small Ostracods.

K_1 = Subzone of *Productus bassus*.

Diagnosis:

Productus bassus, *Chonetes* cf. *Buchiana* and *Eumetria* aff. *carbonaria* are abundant at certain levels.

Fauna:

Productus bassus.
Chonetes cf. *Buchiana.*
Chonetes cf. *crassistria.*
Chonetes cf. *hardrensis.*
Orthothetes cf. *crenistria.*
Leptaena cf. *analoga.*
Eumetria aff. *carbonaria.*
Camarotœchia mitcheldeanensis.

Local detail:—

In the Lower Cutting, K_1 extends from above the Palate Bed up to the low wall which terminates the exposure, and it will be sufficient to examine only the lowest and highest beds in this series since the intermediate beds (some 20 feet of shales and thin limestones) are not richly fossiliferous.

The basal limestones, 2 or 3 feet in thickness, are crowded with fossils, and from them, all the forms cited above should be obtained, with the exception of the three species of *Chonetes* which are rare at the bottom of the subzone. The index fossil, *Productus bassus,* is also somewhat rare here, although it is remarkably abundant at the same level on the opposite side of the river.

The thin limestones at the top of the exposure must be unearthed from beneath the turf; when the right bed has been struck, splitting a slab open will reveal a surface crowded with small *Chonetes* of the three types cited above. With the *Chonetes* are associated Rhynchonellids, Spiriferids and the tails of a small species of '*Phillipsia*.'

The Spiriferids include both *Spirifer* aff. *clathratus* and *Syringothyris* aff. *cuspidata,* but they do not yet play a dominant part in the faunal assemblage.

The zonal coral, *Cleistopora,* has not, as yet, been recorded from K_1 in the Avon Section, but further search will doubtless result in its discovery for it has been found at this level in other parts of the South Western Province, as for example, at Skrinkle, south of Tenby.

K_2 = Subzone of *Spiriferina* cf. *octoplicata.*

Diagnosis:—

Spiriferina cf. *octoplicata* and *Cleistopora* cf. *geometrica* occur somewhat abundantly at certain levels.

The Brachiopods cited as diagnostic of K_1 are rare or absent.

Zaphrentis is absent.

Fauna:—

Corals:

Cleistopora cf. *geometrica.*

Brachiopods:

Chonetes cf. *hardrensis.*
Orthothetes cf. *crenistria.*
Leptaena cf. *analoga.*
Spirifer aff. *clathratus.*
Syringothyris aff. *cuspidata.*
Athyris Royssii, mut. β.
Camarotœchia mitcheldeanensis.

Bryozoa:

Rhabdomeson.
Monticuliporids.
Fenestellids.

[

Crinoids:

Three or four species are represented by fragments which build up the greater part of the limestones, but their identification awaits further work.

Local detail:

Plate I.

As already remarked, the exposures in this subzone are very poor and search must be made wherever a bare patch of rock can be seen. The surfaces of many of the thin limestones are covered with Bryozoans, beautifully weathered out.

A special search should be made for the zonal and subzonal indices, *Cleistopora* cf. *geometrica* and *Spiriferina* cf. *octoplicata*, at the side of the line just north of Press' Quarry; good specimens of both fossils have been obtained from this level.

The Brachiopods above cited are abundant in the thin limestones throughout the subzone and, near the top, the Spiriferids form the dominant feature of the fauna.

The characteristic K_1 forms, such as *Productus bassus* and *Eumetria* aff. *carbonaria*, have not, as yet, been recorded from this subzone in the Avon. On the other hand, the characteristic Lower-*Zaphrentis* Brachiopods (such as *Productus* cf. *burlingtonensis*, *Athyris* aff. *glabristria*, *Athyris Royssii* mut. β, *Reticularia* cf. *reticulata* and *Rhipidomella* aff. *Michelini*) become more and more abundant as we approach the top of the *Cleistopora*-Zone.

Zaphrentis-Zone : $Z \equiv \begin{cases} \gamma \\ Z_2 \\ Z_1 \\ \mathcal{S} \end{cases}$

Zonal index :—*Zaphrentis* aff. *Phillipsi.*

Diagnosis:—

At the base, *Zaphrentis* enters and *Cleistopora* has become extinct.

At the top, *Caninia* becomes abundant.

Horizon β

Diagnosis:—

Spiriferina cf. *octoplicata,* the index fossil of the Upper *Cleistopora*-Zone, occurs in association with *Zaphrentis* aff. *Phillipsi,* the index of the *Zaphrentis*-Zone.

Fauna:—

This horizon, though characterized by a fauna essentially the same as that of the *Zaphrentis*-Zone, contains one or two survivors from the fauna peculiar to the *Cleistopora*-Zone.

Local detail:—

In the Avon Section, this extremely fossiliferous level forms the base of the Black Rock Limestone-massif and, on the Clifton side of the river, it can only be examined in Press' Quarry.

The Brachiopods, with the two principal exceptions mentioned below, are characteristic Lower-*Zaphrentis* forms and in fact, at Horizon β, the Z_1 fauna is already typically developed; hence it is unnecessary to enumerate the forms which are most abundant since they are equally abundant throughout Z_1 and will be sufficiently dealt with in the general account of that subzone which immediately follows.

The two Brachiopods worthy of special notice are *Spiriferina* cf. *octoplicata* and *Athyris Royssii,* mut. β.

In the Bristol Area, *Spiriferina* cf. *octoplicata* is not found above Horizon β; it is the index fossil of K_2, but reaches its maximum abundance at, or just below, Horizon β.

Athyris Royssii, mut. β agrees very closely, in range and distribution, with *Spiriferina* cf. *octoplicata*; it is an abundant and characteristic fossil at Horizon β and is common throughout K_2, but it ranges on into the Z_1 subzone.

The only coral which occurs at this horizon is *Zaphrentis* aff. *Phillipsi* which here makes its earliest appearance; it is not uncommon and good specimens, showing the calyx, can be picked out of the weathered partings.

Cups and stems of Crinoids, spines and plates of a Palechinid, and Bryozoans of several types can be collected at this level, but their accurate determination awaits much-needed research.

Z_1 = Subzone of *Spirifer* aff. *clathratus*.

Diagnosis :—

Zaphrentis aff. *Phillipsi* is the only *Zaphrentis*.
Spirifer aff. *clathratus* is enormously abundant.

Fauna :—

Corals :

Zaphrentis aff. *Phillipsi*.

Brachiopods :

Productus cf. *burlingtonensis*
Chonetes cf. *hardrensis*.
Orthothetes cf. *crenistria*.
Leptaena cf. *analoga*.
Rhipidomella aff. *Michelini*.
Spirifer aff. *clathratus*.
Syringothyris aff. *cuspidata*.
Reticularia cf. *reticulata*.
Athyris aff. *glabristria*.
Camarotœchia mitcheldeanensis.

Bryozoa and Crinoids are abundant.
Palatal teeth of Elasmobranchs (*Psammodus*, etc.) are not uncommon.

Local detail:—

Between Press' Quarry and the Black Rock Quarry, the beds are exposed at the side of the line and most of the fossils cited above can be seen weathered out on the surfaces of the slopes. *Camarotœchia mitcheldeanensis* abounds in one of these beds and this is the highest level in the Avon sequence at which this Brachiopod is an important fossil.

Plate III. The best hunting-ground is, however, the lower portion of the Black Rock Quarry, in the beds which underlie the broad dip slope.

Orthothetes cf. *crenistria* and the two varieties of *Spirifer* aff. *clathratus* occur in thousands ; *Leptaena* cf. *analoga* and *Syringothyris* aff. *cuspidata* are their commonest associates.

Just below the slope, at the top of the Z_1 subzone, the surfaces of the beds are often completely covered with the valves of *Chonetes* cf. *hardrensis*. Associated with this small species of *Chonetes* are the earliest examples of the group of papilionaceous *Chonetes*.

Rhipidomella aff. *Michelini* reaches its maximum near the top of Z_1 and specimens should be looked for on the surfaces on which *Chonetes* cf. *hardrensis* is abundant.

Z_2 = Subzone of *Zaphrentis* aff. *cornucopiae*.

Diagnosis:—

The association of *Zaphrentis* aff. *cornucopiae* with *Zaphrentis* aff. *Phillipsi*, the rarity of *Caninia*, and the gradual decline of the Z_1 Brachiopod-fauna.

The lower part of the subzone is marked by the entrance of *Schizophoria* aff. *resupinata* and by the abundance of *Athyris* aff. *glabristria*; the upper part is characterized by the great abundance of the two species of *Zaphrentis*, and by the entrance of *Caninia* and of the large form of *Syringothyris* aff. *cuspidata* which is so important a fossil of the *Syringothyris*-Zone.

Fauna:—

Corals:

Zaphrentis aff. *cornucopiae*.
Zaph. aff. *Phillipsi*.
Amplexus cf. *coralloides*.
Syringopora θ.
Michelinia, spp.

Brachiopods:

Productus cf. *burlingtonensis*.
Prod. aff. *semireticulatus*.
Chonetes cf. *hardrensis*.
Papilionaceous *Chonetes*.
Orthothetes cf. *crenistria*.
Schizophoria aff. *resupinata*.
Rhipidomella aff. *Michelini*.
Syringothyris aff. *cuspidata*.
Syringothyris cf. *laminosa*.
Athyris aff. *glabristria*.

Bryozoa, Crinoids and *Palechinus*.

Elasmobranchs:

Psammodus, *Orodus*, *Helodus*, etc.

Local detail:—

Plate III. Within the main Black-Rock Quarry, namely that portion which lies south of the broad dip slope below the cave, the whole of the Z_2 subzone is comprised.

The 'Fish Beds' occur about the middle of the subzone and separate two rather distinct faunal assemblages. (It is not worth while to hunt for specimens of fish teeth since they can always be obtained on the opposite side of the river.)

(1) Below the 'Fish Beds.'—

Zaphrentis aff. *Phillipsi* is the only common species of *Zaphrentis*.

Athyris aff. *glabristria* and *Orthothetes* cf. *crenistria* are the most abundant fossils.

Schizophoria aff. *resupinata* makes its first appearance, and is rather common, in the beds immediately above the slope.

(2) Above the 'Fish Beds.'—

Zaphrentis aff. *Phillipsi* and *Zaphrentis* aff. *cornucopiae* are both very common and account for the greater number of coral sections which can be seen in the rock faces, but *Amplexus*, *Michelinia* and *Syringopora* can always be recognized if carefully looked for.

The large papilionaceous *Chonetes* is already firmly established as the dominant *Chonetes* and the genus of *Syringothyris* aff. *cuspidata* is represented for the first time by the large form, *Syringothyris cuspidata*, which is characteristic of the succeeding zone.

Horizon γ.

Diagnosis:—

Caninia cylindrica is, for the first time, abundant and is associated with *Zaphrentis* aff. *Phillipsi*, which is still extremely common.

N.B.—In the Avon section, Horizon γ appears to be inseparably linked with the Z_2 beds below and to be sharply marked off from the *Syringothyris*-Zone above, but this phenomenon is due to the incoming of peculiar physiographic conditions (the 'dolomite phase'). Where the standard conditions persisted into the *Syringothyris*-Zone, as was the case in the Mendip Area, Horizon γ presents its true character as a level of faunal overlap, although, here also, it is more closely linked with the *Zaphrentis* Zone below.[1]

Fauna:—

Syringothyris cuspidata and papilionaceous *Chonetes* are the most striking of the Brachiopods, and there are few survivors of the Z_1 fauna.

[1] J. F. Sibly, Quart. Journ. Geol. Soc., vol. 62 (1906), pp. 330, 331.

Corals abound :

Zaphrentis (both species), *Caninia, Amplexus, Michelinia, Syringopora.*

Local detail:

Horizon γ is represented by the massive bed which immediately underlies the *laminosa*-dolomites at the extreme southern end of the Black-Rock Quarry. Sections and weathered calices of *Caninia cylindrica* can be seen in the rock faces, and *Zaphrentis* is extremely abundant.

Syringothyris-Zone : $C \equiv \begin{cases} C_2 \\ C_1 \end{cases}$

General characters of the zone in those areas in which the standard conditions obtained :—

Lithostrotion is typically absent and *Caninia* abundant.

Fauna :—

Corals :

Michelinia cf. *megastoma* can be found throughout.

Cyathophyllum ϕ is especially characteristic of the upper half.

Zaphrentis aff. *Phillipsi* and *Zaphrentis* aff. *cornucopiae* pass up from the *Zaphrentis*-Zone below, but are only abundant in the lower half of the *Syringothyris*-Zone.

Brachiopods:

Syringothyris cf. *laminosa* and *Syringothyris cuspidata* are characteristic fossils. *Chonetes* cf. *comoides* and papilionaceous *Chonetes* crowd certain beds, especially in the lower part of the zone where they are associated with equally abundant specimens of the C mutation of *Orthothetes* cf. *crenistria.*

Gasteropods :—

A large species of *Bellerophon* is very abundant in association with *Cyathophyllum* ϕ in the upper part of the zone.

Local detail :—

Plates IV., V. and Va. Owing to the peculiar conditions of deposition, the *Syringothyris*-Zone in the Avon section exhibits very few of the above characters and, in fact, it is at the present time useless to attempt the study of the fauna in the section on the Clifton side of the river; a fossiliferous level in C_1 is exposed on the opposite side of the river and will be described later.

From the *laminosa*-dolomites, at the foot of the Gully, good specimens of *Orthothetes* cf. *crenistria* have been obtained and, from the *Caninia*-Oolite Quarry specimens of *Michelinia* cf. *megastoma* and *Syringopora* cf. *reticulata* were formerly collected in fair numbers.

The upper portion of the zone, the *Caninia* shales and dolomites, has yielded no fossils on either side of the Avon Section. There is, however, a fossiliferous development of C_2 as near as Failand.

KIDWELLIAN OR UPPER AVONIAN.

Seminula-Zone : $S \equiv \begin{cases} S_2 \\ S_1 \end{cases}$

Zonal index :—*Seminula ficoides.*

Diagnosis :—

The first abundance of *Lithostrotion* occurs at the base of the zone.

The first abundance of *Dibunophyllum* occurs above the top of the zone, at the base of the succeeding zone.

Lithostrotion Martini is the dominant coral throughout the zone and no *Zaphrentis* or *Dibunophyllum* has yet been recorded from the zone.

Seminula ficoides is the dominant Brachiopod.

S_1 : subzone of *Caninia cylindrica,* mut S_1.

Diagnosis :—

The S_1 subzone is characterized by the establishment of a dominant Kidwellian fauna (*Lithostrotion, Seminula,* etc.) with which are associated several mutations which are the direct descendants of Clevedonian forms (*Caninia cylindrica,* certain *Producti,* etc.).

Fauna:—

Corals:

Caninia cylindrica, mut. S_1
Lithostrotion Martini.
Lithostrotion bristolense.
Syringopora cf. *reticulata.*
Syr. cf. *distans.*

Brachiopods:

Productus θ.
Productus semireticulatus, mut. S_1.
Athyris cf. *planosulcata.*
Syringothyris cf. *laminosa.*

Bryozoa:

Heterotrypa cf. *tumida.*

Gasteropods:

Bellerophon, *Loxonema*, etc.

Local detail:

Plate VI.

The rifle butts in the Great Quarry stand at the top of a dip face which slopes down to the floor of the quarry at its north end. Another dip face, lower down in the sequence, forms a second and larger slope behind the butts. The rocks are best examined from these two slopes which will be referred to as ‘ front slope ’ and ‘ back slope ’ respectively.

The dendroid coral *Lithostrotion Martini*, which abounds throughout the *Seminula*-Zone, often builds up entire beds.

The massive coral, *Lithostrotion bristolense*, is only abundant in a thick bed just above the ‘ back slope.’ Specimens were formerly obtained from a petroleum-stained patch at this level and are common in old collections, where they are usually labelled *Lithostrotion aranea.*

Syringopora cf. *reticulata* is, locally, a valuable diagnostic fossil, as it is not known, in the Bristol area, above S_1 or below the *Syringothyris*-Zone.

The subzonal coral, *Caninia cylindrica*, mut. S_1, is only abundant in a thick bed a few feet above the ‘ front slope.’

Seminula ficoides is enormously abundant at frequent intervals throughout the *Seminula*-Zone.

The shaley partings in the S_1 subzone are frequently crowded with crushed *Seminulae* and, resting immediately upon the 'back slope,' is a massive bed which teems with uncrushed specimens. All the characters of the fossil can be readily made out in the numerous cross sections exposed in the rock face, but solid specimens are very difficult to extract.

Productus θ is a common fossil but is difficult to determine from the specimens seen *in situ*, which are usually mere cross sections or partially exposed valves. Specimens can however often be picked up from among the débris which is littered over the slopes. (The same level on the opposite side of the river is, however, a better hunting-ground.)

Productus semireticulatus, mut. S_1 is represented by crushed valves and long spines in the shaley partings. The best collecting level is just above the 'front slope,' where the weathered surfaces are covered with the spines of this *Productus*,[1] associated with the tails of a small '*Phillipsia*' and with abundant specimens of *Heterotrypa* cf. *tumida*.

Athyris cf. *planosulcata* is common at the same level on the opposite side of the river.

Heterotrypa cf. *tumida* is abundant at several levels in the shaley partings and good specimens can be obtained from the Trilobite Bed. Fenestellids are common associates.

Gasteropods belonging to several genera can be seen cross-sectioned in the rock faces, especially at the top of the subzone.

S_2 : Subzone of *Productus corrugato-hemisphericus* (= *Prod.* aff. *Cora*, mut.).

Fauna:—

Throughout the South-Western Province very few gentes are represented in this subzone, but those which occur are remarkably rich in individuals. *Lithostrotion, Syringopora, Seminula*, papilionaceous *Chonetes*, and variants of *Productus hemisphericus* build up thick bands and recur again and again.

[1] This level has often been referred to as the 'longispinus bed,' but the designation is unfortunate since the *Productus*, whose spines have suggested the name, is very different from *Productus longispinus*. The term 'Trilobite bed' is to be preferred.

Corals :—

In addition to *Lithostrotion* and *Syringopora* which are extremely abundant, *Carcinophyllum* and *Alveolites* occur somewhat sparingly, and *Cyathophyllum* has been recorded from the uppermost beds in two localities only. These are the only corals found in this subzone throughout the South-Western Province; *Zaphrentis, Caninia, Dibunophyllum*, etc., being all absent.

Brachiopods :—

Productus hemisphericus (abundant).
Prod. corrugato-hemisphericus (abundant).
Prod. giganteus (from the uppermost beds only).
Prod. punctatus (rare).
Chonetes cf. *papilionacea* (abundant) and *C.* aff. *comoides.*
Orthothetids (rare).
Cyrtina carbonaria and var. (especially abundant near the base).
Athyris (rare).
Seminula ficoides and vars. (abundant).

The above list comprises *all* the Brachiopods which have as yet been recorded from the S_2 subzone throughout the South-Western Province. *Spirifer, Syringothyris, Schizophoria* and *Leptaena* are all absent and, although *Seminula* is so remarkably abundant, *Athyris* is very rare.

The limited nature of the fauna points clearly to the existence, during Upper-*Seminula* time, of very special conditions throughout the whole of the South-Western Province.

[Recent work has added considerably to our knowledge of the area over which the S_2-Phase extended. Mr. T. F. Sibly has shown that there is very little evidence of the development of a typical S_2 in the Eastern Mendips, Dr. Wheelton Hind has discovered indisputable evidence of the presence of this Phase in North Wales, and work by Mr. E. E. L. Dixon and myself has shown that the peculiar 'pisolite' rock-type reaches the acme of its development in the Gower Peninsula. Hence it appears probable that the S_2-Phase extended round the old Welsh land-area during *Seminula*-time in the shape of a horse-shoe, and ceased somewhat suddenly at a certain distance from the shore-line.]

The groups which are unrepresented in the S_2 fauna either migrated from the Province during S_1 time, before the establishment of the new conditions, or lived on in the area until they suffered local extinction. (*Productus* aff. *semireticulatus*, mut. S_1, in its profusion of spines and in its marginal extensions, exhibits very convincingly the moribund characters which prognosticate approaching extinction).

Local detail:—

Plate VII.

North of the Great Fault, only the base of the S_2 subzone can be examined on the Clifton side of the Avon, and this portion of the series is represented by the thick *Seminula*-Oolite at the southern end of the Great Quarry.

Seminula ficoides, *Lithostrotion Martini*, *Chonetes* cf. *papilionacea*, *Syringopora* cf. *distans* and *Productus corrugato-hemisphericus* build up distinct and recurring seams.

Carcinophyllum and the Bryozoan, '*Chaetetes* cf. *radians*,' can always be detected by careful searching.

Cyrtina carbonaria, which is so extremely abundant at the base of S_2 in certain parts of the South-Western Province (e.g. Wickwar), has not been recorded from the Avon section.

Plate XI.

In the repetition of the series, south of the Great Fault, the entire S_2 subzone is splendidly exposed between the bottom of Bridge Valley Road and a point a few yards north of the foot of the Old Zig-zag. The repeated seams of *Lithostrotion*, *Seminula*, *Productus* and *Chonetes* can be readily examined, but very few other fossils have, as yet, been recorded.

Dibunophyllum-Zone : D $\equiv \begin{cases} \epsilon \\ D_2 \\ D_1 \end{cases}$

Zonal Index :—The *Dibunophyllum* group of the Clisiophyllidan Corals.

Diagnosis:—

Corals:

In general, the abundance of Clisiophyllidan Corals is remarkably striking, both as regards species and individuals; in particular, the predominance of the *Dibunophyllum* section and the occurrence of the *Aulophyllum* section are noteworthy features.

Narrow-tubed Lithostrotions, such as *Lithostrotion irregulare* and *L. Portlocki*, are the dominant forms of that genus.

Brachiopods:—

In general, the abundance of *Producti*, both as regard species and individuals, is a salient feature and in particular, the predominance of the giganteid section and the entrance of the scabriculate and longispinous groups are the facts of chief importance.

Of the true Spirifers, *Sp. bisulcatus* is the dominant species.

D_1 = Subzone of *Dibunophyllum θ*.

Diagnosis:—

The entrance of *Dibunophyllum* and the predominance of those species of the genus which have a simple type of structure.

The absence of highly specialized Clisiophyllids, such as *Lonsdalia*.

The maximum abundance of *Cyathophyllum Murchisoni* and of *Productus hemisphericus*.

Fauna:—

Corals:

Dibunophyllum θ., *Dib. φ.*, *Carcinophyllum θ.* — abundant.
Cyclophyllum pachyendothecum (rare).
Koninckophyllum θ (common locally, e.g. at Sodbury).
Campophyllum aff. *Murchisoni.*
Cyathophyllum Murchisoni (very abundant).
Diphyphyllum.
Lithostrotion irregulare.
Lith. Martini.
Lith. junceum.
Syringopora cf. *geniculata.*
Syr. cf. *ramulosa.*
Syr. cf. *distans.*
Alveolites septosa (abundant).

Brachiopods:—

Productus giganteus., *Prod. hemisphericus.*, *Prod. corrugato-hemisphericus.* } abundant.
Chonetes (*Daviesiella*) aff. *comoides.*

Orthothetids, especially *Derbya* (rare, except locally e.g. at Westbury).
Cyrtina septosa (rare, except locally e.g. at Lydstep).

Local detail:—

Plate VIII.

This subzone can be examined in the rail-side exposure immediately south of the level-crossing, at the bottom of the new Zig-zag; it is, however, best studied in the very numerous exposures of bare rock on the slope north of that path. (The New Zig-zag should be ascended until the steepest portion has been surmounted and the slope on the left-hand side should then be climbed as far as the edge of the cliff section.)

In the repetition of the series, south of the Great Fault, the fossils characteristic of the D_1 subzone can be readily recognized in the rock-face between the Colonnade and the foot of the Old Zig-zag, as well as in the exposures by the side of that path. (The Old Zig-zag path practically follows a dip-slope and consequently the level of the beds which are exposed at the side continues to be approximately the same, from bottom to top.)

Cyrtina septosa and *Derbya* have not yet been recognized on either side of the Avon Section.

D_2 = Subzone of *Lonsdalia floriformis.*

Diagnosis:—

The presence of highly specialized Clisiophyllids, (such as *Lonsdalia*, and *Dibunophylla* of the type of *Dib.* ψ.).

The entrance of compound *Cyathophylla*, and the importance of the *Martinia* section of the Spiriferids.

Fauna:—

Corals:

Lonsdalia floriformis. } abundant.
Lons. aff. *rugosa.* }
Acrophyllum.
Dibunophyllum φ. } common.
Dib. ψ. }
Aulophyllids (rare).
Campophyllum.
Cyathophyllum Murchisoni. } common.
Cyathophyllum regium. }

Lithostrotion irregulare (very abundant).
Lithostrotion junceum.
Lithostrotion Martini, with Clisiophylloid and Diphyphylloid variants (abundant).
Lithostrotion Portlocki and *Lith. M'Coyanum* (abundant).
Lith. ensifer.
Petalaxis Portlocki.
Alveolites septosa (common).
Syringopora cf. *distans.*

Brachiopods:

Productus latissimo-giganteus. } abundant.
Choneti-Productus. }
Prod. hemisphericus (common).

Spirifer striatus.
Sp. bisulcatus. } rare
Sp. planicosta. }
Martinia ovalis. }
Reticularia lineata. }
Athyris planosulcata. }
Seminula ambigua. }
Dielasma. }

The above lists include only those species which have been recorded from D_2 in the Avon section. If the lists were extended to include all the Brachiopods and Corals found in the same subzone from all parts of the entire South-Western Province, the identity of the Avon fauna would be completely concealed, for such a list would include almost all the species of these two groups which have been recorded from the rich collecting grounds of the Midland and Yoredale Provinces.

Local detail:—

Plate IX.

The only exposures of D_2 beds on the Clifton side of the Avon are, (1) at 'Round Point,' immediately south of 'Point Villa,' and (2) by the side of the Bridge Valley Road, where the same beds crop out again at a higher level.

Clusters of *Lithostrotion irregulare* are very common, while *Lithostrotion Martini* and its variants build up the greater portion of several beds. The greater number of the species cited in the foregoing lists can be detected by careful search on the rock-faces at 'Round Point' and it was in cutting this Point that most of the 'Clifton Corals,' so common in collections, were originally obtained.

Horizon ϵ. Passage beds from the Carboniferous Limestone into the Millstone Grit.

In the Avon section, this horizon consists chiefly of massive calcareous grit and is usually included in the 'Millstone Grit' series.

Fauna:

Productus scabriculo-costatus (extremely abundant).

Prod. corrugatus and Orthothetids (common).

In the repetition of the series, south of the Great Fault, this horizon is concealed behind the 'General Draper' Public House and is no longer accessible; in the main section, north of the Fault, the sequence is cut short near the top of D_2, before this horizon is reached.

In other parts of the South-Western Province, the Limestone series extends above Horizon ϵ and includes a small portion of the subzone D_3 which is so important a subdivision of the Lower Carboniferous in the Midland and Yoredale Provinces.

Hence it is impossible to avoid the conclusion that 'Millstone Grit' conditions did not commence at the same time over even so small an area as the South-Western Province and that, consequently, the 'Millstone Grit' of one locality is the time-equivalent of part of the 'Carboniferous Limestone' of another,

'Millstone Grit.'

The massive quartzite-like grits, included under this title, immediately succeed Horizon ϵ in the Avon section without any break, and, since the upper part of D_2 contains several bands of grit which herald the incoming of prolonged grit conditions, we may fairly assume the conformity of the 'Millstone Grit' with the underlying 'Carboniferous Limestone' in the immediate neighbourhood of Bristol.

III. THE SECTION ON THE LEIGH WOODS SIDE.

Seeing that the sequence on the right bank of the Avon has been so fully dealt with, it will be unnecessary to give a detailed account of that on the left bank. The descriptive account which follows consists, therefore, of a series of short notes explanatory only of the most striking facts, and especially of those which cannot be so satisfactorily observed on the Clifton side of the river.

We may conveniently start from Clifton Bridge Station and, before entering on the riverside traverse, it will be advisable to visit the quarry on Rownham Hill.

If the hill be ascended as far as the fork in the road, the left-hand branch must be taken and the quarry then lies a short distance farther along, on the right hand side of the road. (If Clifton Bridge Station is reached from the Suspension Bridge, the quarry should be examined on the way down.)

'Rownham Quarry' lies in the upper part of the *Dibunophyllum*-Zone (D_2), and in the repetition of the Carboniferous Series, south of the Great Fault. The lowest beds exposed in the quarry are massive limestones poor in fossils; these beds are worked for road metal. Resting upon these massive beds is a thick bed of rubbly limestone which contains numerous patches of clay, and it is from these patches that the finest specimens of D_2 corals have been obtained.

Subjoined is a complete list of the Corals and Brachiopods which have been collected from Rownham Quarry:—

Corals:

Lonsdalia floriformis.
Lons. aff. *rugosa.*
Axophyllum.
Lithostrotion irregulare.
Lith. Portlocki.
Lith. M'Coyanum.
Lith. ensifer.
Dibunophyllum ψ.
Cyathophyllum regium.
Cyath. Murchisoni-regium.
Campophyllum Murchisoni.
Alveolites septosa.
Syringopora cf. *distans.*

Lonsdalia, Lithostrotion irregulare and *Cyathophyllum regium* are the most abundant Corals.

Brachiopods:

Productus latissimo-giganteus.	*Spiriferina* cf. *biplicata.*
Choneti-Productus.	*Martinia ovali-glabra.*
Spirifer bisulcatus.	*Athyris planosulcata.*
Sp. planicosta.	

Giganteid *Producti* are the only Brachiopods which are abundant; Spiriferids and Athyrids are rare.

Bryozoa are not uncommon, and *Calamites* occurs in a thin grit band.

Returning to Clifton Bridge Station, we will now commence our walk downstream along the towing path.

The *Dibunophyllum*-Zone is poorly exhibited in the rail-side cutting, the beds which we have just examined in Rownham Quarry cropping out again at the southern end of this exposure.

As we pass under the Suspension Bridge, the upper *Seminula*-Zone is well exposed in the cliff-face but presents no new points of special interest.

In Nightingale Valley, which lies immediately north of the Suspension Bridge, the continuation of the Great Fault has been traced by Professor Lloyd Morgan.

At this point, therefore, we enter upon the main Avon Section which includes, without a break in the sequence, all the zones, from the upper part of the *Dibunophyllum*-Zone down to the base of the *Cleistopora*-Zone and its conformable junction with the Upper Old Red Sandstone.

D_2.

North of Nightingale Valley, the D_2 beds form a high mural exposure which can be examined in Quarry 6. This quarry has been long disused, and will scarcely repay a short visit. Most of the fossils obtained at Rownham Quarry can also be found here, and *Fistulipora* cf. *incrustans*, a Monticuliporid characteristic of D_2, is somewhat abundant, as are also the narrow-tubed massive forms of *Lithostrotion*. The fossils occur, as on Rownham Hill, in a thick rubbly limestone; this bed can be followed up the slopes, and is well exposed on the sides of Stoke Leigh Camp.

Continuing our traverse, there are no satisfactory exposures until we reach the 'Point,' where the lowest beds of the *Dibunophyllum*-Zone are exposed.

D_1.

Some years ago, when the 'Point' was being cut back, beds, a little higher than those which are well exposed by the side of the towing-path, were quarried in the river bank. *Productus corrugato-hemisphericus*, mut. D_1 is an abundant fossil in these beds and fine specimens could then be obtained; even now, although the beds are almost completely covered up by vegetation where they crop out at the side of the towing path, this characteristic brachiopod can always be obtained by a little work.

Plate XII. The rock-faces in the main exposure by the side of the path should be very carefully examined, and the numerous coral sections should be minutely studied. The dip slope of rubbly limestone will also yield solid specimens of D fossils if patiently looked over.

The following fossils can all be detected in this exposure :—

Corals:

Dibunophyllum θ.
Dib. ϕ.
Carcinophyllum, θ.
Campophyllum aff. *Murchisoni*.
Cyathophyllum Murchisoni.
Diphyphyllum.
Lithostrotion irregulare.
Lith. junceum.
Lith. Martini and a Clisiophylloid variant.
Syringopora cf. *geniculata*.
Syr. cf. *ramulosa* and *S.* cf. *distans*.
Alveolites septosa.

Brachiopods:

Productus hemisphericus.
Prod. giganteus.
Chonetes cf. *papilionacea*.
Ch. aff. *comoides*.

Productus giganteus and *Cyathophyllum Murchisoni* reach their maximum abundance at this level; large specimens of *Productus giganteus* almost cover the surfaces of certain beds, and some examples of *Cyathophyllum Murchisoni* attain a length of 2 feet.

S_2.

Plate XII. Immediately below the D_1 beds there is a good exposure of the 'Concretionary Beds' which form the uppermost part of the *Seminula*-Zone. These beds are well exposed on the broad slope which here rises steeply from the towing-path. Although there is no stratigraphical break between the base of D_1 and the top of S_2, yet the faunal break (as also the lithological break) is remarkably striking and, at first sight, well-nigh complete. In the Avon sequence, the D_1 beds, with their rich coral fauna, are underlain by the S_2 'Concretionary Beds' which contain few fossils beyond recurrent seams of *Seminula*. (Although the sharpness of the faunal break between the *Dibunophyllum* and *Seminula*-Zones is seen to be less perfect the more closely we examine any one locality, and the more widely we extend our observations, it yet remains a striking feature of the sequence throughout the South-Western Province and undoubtedly indicates a very considerable change of conditions.)

The only other points worthy of special note with regard to the 'Concretionary Beds' at the top of S_2 are :—

(1) The 'Cotham Marble' structure, which causes certain of the limestone beds to appear as if mottled by irregular black patches.

(2) The abundance of *Seminula ficoides* and its variants, which occur in repeated seams.

Quarry 5, which lies north of the slope, exhibits upper S_2-beds which present no special features worthy of more than the briefest examination.

Seminula ficoides and *Lithostrotion Martini* are both abundant. (Certain of the beds in this quarry, and in the tunnel immediately south of it, are crowded with *Seminula ficoides*, and rock specimens from these beds, when cut and polished, afford the best material for studying the characters of this important zonal brachiopod.)

The large exposed bedding-slope which forms the north end of the quarry affords an excellent opportunity of obtaining the dip and strike of the beds very accurately.[1]

Plate XIII. Resuming the traverse along the towing-path, we soon reach Quarry 4 which is no longer in work. In this quarry the lower part of S_2 and the top of S_1 are satisfactorily exposed.

The broad white band of *Seminula*-Oolite can be easily made out in the tall quarry wall.

Large blocks of limestone crowded with *Seminula ficoides*, and others built up almost entirely of *Lithostrotion Martini*, lie strewn over the floor of the quarry.

S_1.

The main interest of Quarry 4 centres, however, in the exposure of the S_1 subzone.

The slope which forms the north end of the quarry lies immediately above the level of the 'Trilobite Bed' of the 'Great Quarry.' There is, in fact, a small exposure of this bed in the north-eastern corner of Quarry 4 where a few trilobite tails can be recognized on the bedding-surface; a frilled Athyrid, with the form of *Athyris planosulcata*, is not uncommon but *Productus semireticulatus*, mut. S_1 has not been detected.

If we now climb the main slope and examine the exposures of bare rock which lie in position upon it, *Caninia cylindrica*, mut. S_1 is seen to occur abundantly, with *Lithostrotion Martini* and *Seminula ficoides*. In the débris scattered over the highest part of the slope, at the extreme north end of the quarry, *Productus* θ is abundant; this Productus can be seen, *in situ*, in a bed a

[1] The observations are best made from the towing-path on the opposite side of the river, and the strike should be determined by walking slowly from south to north until the surface of this slope is just lost to view at the level of the observer's eye; the bearing of the slope at this level can then be most accurately read off by employing a prismatic compass.

few feet above the slope where *Athyris* cf. *planosulcata* is also not uncommon.

Good rock-specimens of the S_2-'pisolite' can be picked up from the débris, and it is not unusual to see in such specimens a shell of *Seminula* surrounded by a concretionary coat half an inch thick.

C_2.

After leaving Quarry 4, the C_2-dolomites and shales can be recognized, both in the river bank and also by the side of the line, but the exposures are unsatisfactory and there is nothing to delay us until we reach Quarry 3 (The 'Oolite Quarry').

C_1.

Plate XIV. The thick band of *Caninia*-Oolite forms a striking feature in the wall of this quarry. The well-bedded shales and thin limestones capping the thick massive oolite, in which the bedding is difficult to recognize, give a momentary suggestion of unconformity which is heightened by the vertical jointing of the oolite mass, but the impression is immediately corrected by the obvious bedding to be seen in the rocks below the Oolite, and by the traces of bedding which can be made out in the oolite-mass itself.

The texture of the oolite should be examined under a lens; the oolite grains are usually very much smaller than is the case in the oolitic bands at higher levels and the amount of interstitial cement is relatively less; the concretionary structure of the grains extends almost from surface to centre.

Fossils are rare in the Oolite but *Syringopora* cf. *reticulata* and *Michelinia* cf. *megastoma* occur sparingly.

The beds below the Oolite form the uppermost portion of the *laminosa*-dolomites, a division of C_1 in which recurrent shell seams form a characteristic feature. One of these seams can be examined on the bare slopes at the northern end of the quarry.

Orthothetes cf. *crenistria* and papilionaceous *Chonetes* occur in great numbers, and a few specimens of the subzonal index, *Syringothyris* cf. *laminosa*, can always be seen.

We may now proceed at once to Quarry 2, which is in continuous work.

Plate XV. A thin capping of *laminosa*-dolomites overlies the massive γ bed at the southern end of the quarry, but is inaccessible.

Z_2.

Horizon γ is exposed at the southern end of the quarry and fossils can readily be made out on the rock-faces.

Caninia cylindrica, Zaphrentis aff. *Phillipsi* and *Zaphrentis* aff. *cornucopiæ* are the most abundant forms.

The 'Fish Beds' yield large numbers of palatal teeth (*Psammodus, Orodus,* etc.) but spines can rarely be obtained.

In the lowest beds, at the northern end of the quarry, Brachiopods are abundant and constitute a characteristic *Zaphrentis* assemblage. The commonest forms are :—

Spirifer aff. *clathratus, Orthothetes* cf. *crenistria, Chonetes* cf. *hardrensis, Athyris* aff. *glabristria, Syringothyris* aff. *cuspidata, Reticularia* cf. *reticulata* and *Rhipidomella* aff. *Michelini.*

The earliest occurrence, in the Bristol Area, of a corrugate Productus is recorded from these beds.

Proceeding to Quarry 1, which lies immediately north of Quarry 2, the lowest beds of Quarry 2 are seen to form the uppermost beds of Quarry 1.

Z_1 and K_2.

The most interesting portion of the quarry is, however, the northern end, where the lowest beds are exposed.

A small cutting faces the entrance and, here, the uppermost beds of the *Cleistopora*-Zone can be examined. They consist of shales and thin limestones in which Brachiopods are abundant. The zonal index, *Cleistopora* cf. *geometrica*, has been obtained from this cutting.

Climbing out of the cutting at its farther end, we find ourselves upon the bedding slope which bounds the main quarry on its northern side. This slope is formed by the lowest beds of the massive limestone series which constitute the *Zaphrentis*-Zone in the Avon Section. At this level several of the fossils which are characteristic of the *Cleistopora*-Zone occur in association with a typical *Zaphrentis*-fauna, and it is to this fact that the level owes its differentiation as Horizon β.

The following Corals and Brachiopods have all been collected from Horizon β in Quarry 1 :—

(*a*) Brachiopods which may be considered to be characteristic of the *Cleistopora*-Zone :—

Spiriferina cf. *octoplicata*.
Chonetes cf. *Buchiana*.
Athyris Royssii and its variant, mut. β.
Camarotœchia mitcheldeanensis.

(*b*) *Productus* cf. *burlingtonensis*, mut. β is common and may be considered to be equally indicative of the uppermost part of K and the lowest part of Z.

(*c*) *Zaphrentis* aff. *Phillipsi*, which by definition is diagnostic of the *Zaphrentis*-Zone, is less common in Quarry 1 than it is on the Clifton side of the river, in Press' Quarry.

(*d*) The general *Zaphrentis*-assemblage of Brachiopods which has already been specified in the description of the lowest beds of Quarry 2.

Leaving Quarry 1, we must walk northward, along the towing-path, as far as the southern end of a good exposure by the side of the line.

K_1.

Here the K_1 subzone is finely exposed and there is a satisfactory sequence from the normal development of K_1, down through the '*Modiola*-Phase,' into the uppermost beds of the Old Red Sandstone.

The rail-side section is, however, less convenient for work than the river-side exposure which lies between the towing-path and the river, below the level of the path.

Walking along this exposure, the red ' Bryozoa Bed ' is easily recognized and is seen to separate the normal K_1 beds to the south from the ' *Modiola*-Phase ' to the north.

The normal K_1 series should be worked bed by bed, fragments being split off parallel to the bedding planes.

Orthothetes cf. *crenistria*, mut. K_1, *Leptæna* cf. *analoga*, *Productus bassus* and *Camarotœchia mitcheldeanensis* occur in great abundance.

Eumetria aff. *carbonaria* and *Athyris Royssii* are common.

Bryozoa are very abundant, especially the genera *Rhabdomeson* and *Rhombopora* and certain members of the Monticuliporid group.

Small Gasteropods (*Bellerophon*, *Capulus*, etc.) are common, and the species appear to be characteristic of the level.

Small palatal teeth occur sparingly as we approach the Bryozoa Bed.

The Bryozoa Bed is well developed but calls for no special notice.

The ' *Modiola*-Phase ' immediately north of the Bryozoa Bed, contains thick bands of shale which are practically unfossiliferous ; a few imperfect specimens of *Modiola lata* have been discovered but Ostracods appear to be absent.[1] The lowest beds of the ' *Modiola*-Phase ' contain obscure Modioliform lamellibranchs, and small *Spirorbis*-like tubes are weathered out on the surfaces of certain beds.

O. R. S.

The lowest beds of the ' *Modiola*-Phase ' pass down with perfect conformity into the coloured marls and grits which characterize Old Red Sandstone conditions.

From certain beds near the top of the Old Red Sandstone were obtained the scales of *Strepsodus* (?) to which reference has already been made.

[1] *Modiola lata* and Ostracods are, however, common in the rail-side exposure.

IV. Notes on the Genera of Carboniferous Corals and Brachiopods.

These notes are designed for the use of students who have already a general acquaintance with the structure of fossil corals and brachiopods, but who are unacquainted with the generic distinctions which have been made in recent years.

Only those characters are described which can be readily observed in the specimens and cross-sections with which the field-geologist has usually to deal.

CORAL GENERA.

Note.—The only readily-accessible work of reference, in which Carboniferous corals are figured, is the 'Monograph of British Fossil Corals' by Edwards and Haime (Pal. Soc. 1852). Reference is here made to this work (under the abbreviation Ed. and H.) in all cases where a genus is adequately illustrated in it. In other cases, a diagrammatic figure has been introduced into the text.

Syringopora.

Corallum compound.

Corallites: narrow, flexed, cylindrical tubes connected by hollow tubular connectors.

Septa: longitudinal rows of spines.

Tabulæ: funnel-shaped sheets which are attached to the thick wall and hang downward into the cavity of the tube.

A horizontal section cuts the corallites in circular or oval rings which are connected by cross tubes wherever the section happens to have cut through a connector. Inside the wall of each corallite, there are usually one or more thin concentric rings which result from the intersection of the plane of section with the internal tabulæ.

A vertical section shows the longitudinal tubes connected by a series of cross tubes; the tabulæ are seen as a series of funnels, very irregular in shape, which hang down, one inside the other.

The rows of septal spine-bases are to be seen most clearly on the inside of tubes which have been split longitudinally and from which the tabulæ have been removed by weathering.

It was pointed out by Nicholson that *Syringopora* is a Favositoid genus in which the tubes are separated, and that, in consequence, the mural pores of *Favosites* are represented by the tubular connectors of *Syringopora*. Both genera possess the same type of septal structure.

Figures: Ed. and H. Plate 46.

Alveolites and *Chætetes*.

The only group with which we are here concerned is '*Alveolites*' aff. *septosa*. Nicholson has shown that this group is, probably, more correctly assigned to *Chætetes*; but, since the evidence is not conclusive, it seems preferable to retain the older and better-known designation.

Corallum massive.

Corallites: narrow, prismatic, contiguous tubes, probably unconnected by mural pores.

Septa (?) none or, more usually, represented by one or more projections from the wall into the calyx.

Tabulæ horizontal and extending completely across the tubes.

A horizontal section shows the closely-packed, adjacent polygonal cross-sections of the tubes, separated by thick undivided walls. A large number of the cross-sections exhibit one or more 'septal' projections.

A vertical section shows the contiguous tubes completely crossed by numerous thin horizontal tabulæ and also exhibits the division of the whole corallum into thick concentric layers.

[The ultimate reference of this group to either *Alveolites* or *Chætetes* must rest upon the following diagnostic characters:—

Alveolites is a Favositoid genus, characterized by mural pores and by longitudinal rows of septal spines.

Chætetes is a Monticuliporoid genus distinguished by imperforate walls and by a fissiparous manner of growth.

If '*Alveolites*' aff. *septosa* be referred to *Chætetes*, the septal projections must be regarded as infolds of the walls, brought about by incomplete fission of the corallites.]

Figures: Ed. and H. Plate 45

Michelinia.

Corallum massive; the base usually covered with a thick wrinkled epitheca.

Corallites: large contiguous prismatic tubes connected by numerous conspicuous mural pores.

Septa numerous, but projecting a very short distance into the tube so that the inner surface of the calyx appears to be longitudinally ribbed.

Tabulæ vesicular, convex upward and very rarely stretching completely across a tube.

The calyx-view of a well-weathered corallum presents a remarkable resemblance to a honeycomb; the floors of the calices are strongly convex, as if the tubes were filled with large bubbles; the walls of the calices are closely ribbed by the septal ridges.

A horizontal section exhibits the vesicular infilling of the tubes and, in many places, the walls are interrupted where the plane of section has cut along a mural pore.

A vertical section shows the characteristic wedge-like manner of growth, and the interior of the tubes is seen to be filled with a mass of large bubbles, all convex upward and in very few instances stretching completely across a tube.

Figures: Ed. and H. Plate 44

'*Beaumontia*' includes species of *Michelinia* in which the tubes are narrower and more elongate than is the case in *Michelinia* proper, and in which the tabulæ are only slightly convex and usually stretch completely across the tubes.

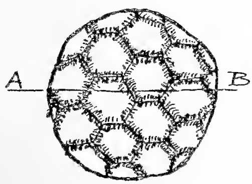
This genus was founded in the belief that mural pores were absent, but good specimens demonstrate that this is an error ; consequently *Beaumontia* can only be regarded as a section of the genus *Michelinia*.

Figures: Ed. and H. Plate 45

Certain small forms of *Beaumontia* are difficult to separate from *Favosites*, and these occur, with the typical examples of *Beaumontia*, at the very top of the Avonian.

The continuous series : *Favosites, Michelinia, Beaumontia* and cf. *Favosites*, affords an excellent example of one of the simplest lines along which evolution works : (1) stability and simplicity, (2) instability and exaggeration, (3) reversion to simplicity, (4) extinction.

Cleistopora.



Calyx view.

Vertical section, showing the coral attached to a foreign body.

The true relationship of this genus is extremely obscure. The corallum is a thick circular or oval plate whose upper surface is divided by low walls into not-numerous hexagonal calices ; the lower surface is flat and attached to foreign bodies.

The floor of the calyx is flat, but rough (as if laid with tiny cobbles).

The calyx view of the corallum resembles that of *Michelinia*, but the walls and floor in *Cleistopora* are built up of a closely-packed mass of spongy tissue.

Figures (showing structure): Nicholson, *Manual of Palæontology.* (1889), p. 310.

Amplexus.

Corallum simple, long and cylindrical, with a conical base; thick-walled.

Septa projecting from the wall, short and straight, of equal length and stopping abruptly; attached to the upper surfaces of the tabulæ.

Tabulæ very numerous; extending completely across the tubes and horizontal throughout their extent, except in the immediate neighbourhood of the wall.

Vesicles: none.

Figures: Ed. and H. Plate 36

This is one of the most remarkable coral genera and must, in my opinion, be restricted to the type species, *Amplexus coralloides,* Sow. I cannot agree that there is any real affinity between *Amplexus coralloides,* Sow. and the group typified by '*Amplexus*' *nodulosus,* Phillips in which the septa are flexuous and unequal and the tabulæ are sub-vesicular. The latter group appears to be an example of the reversion to simplicity which frequently precedes extinction. In a forthcoming paper, I am suggesting a new genus *Pseudamplexus,* to include *Amplexus nodulosus,* Phillips and closely related species, all of which are mainly characteristic of D_3.

The ZAPHRENTIDS.

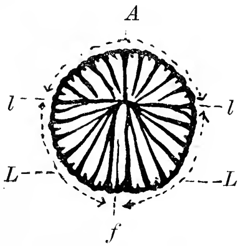
(Including *Zaphrentis* and *Caninia*).

This group is distinguished among the Carboniferous Corals by the possession of a conspicuous radial depression (' Fossula ') in each tabula; the fossulæ are so arranged as to always lie towards the same part of the corallum, and therefore to fit into one another from above downward.

The septa are bilamellar and the two lamellæ open out at the base of each septum; the branch from one septum unites, across the interseptal space, with a branch from the adjacent septum so as to form a dense wall.

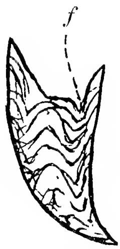
In *Zaphrentis* proper, this wall is in contact with the epithecal covering; but in *Caninia*, this wall is separated from the epitheca by a broad ring of vesicles. Interseptal vesicles are only feebly developed.

Zaphrentis.



Horizontal section.

f='Fossula'
l, *l*=lateral breaks
L. *L*=lateral groups
A=antifossular group



Vertical section, showing cystoid tabulæ and fossula.

Generalized Diagrams.

Corallum simple, conical and curved ('cornute') and usually small. Wall thick and composed of two distinct parts in close contact, the epitheca and the inner wall.

Epitheca marked by concentric wrinkles and longitudinal rugæ.

Septa attached to the wall by thickened bases and tapering inward.

The primary septa are long and extend nearly, or quite, to the centre of the corallum.

The secondary septa are usually inconspicuous (except in the calyx-wall) and extend only a short distance from the wall. (They mark the junction of the septal lamellæ which are formed by the forking of adjacent primary septa.)

Septal breaks and groups:

There are three main breaks in the septal sequence which divide the whole series of septa into three distinct groups.

The fossula is a conspicuous radial gap which separates the two lateral septal groups.

The lateral breaks are usually less conspicuous and separate the antifossular group from the two lateral groups. (These breaks are usually represented by the shortening of a primary septum on either side of the corallum.)

In each lateral group, the septa are confluent at their inner ends and form a wedge-shaped mass.

In the antifossular group, the two bounding septa usually meet and form a single plane which bisects the corallum. The rest of the septa of the group converge towards this plane without, as a rule, meeting one another.

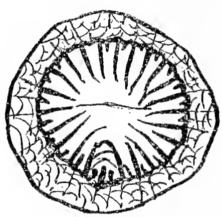
Tabulæ arched in the centre ('cystoid') and deeply depressed in the region of the fossula.

Vesicles: In the neighbourhood of the wall, the tabulæ split up into broad shallow vesicles which are directed upward and outward.

A calyx view exposes the deep fossula and the three septal groups; the secondary septa are more conspicuous in this view than in a horizontal section.

Figures: Ed. and H. Plate 34

Caninia.



Corallum simple, elongate, cylindro-conical and usually large.

A horizontal section exhibits three areas :—

(1) A central area, practically free from septa, which is occupied by the tabulæ.

(2) A medial area, radiated by subequal thickened primary septa which fork at their bases to form a thick inner wall, as above explained.

(Short thickened secondary septa are usually, but not invariably, developed.)

(3) An outer area which is built up of closely-packed vesicles, and is imperfectly radiated by thin prolongations of both series of septa.

Tabulæ broad and flat across the central and medial areas, but bent downward at the inner wall.

(In the medial area, the septa are attached to the upper surfaces of the tabulæ.)

The septal break is marked out by the shortening of one of the primary septa and by the arching of the adjacent septa round it.

The fossula is a deep depression of each tabula at the septal break; it is recognized in a horizontal section by a series of arched tabular intersections.

(The septa on the fossular side of the corallum are often remarkably thickened.)

The essential characters of *Caninia* are :—

(1) The deep fossular depression and marked septal break.

(2) The practically-radial symmetry, due to the suppression of a *Zaphrentis* type of grouping.

(3) The envelope of closely-packed vesicles.

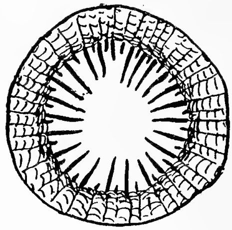
(4) The thickened septa and the construction of the inner wall.

(5) The broad flat tabulæ.

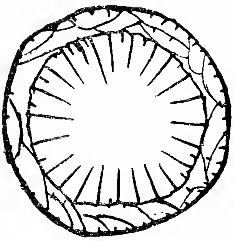
Figures: Ed. and H. Plate 35

Campophyllum.

Caninoid group.



Clisiophylloid group.



Corallum cylindro-conical, with thick, annulated epitheca.

Central area tabular and free from septa.

Medial area occupied by a ring of equal primary septa which are attached to the tabulæ.

Outer area vesicular and either devoid of radial structure, or radiated, more or less perfectly, by thin septal prolongations of both series of septa.

Septal break inconspicuous.

Fossula undeveloped in typical examples.

Tabulæ broad and flat, and stretching completely across the central and medial areas.

Secondary septa short.

The essential characters of this genus are :—

(1) Broad, flat tabulæ.

(2) No fossula.

(3) A uniform ring of primary septa which do not reach the centre.

(4) An outer area in which vesicles are strongly developed, but in which radial structure is inconspicuous.

This genus is unsatisfactory on two counts :—

(*a*) It includes corals with very distinct types of structure.

(*b*) In the Caninoid section, certain species possess a distinct but shallow fossula and their reference to *Campophyllum*, rather than to *Caninia*, is the result of a careful comparison of all their characters with typical examples of both genera.

Two sections of this genus are markedly distinct :—

I. The Caninoid section, characterized by a well-marked inner wall and a purely vesicular outer area. (A series of septal teeth project from the outer wall into the vesicular area.)

Of this section there are two subsections :—

(*a*) A group in which the septa are long, thick and tapering and very closely approximated.

(*b*) A group in which the septa are short, thin, and broadly spaced (*Campophyllum* aff. *Murchisoni*, Vaughan belongs here).

II. The Clisiophylloid section, characterized by its broad vesicular area which is distinctly and regularly radiated by thin prolongations of both series of septa. The interspaces between these prolongations are filled in with close-set vesicles which are more closely approximated at the inner boundary of the area, and consequently mark out a conspicuous inner wall.

In this section, the vesicular area is identical in structure with that of the external area in the Clisiophyllid group.

(*Campophyllum derbiense*, Vaughan [M.S.] is a typical representative of this section.)

[The type figure of *Campophyllum Murchisoni*, Ed. and H. (Plate 36, Figs. 2, 2*a*,3,) probably represents a species belonging to this section, but, if so, the inner wall is incorrectly drawn.]

Cyathophyllum.

Corallum simple and cylindro-conical, or compound and massive.

Septa numerous, close-set, radial, alternate in length and of nearly uniform thickness among themselves and throughout their length. The primary septa extend to the centre.

A septal break is usually marked out by the shortening of one of the primary septa. This break is inconspicuous in a horizontal section, but is often represented, in the floor of the calyx, by a deep radial groove (' pseudofossula ') ; especially is this the case when the floor is arched up into a broad central boss.

The tabulæ vary remarkably in the degree of their development :—

The early Caninoid *Cyathophylla* (such as *Cyath.* ϕ) from the *Syringothyris*-zone have broad, close-set, flat tabulæ.

In *Cyathophyllum Murchisoni*, the tabulæ are, for the most part, replaced by horizontal rows of vesicles, but true tabulæ occur at intervals of every five or six rows of vesicles.

In the Clisiophylloid *Cyathophylla* (such as *Cyath. regium*), from the Upper *Dibunophyllum*-zone, tabulæ are typically absent, and are replaced by arched rows of small vesicles.

The interseptal spaces are crowded with small, closely-packed vesicles, which are relatively scarce at the outer boundary of the central area.

In the compound forms, the corallites are united by vesicular tissue and walls are only represented by a series of solid vertical rods, placed at intervals round each corallite.

The essential characters of the Carboniferous *Cyathophylla* are :—

(1) Very numerous, close-set septa, alternate in length, and not specially thickened at any point of their length.

(2) The primary septa extend nearly or quite to the centre.

(3) Vesicles are abundant from circumference to centre.

Figures: Ed. and H. Plates 32 and 33

Lithostrotion.

Corallum compound and either dendroid or massive.

Septa alternate and attached to the outer wall; uniform in thickness, without special thickening at any point of their length.

The primary septa usually stop short of the centre. The secondary septa never project far beyond the inner wall.

Septal break inconspicuous.

An external area, radiated by both series of septa, is always developed but is very variable in width, being almost absent in *Lith. junceum,* and very broad in *Lith. affine.*

The tabulæ are broadly convex in the dendroid species, and strongly conical in the massive forms.

A solid lath-shaped columella is always present, but its degree of development varies considerably, being greatest in those species which have strongly arched or conical tabulæ, and least in those with flattened tabulæ.

Vesicles are practically confined to the external area and vary in number with its width.

An inner wall is formed by the closer approximation of the vesicles at the inner boundary of the external area.

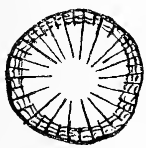
The essential characters of the genus are :—

(1) The lath-shaped columella.

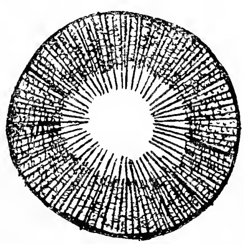
(2) The absence of plates starting from the columella and radiating outward (lamellæ).

Figures: Ed. and H. Plates 38 to 42

Diphyphyllum.



Lithostrotion-like.



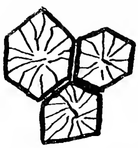
Cyathophyllum-like.

This genus, as originally defined, includes only *Lithostrotion*-like corals in which there is no trace of a columella, and in which the tabulæ are broad and almost flat.

The septa are well spaced, and the secondary series is relatively short.

Thus restricted, *Diphyphyllum* includes those Lithostrotions in which the columella is apparently never developed, but, since the degree of development of this structure in typical examples of *Lithostrotion* is known to vary with the elevation of the tabulæ, it is clear that the distinction is not a natural one. The genus may, however, be usefully retained as a descriptive term, and it is convenient to extend its connotation so as to include *Cyathophyllum*-like forms with close-set septa and broad external area, in which the primary septa do not extend to the centre. The *Diphyphyllum* cited among the D_1 corals belongs to this section.

Petalaxis.



Petalaxis Portlocki.

Corallum compound and massive; built up of narrow prismatic corallites, which are easily separable since the walls of the separate corallites are perfectly distinct.

Septa few and flexuous.

Tabulæ conical and well spaced.

Columella usually conspicuous, but often apparently undeveloped, its place being taken by the inner end of a long septum.

Vesicular tissue very sparingly developed.

I have considerable doubt of the validity of this genus, since I am convinced that the specimen figured by Edwards and Haime under the name *Petalaxis Portlocki* (Pl. 38, Figs. 4, 4*a*) is merely a form of *Lithostrotion irregulare* in which the corallites have become prismatic by pressure (a condition of very common occurrence).

In this paper I have retained the generic name for certain corals which differ markedly from the normal types of *Lithostrotion* in their spidery septa, as well as in the absence of a columella in many of the corallites.

The only species is *Petalaxis Portlocki*, Ed. and H., emend. Vaughan, from the upper *Dibunophyllum*-zone.

The CLISIOPHYLLIDS.

All the members of this group are conical or cylindro-conical. *Lonsdalia* is invariably compound, and *Koninckophyllum* is not infrequently so. The remaining genera described below are almost invariably simple, although compound forms have been occasionally met with in all.

No coral of this group can be definitely named except by the careful examination of a horizontal section and, consequently, the descriptions which follow deal mainly with the structures which are exhibited by such sections.

The essential characters of this group are :—

(1) The vaulting of the tabulæ in the central area.

(2) The development of 'lamellae,' a special series of plates which are attached to the upper surface of the arched tabulæ, and which run, radially or spirally, down the sides of the tabular vault.

The central area, in a horizontal section, exhibits, in consequence, a very characteristic spider-web structure which is produced by the intersection of the plane of section with the arched tabulæ and with the radiating lamellæ.

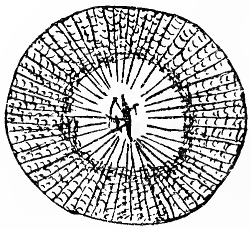
The medial area is radiated by the ring of primary septa, the interspaces between which are occupied by large vesicles.

The external area is radiated by the thin prolongations of the primary septa, and also by an equally thin intermediate series which is usually only imperfectly developed. The interspaces are filled with small, closely-packed vesicles which, by closer approximation at the inner boundary of the area, form a distinct inner-wall.

The peripheral area, when present, is characterized by larger vesicles, and by the absence of conspicuous radiation ; it usually merges, quite continuously, into the external area.

In the following descriptions of the best-known genera of the Clisiophyllids, attention is directed solely to diagnostic characters.

Koninckophyllum.

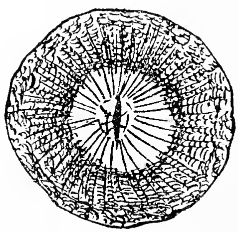


Central area narrow and crossed by a mesial plate from which very few lamellæ radiate outward.

Septa alternate and fully developed, close-set and extending to the outer wall, uniform in thickness among themselves and throughout their length.

This section is especially characteristic of D_1 in the South-Western Province, and is closely related to *Lithostrotion.*

Acrophyllum.

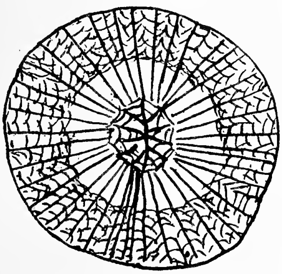


This genus is closely related to the preceding, of which it is, in fact, a more specialized representative. The essential difference lies in the structure of the outer areas.

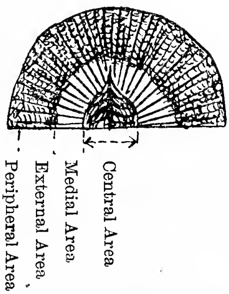
In the external area, the vesicles are very densely packed, and the septal prolongations gradually thin out toward the outer wall. A peripheral area is developed in which the vesicles lie close together in parallel festoons.

This genus is characteristic of D_2 and, in its general type of structure, exhibits convergence with *Lonsdalia*.

Dibunophyllum.



Early and simple type.



Late and specialized type.

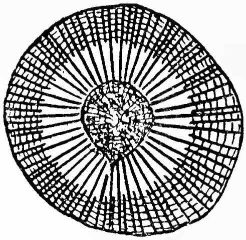
Central area bisected by a long mesial plate from which well-spaced, strong lamellæ radiate outward.

In the early forms, which are especially characteristic of D_1, interseptal vesicles are loosely-packed and an inner wall is very indistinctly developed.

In the later forms, characteristic of D_2, the structure is highly specialized; the external area is well developed, and there is usually a narrow peripheral area; the central area is strongly differentiated and cuspidate; vesicles are closely-packed and an inner wall is very distinctly marked out.

This section must be regarded as the type genus of the Clisiophyllids.

Cyclophyllum.



Central area surrounded by a distinct wall and crowded with minute vesicles. (So strongly is the bounding wall of this area developed that, in weathered specimens, the central portion often stands out as a distinct tube.) In the very centre of the area the vesicles are comparatively large, whereas, near the circumference, they are extremely minute. Very numerous thin radii extend from the circumference inward for a short distance.

The medial and external areas resemble those of Koninckophyllum.

[N.B.—*Aulophyllum* is separated from *Cyclophyllum* by the presence of flat tabulæ in the middle of the central area, but, since the vesicles of a *Cyclophyllum* always become broad and flat at the very centre of the coral, it seems doubtful whether the distinction can be usefully maintained.]

The genesis of this section is not yet clearly understood, but it may be pointed out that *Cyclophyllum pachyendothecum* could be derived from *Cyathophyllum Murchisoni* by the enclosure of the inner vesicular mass within a special tube (involving the inclusion also of the inner portions of the septa).

Lonsdalia.

Corallum always compound and either dendroid or massive.

Central area circular and reticulate ; mesial plate short and entirely included within the area ; lamellæ frequently very numerous and purely radial, crossed by concentric tabular intersections.

Septa not numerous, thickened in the middle, and seldom reaching the outer wall ; intermediates present or absent.

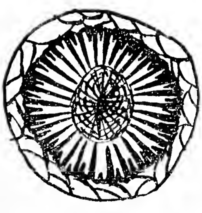
The external area is only represented by the dense ring of vesicles which forms the inner wall.

The peripheral area is usually very broad and built up entirely of large vesicles. (It is within this area that the young corallites separate out.)

Figures : Ed. and H. Plate 43

[N.B.—*Axophyllum* may be regarded as a *Lonsdalia* in which the whole of the central area forms a solid rod, for a horizontal section of the solid central columella in this genus exhibits the characteristic *Lonsdalia*-structure. The external area is, however, of an *Acrophyllum*-type.]

Carcinophyllum.



This genus is usually simple, but compound forms have been found.

Central area oval and with a well-defined boundary ; mesial plate short, and entirely surrounded by a reticulate network ; lamellæ approximately equal in number to the septa.

Primary septa, usually 33 in number, well spaced and thickened, especially at the inner wall.

Secondary septa short and stout, and also thickened at the inner wall.

Peripheral area purely vesicular, the vesicles being large. (In weathered specimens of this coral, the peripheral area is very liable to destruction on account of its loose structure.)

An external area is practically undeveloped.

This genus ranges from S_1 to D_1 in the South-western Province.

The essential distinction from *Lonsdalia* lies in the structure of the inner wall. In certain of the earliest forms from S_1, the inner wall is produced by the coalition of the thickened ends of the two series of septa, a type of structure which indicates convergence with such a form as *Zaphrentis* aff. *cornucopiæ*.

In the later forms from S_2 and D_1, the septa are more spaced and the inner wall is formed by the forking of the septa at their base and by the union of the branches from two adjacent septa, a type of structure which is characteristic of *Caninia*.

It is not, however, unusual to find, in specimens from D_1 that the inner wall is weakly vesicular and such specimens exhibit an approach towards the structure of *Lonsdalia*.

It is possible that *Lonsdalia* is directly derived from *Carcinophyllum*, but the evidence is, as yet, very incomplete.

Already in D_1, *Carcinophyllum* exhibits old age characters, as shown by the excessive development of the peripheral vesicular area, and by the growth of roots (characters which are also well shown in *Lonsdalia*).

BRACHIOPOD-GENERA.

(In the descriptions of Brachiopod genera which follow, it would be impossible to estimate the amount of my indebtedness to Hall's classical work on the 'Genera of Palæozoic Brachiopoda.')

For figures illustrative of the several genera of Carboniferous Brachiopoda, I refer throughout, under the abbreviation 'Dav.', to Davidson's 'Monograph of British Carboniferous Brachiopoda,' vol. 2. (Pal. Soc. 1857-1862).

Productus.

Hinge-line straight.

Pedicle-valve convex, with large incurved beak.

No area or teeth.

The much-branched adductor-scars are bisected by a mesial ridge.

The large diductor-scars lie below and outside the adductors.

Brachial-valve concave.

No sockets.

The mesial septum is a strong ridge which terminates at the hinge line in the massive cardinal-process.

The adductors lie one on each side of this ridge.

Each of the two brachial ridges starts out horizontally from the lower corner of an adductor scar and curves round like a crook.

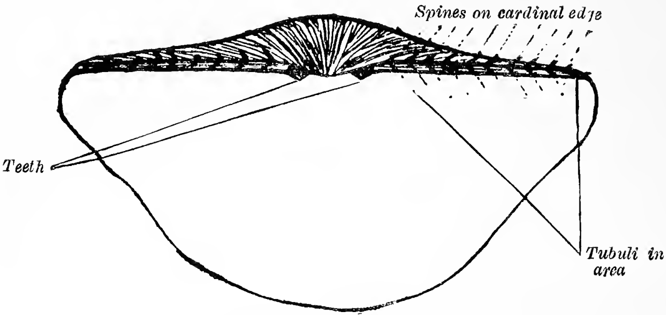
External ornament:

Close longitudinal ribs, usually crossed by concentric wrinkles in the region of the beak.

Hollow spines projecting from the ribs, especially on the shoulders of the valve in the neighbourhood of the hinge-line.

Figures: Dav. Plates 31 to 44.

Choneti-Productus.



Choneti-Productus : pedicle valve.

The forms included here only differ from *Prod. giganteus* in the possession of :—

(1) Narrow area,

(2) Well developed teeth,

(3) Tubuli which perforate the shell immediately below the surface of the area.

[The row of spines along the cardinal edge occurs also in typical specimens of *Prod. corrugatus*, *Prod. hemisphericus* and *Prod. giganteus*.]

In *Choneti-Productus* Chonetoid convergence is clearly indicated, but this is rather the expression of instability in the species than of true mutational variation, for, among a large number of specimens of *Prod. giganteus* collected from the same bed and agreeing in all other characters, Chonetoid convergence is only exhibited in a small number.

This Chonetoid-tendency has only been remarked in specimens from D_2, and it is synchronous with the Clisiophylloid-tendency which is exhibited by certain specimens of *Lithostrotion Martini*.

Chonetes.

Valves transverse, flattened.

Hinge line straight, forming the widest part of the shell.

P e d i c l e v a l v e shallow-convex.

Beak not differentiated from the flanks, and its apex not incurved over the area.

Teeth well developed.

Muscular scars arranged on the Productoid pattern, but very lightly impressed.[1]

A row of hollow spines along the cardinal edge; these spines are the bent continuations of slender tubuli which perforate the shell immediately below the surface of the area.

Brachial valve weakly concave or flat, with strong sockets, mesial septum and thickened cardinal process.

Ornament:

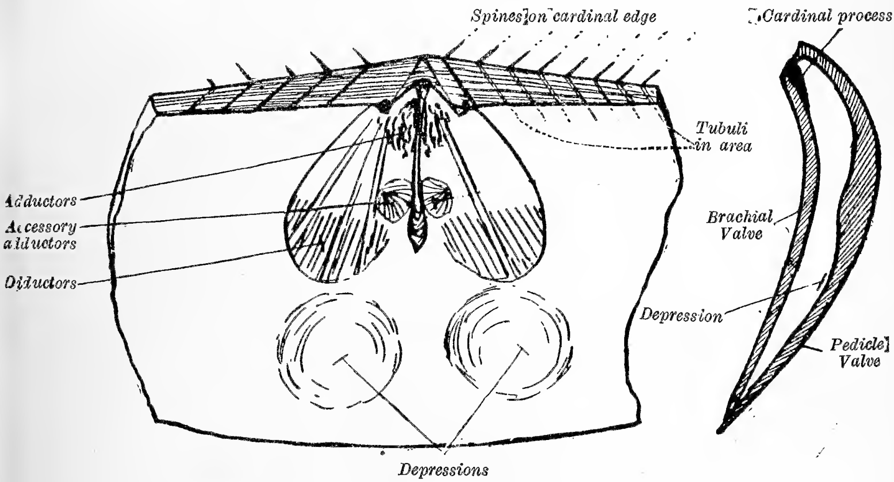
Longitudinal ribs which increase by forking and intercalation.

Spines practically absent, except along the cardinal edge.

The under layer of shell exhibits very characteristic rows of close-set pits along every furrow; into these pits fit corresponding rows of small spikes which project from the under-surface of the outermost shell-layer.

Figures: Dav. Plate 47.

Daviesiella.



Daviesiella (=*Producti-Chonetes*) aff. *comoides*.
Pedicle valve and section.

[1] The weak impression of the muscular scars is the direct consequence of the thinness and flatness of the valves.

Valves thick-shelled, large.

Pedicle valve convex (often strongly so).

Beak usually well-differentiated.

Teeth, area, spines and tubuli as in *Chonetes.*

Muscular scars deeply impressed and arranged as in the giganteid *Producti.* An additional pair of circular adductor scars are placed below the principal adductors (as is often the case in the giganteid *Producti*).

Brachial valve:

Adductor scars deeply impressed and brachial ridges conspicuous; mesial septum and cardinal process strongly developed.

Ornament:

Fine, close-set longitudinal ribs.

Spines practically absent, except from the cardinal edge.

Rows of pits as in *Chonetes.*

Figures: compare Dav. Plates 45 and 55.

NOTES:—The genus *Daviesiella* was created by Waagen to include massive Productoid forms, with strongly-developed teeth and accessory adductors in the pedicle valve. The geno-type is *Productus llangollensis*, Dav. (Dav. Plate 55, figs. 9 and 10) and *Chonetes comoides* (J. Sow.) is a syngeno-type (compare Dav. Pl. 45, fig. 7).

'*Chonetes*' aff. *comoides*, figured above, agrees with '*Chonetes*' *comoides* in all essential points, although it never attains either the large dimensions or the thickness of shell which are so marked in that species. There can however be no hesitation in referring '*Chonetes*' aff. *comoides* to Waagen's genus.

This species is very abundant in D_1, in the South-Western Province.

A difficulty arises however with regard to the classification of *Chonetes* cf. *papilionacea* from S, and of *Chonetes* cf. *comoides* from C.

Chonetes cf. *papilionacea* has a strongly Chonetoid aspect, since its beak region is not appreciably differentiated from the flanks and the apex of the beak is not incurved; also, the valves are usually flattened. Hence, this form bears a strong resemblance to the large finely-ribbed *Chonetes* which are usually assigned to *Chonetes papilionacea*, (Phillips).[1]

The muscular scars, which include a pair of accessory adductors, are arranged on exactly the same plan as they are in *Chonetes* aff. *comoides*, although they are much less impressed (a necessary result of the diminished shell-thickness and convexity). Hence, there seems to be little doubt that *Chonetes* aff. *comoides* was derived from the earlier *Chonetes* cf. *papilionacea* by convergence with *Productus giganteus* in D_1.

Chonetes cf. *comoides* is difficult to classify because it is as yet incompletely known, in spite of its great abundance. In size and thickness of shell, this form often surpasses the largest *Daviesiella*, but the aspect is usually markedly Chonetoid. Area, teeth, spines and tubuli are well developed, as also are the rows of pits; the muscular scars are as yet very imperfectly known. It seems probable however that *Chonetes* cf. *comoides*, *Chonetes* cf. *papilionacea* and *Chonetes* aff. *comoides* are all mutations of the same gens. (It seems possible that, at the birth of the gens of papilionaceous *Chonetes*, the environment was so eminently suitable that the animals were encouraged to build large and ponderous shells, a habit which they had to partially discard during *Seminula*-time.)

Leptæna.

Hinge line straight and forming the widest part of the shell.

P e d i c l e v a l v e usually horizontal and convex, with a dependent margin.

Ornament consisting of fine thread-like radial ribs, crossed by coarse concentric wrinkles which are confined to the horizontal portion.

Area narrow; teeth prominent.

Two large fan-shaped diductors, enclosing a narrow mesial adductor.

[1] This species is actually unknown since the holotype is an imperfect specimen which only exhibits a portion of the interior of the brachial valve.

Brachial valve: horizontal portion flattened, and usually concave (but convex in a common D. species).

Cardinal process and mesial septum well developed.

Muscular scars (two pairs of adductors) deeply impressed and circumscribed by strong ridges.

[Broad, ribbon-like, vascular (?) markings start near the line of geniculation, and run down, over the dependent portion of the valve.]

Figures: Dav. Plate 28 (under the generic name *Strophomena*).

Orthothetes.

Hinge line straight, and usually forming the widest part of the shell.

Ornament consisting of sharp erect, thread-like radial ribs which are conspicuously periodic in strength and length (usually at least triserial).

Pedicle valve flattened or concave when viewed as a whole, but the beak region is usually convex.

Area usually narrow, with a central delthyrium.

Teeth strong.

No mesial septum.

The diductor-scars form a continuous fan-shaped area in the centre of which is enclosed the small inconspicuous adductor-scar.

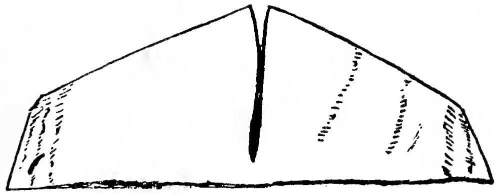
Brachial valve convex (and often geniculate) when viewed as a whole, but the beak region is usually flattened and often concave.

The cardinal process combines with the crural plates to form a thick, transverse projection from the middle of the hinge-line.

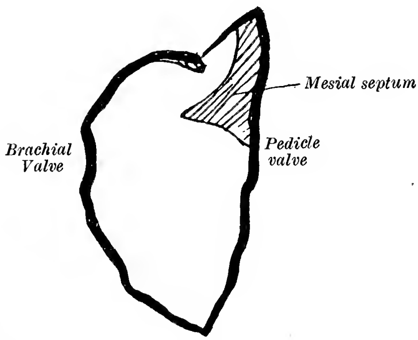
The muscular area (adductors) is fan shaped and bisected by a low mesial ridge.

Figures: Dav. Plate 26 (under the generic name *Streptorhynchus*).

Derbya.



Cast of pedicle valve (beak region only), showing impression of mesial septum.



Back-and-front section, showing mesial septum in pedicle valve.

This genus is separated from the normal type of *Orthothetes* by the following characters :

Strong mesial septum in the pedicle valve.

[Strongly convex brachial valve and flattened pedicle valve.]

Large area whose surface is usually bent out of one plane.

Delthyrium usually twisted to one side.

Surface of valves very irregular in curvature and often undulated.

Figures: Dav. Plate 27, figs. 1, 2, 3, 4 (*Streptorhynchus crenistria*, var. *senilis*).

Schizophoria and *Rhipidomella.*

Characters common to both genera :—

Valves biconvex.

Hinge line straight, and less than the greatest width of the shell.

A triangular area, with central delthyrium, in each valve.

Ornament: narrow, close-set radial ribs which usually bear short procumbent spines.

Outer shell-layer strongly punctate, especially on the ribs.

Teeth and cardinal process well developed.

Muscular scars deeply impressed and surrounded by a thickened margin.

Distinctive characters:

Schizophoria

Pedicle valve flattened; the muscular scars, which occupy a relatively small area, are narrow and flabelliform and are separated by a strong ridge.

Brachial valve strongly convex, often globose; the two adductor-scars which lie on the same side of the middle line are not sharply marked off from each other, and the adductors on one side are separated from those on the other by a broad central plateau.

Figures: Dav. Plates 29 and 30 (*Orthis resupinata*).

Rhipidomella

Both valves flattened and approximately equal.

The muscular scars of the pedicle valve cover a very considerable portion of the whole interior area of the valve.

In the brachial valve, the two adductor-scars which lie on the same side of the middle line are sharply marked off from each other by a ridge which runs out, perpendicularly, from the mesial septum.

Figures: Dav. Plate 30 (*Orthis Michelini*).

NOTE:—The essential distinction between the above two genera is the very large size of the muscular scars in the pedicle valve of *Rhipidomella*. But, although this character will always serve to distinguish a typical specimen of *Orthis Michelini* from a typical specimen of *Orthis resupinata*, yet, in the case of specimens which are intermediate in outward form, the degree of development of the muscular scars is also intermediate, and the separation of the two genera becomes impossible.

The SPIRIFERIDS include all Brachiopods which exhibit the following characters :—

(1) Straight hinge line.
(2) An area with central delthyrium.
(3) A pair of internal 'spires' whose apices are directed towards the sides.
(4) The apex of the beak unperforated.

Spirifer.

This genus is employed in this paper to denote those carboniferous Spiriferids which possess :—

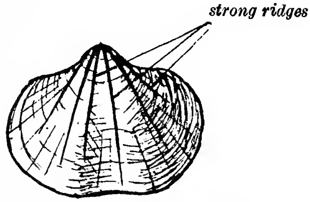
(1) A well-developed area.
(2) A pointed beak, curved over the area.
(3) Mesial fold and sinus.
(4) Strongly marked radial ribbing over fold and sinus as well as over the flanks.

The hinge-line is usually the widest part of the shell, as for example in the groups of *Sp. striatus* and *Sp. bisulcatus.*

Figures: Dav. Plates 2 and 6.

But, in certain species, the hinge line is shorter than the greatest width, for example in *Spirifer planicosta* (see Dav. Pl. 6, fig. 20).

Martinia.



Martinia: pedicle valve (cast).

This genus includes the groups of *Spirifer glaber* and *Spirifer ovalis.*

Form oval (either transverse or elongate).

Hinge-line short and the area small and triangular

The surface is either smooth, or divided by a small number of radial grooves into broad flattened ' ribs.'

No dental plates and consequently, in the cast, the sides of the beak are rounded.

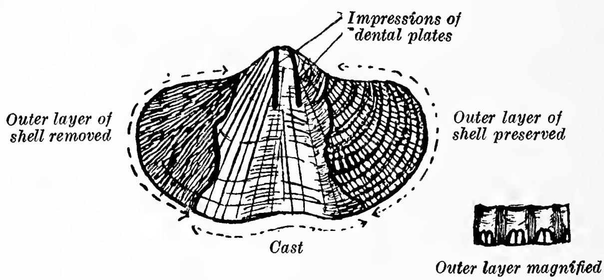
The thin outermost shell-layer is strongly punctate (a fact which accounts for the glistening surface).

The internal surface of the valves has deep, narrow radial grooves which diverge from the beak, and consequently the cast has corresponding sharp, septum-like ridges.

The essential characters are the smooth exterior, the short hinge-line, the punctate outer layer and the absence of dental plates.

F i g u r e s : Dav. Plates 9, 11 and 12.

Reticularia.



Generalized diagram of the pedicle valve.

This genus is here retained, tentatively, to include all those Spiriferids whose external ornament consists of concentric rows of adpressed, hollow radial spines ; the general form agrees with that of *Martinia.*

It is however very doubtful whether all the forms which come under this general definition are correctly grouped together in a single genus.

The genotype is *Spirifer imbricatus* (Sow) which has strong dental plates in the pedicle valve and an external ornament composed of double barrelled (nostril-like) spines (see figure above).

Spirifer lineatus (Mart.), as typified by small transversely-oval forms, without fold or sinus, agrees in external ornament, but differs in the absence of dental plates.

Reticularia cf. *reticulata*, which is especially characteristic of the *Zaphrentis*-Zone, is remarkable for the reticulate underlayer, formed of slender, much-bent rods which fork and intercalate (see figure above). This species has strong dental plates, but the external spines appear to be single-barrelled in the majority of cases (although specimens which exhibit the normal structure very clearly occur in the same zone).

Figures: Dav. Plate 13.

Spiriferina.

The Carboniferous members of this genus exhibit the following characters :—

Shells oval with a short hinge line and a triangular area which is concave and often of considerable height.

Beak pointed and curved over the area.

Ornament:

Strong radial pleats,[1] separated by equally strong furrows. (The valve-intersection is consequently strongly maxillated.)

Mesial fold formed of a single large central pleat which is usually undivided (but frequently grooved along its middle line).

The concentric ornament usually consists of close imbricating lamellæ.[1]

The shell is strongly punctate throughout (a structure which is often beautifully displayed on the cast).

Internal Septa

In the pedicle valve, the dental plates are strongly developed, but do not converge and unite ; a tall septum projects from the middle line of the valve.

[1] In the genotype, *Spiriferina rostrata* of the Middle Lias, radial pleats and concentric lamellæ are absent.

The essential characters of the genus are :—

(1) Pointed incurved beak and concave area.
(2) Strongly punctate shell.
(3) Prominent mesial septum in the pedicle valve.

Figures: Dav. Plate 7, figs. 37 to 55.

Syringothyris.

Hinge-line almost, or quite, as wide as the shell.

Shell dispersedly punctate.

Brachial-valve transverse.

Mesial fold usually composed of a single, large undivided [1] pleat.

Simple radial ribs on the flanks.

A mesial septum usually developed.

Pedicle-valve semiconical, the beak forming the apex and not curved over the area.

Area very large, triangular, and usually flattened: sinus deep, semiconical, and usually devoid of ribs.[2]

Ribs on flanks numerous, but usually much flattened.

Internal characters of the pedicle valve :—

Mesial septum and dental plates strongly developed. A transverse sheet stretches across the delthyrium, just within the aperture, and, along the middle line of the inner surface of this sheet, a split-tube (the '*syrinx*') is formed by the growth of two curved plates towards each other.

The essential character of *Syringothyris* is the presence of a syrinx, and it is only by demonstrating the presence of this structure that specimens can be definitely separated from *Spiriferina*, a genus in which the area may become large and flat, and in which the delthyrium is occasionally partly closed by a rostral callus.

(*Syringothyris* cf. *laminosa* is an instance of a Spiriferid which is not yet definitely separated from *Spiriferina*.[2])

[1] In *Syringothyris distans*, both fold and sinus are irregularly ribbed.
[2] See Q.J.G.S. vol. 61, p. 301.

Figures: Dav. Plate 8.

Cyrtina.

The Carboniferous members of this genus exhibit the following characters :—

Form: either *Syringothyris*-like, as in *Cyrtina septosa,* or *Spiriferina*-like, as in *Cyrtina carbonaria.*

The area is large and triangular, with a large central delthyrium.

Ornament:

The mesial fold is scarcely differentiated from the flanks, and the same type of ribbing extends over the whole shell.

The ribs are usually thick and frequently forked.

Internal structure of the pedicle valve:

Mesial septum and dental plates are strongly developed.

The dental plates converge and unite with each other, and with the mesial septum, to form a prominent *spondylium.*

The shell structure is strongly punctate.

The essential characters of the genus are the prominent spondylium and the strongly punctate shell.

Figures: Dav. Plates 14 and 15.

The Athyrids

The Carboniferous species of this group are distinguished by the following characters :—

Curved hinge line and no area.

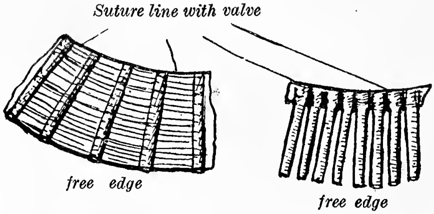
Perforated beak.

Internal spires, directed to the sides.

Shell structure non-punctate.

Notwithstanding the large amount of work which has been done upon the members of this group, the divisions into which it has been separated cannot as yet be regarded as entirely satisfactory. Since also the essential distinctions between the divisions rest upon the structural characters of the spires, a critical discussion of their value would be entirely out of place in an elementary introduction such as is attempted in this section. I shall consequently subdivide the group into two genera only, *Athyris* and *Seminula*, based entirely upon the nature of the external ornament.

Athyris.



Actinoconchus. *Cliothyris.*
Expansions magnified.

Here I include all Athyrids in which the concentric ornament consists of imbricating expansions. The true nature of the expansion is usually difficult to settle, since it is only in exceptionally-weathered specimens that the structure is obvious and an excess of weathering, by destroying part of the expansion, leads to an erroneous conception of its true nature.

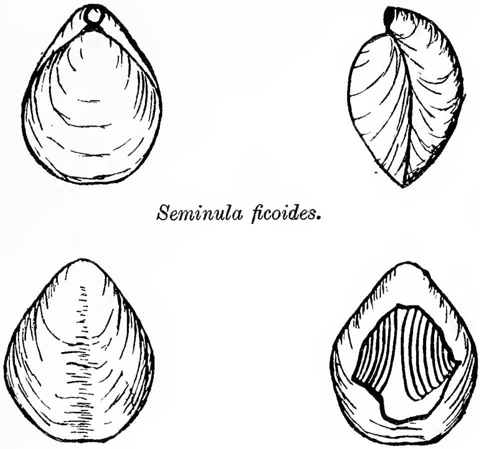
Two distinct types of expansion are figured above :—

(1) The *Actinoconchus*-type in which the lamellæ consist of flattened tubes, united by a web. This structure is typically developed in certain specimens which are referred to *Athyris planosulcata*. When the expansion has been laid bare by a lucky fracture, the tubes appear as ribs upon a broad lamella ; but when a specimen has been subjected to weathering, the web is removed faster than the ribs and the expansion consequently appears to be fringed.

(2) The *Cliothyris*-type in which the expansion consists of close-set, disunited, flattened tubular spines which spring from a narrow basal lamella. This structure is characteristic of *Athyris Royssii*.

Figures: Dav. Plates 16 and 18.

Seminula.



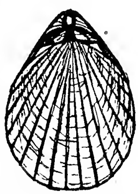
Seminula ficoides.

Elongate-oval and smooth (Terebratuliform).
Strong concentric lines of growth, but no expansions.

This genus bears a close outward resemblance to *Dielasma*, from which however it is fundamentally separated by the possession of :—

(1) Non-punctate shell.
(2) Internal spires.

Eumetria aff. *carbonaria.*



Eumetria aff. *carbonaria.*

It cannot be definitely asserted that this species belongs to Hall's genus *Eumetria* since specimens showing the internal characters, upon which the diagnosis of the genus rests, have not as yet been discovered.

The reference to *Eumetria* rests upon the striking similarity of the external characters, as shown in the following list of properties common to our species and to the type figures of *Eumetria* :—

Elongate oval form.

Absence of fold or sinus, and uniplanar valve-intersection.

Simple low radial ribs, all of the same pattern.

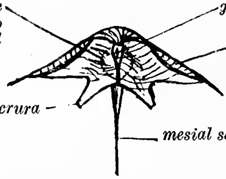
Small ears to the brachial valve, giving it a *Pecten*-like appearance.

In the pedicle valve, a tall area formed laterally of two concave narrow strips which are marked off from the rest of the valve by sharp ridges ; triangular delthyrium.

Shell structure strongly punctate.

The Rhynchonellids.

Camarotœchia.



Camarotœchia mitcheldeanensis.
Hinge plates of Brachial valve.

Here are included small ' Rhynchonellas ' in which :—

The ribs are sharp and continuous from back to margin.

Fold and sinus are well developed.

The beak is small and pointed.

The genus is however based entirely upon internal characters :—

In the brachial valve, the ' hinge-plate ' (from which the cruræ project) is formed of two plates closely approximated in the middle line ; each separate plate is supported, underneath, by one of the sheets of the spondylium into which the mesial septum splits.

The sockets are crenulated.

In the pedicle valve, dental plates are well-developed.

Note:—In the genotype, *Rhynchonella congregata* of the Devonian, the two portions of the hinge plate are not in contact along the middle line, but, in *Camarotœchia mitcheldeanensis*, these two portions are united anteriorly, although they are separated by a gap near the beak.

The Terebratulids

Dielasma.

Terebratuliform, elongate-oval, smooth shells with perforated beak.

Shell structure punctate.

Internal loop.

Strong dental plates.

This genus is very rare in the South-Western Province; it is at once distinguished from *Seminula* by the possession of an internal loop and a punctate shell.

Figures: Dav. Plate I.

[Note.—The figures of the pedicle valve of *Daviesiella* aff. *comoides* and of the brachial valve of *Camarotœchia mitcheldeanensis* are reproduced from *Quart. Journ. Geol. Soc.*, vol. 61, pp. 295 and 302.]

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EXPLANATION OF PLATES.

PLATES I. to XI. illustrate the section on the Clifton side of the Avon; they are arranged in ascending order of the strata, from North to South.

PLATE I. The Northern end of the section, in the vicinity of 'Cook's Folly.'

To the left: *Modiola-Phase* (Km) capped by 'Bryozoa Bed.'

In the middle: the main *Cleistopora*-zone (K_1 and K_2), poorly exposed.

To the right: the *Zaphrentis*-zone, constituting the 'Black-Rock.'

PLATE II. The two railway cuttings, north of 'Cook's Folly.'

To the left: *Modiola*-shales (Km), capped by 'Bryozoa Bed'; succeeded, near the signal-post to the right of the plate, by the normal development of the Lower *Cleistopora*-zone (K_1).

PLATE III. The Black-Rock Quarry and the North-slope of the Gully (Durdham Down).

To the left (below the cave): Lower *Zaphrentis*-zone (Z_1).

Main quarry: Upper *Zaphrentis*-zone (Z_2 and γ).

Immediately below the Gully-slope: base of *Syringothyris*-zone (C_1, *laminosa*-dolomites).

PLATE IV. The gully and the 'Oolite Quarry' (North-end of Clifton Down).

To the left (north slope of gully): *laminosa*-dolomites (base of C_1).

To the right ('Oolite Quarry'): *laminosa*-dolomites and *Caninia*-oolite, capped by *Caninia*-shales (C_1 capped by C_2).

PLATE V. Gully to Great Quarry.

To the left: *Caninia*-oolite (C_1).

In the middle: *Caninia*-shales and *Caninia*-dolomites (C_2).

To the right (north end of Great Quarry): Lower *Seminula*-zone (S_1).

PLATE VA. Railway cutting between the Oolite-Quarry and the Great Quarry.

The *Caninia*-shales and *Caninia*-dolomites (C_2).

PLATE VI. The Northern end of the Great Quarry.

Lower *Seminula*-zone (S_1).

PLATE VII. The Great Quarry and the New Zig-zag.

The *Seminula*-zone (S) capped, immediately below the north-slope of the New Zig-zag, by the basal beds of the Lower *Dibunophyllum*-zone (D_1).

To the right: Exposure of D_1 beds, south of the New Zig-zag.

PLATE VIII. The Northern part of Clifton Down, dissected by the depression of the New Zig-zag.

(Bridge Valley Road is seen, encircling the southern slope of this depression, and to the right of the plate lie Point Villa and the entrance to the Hotwell Tunnel.

The *Seminula*-zone (S) and the Lower *Dibunophyllum*-zone (D_1).

PLATE IX. The lower portion of Bridge Valley Road and the northern end of Observatory Hill.

The Upper *Dibunophyllum*-zone is exposed along the sides of the Towing Path and of Bridge Valley Road.

To the right: The massive Upper-*Seminula* beds (S_2) of Observatory Hill are seen, faulted against contorted beds which belong to the Upper *Dibunophyllum*-zone (D_2).

PLATE X. Observatory Hill and the Great Fault.
The plane of overthrust is seen, separating sharply the massive S_2 beds above from the contorted D_2 series below.

PLATE XI. The Southern end of Clifton Down; Observatory Hill and the Suspension Bridge.
The Upper *Dibunophyllum*-zone (D_2) of the main section is seen to the left, sharply separated from the Upper *Seminula*-zone (S_2) of Observatory Hill by the Great Fault.
At the right of the plate, the massive base of the Lower *Dibunophyllum*-zone is indistinctly seen, along the side of the upper part of the Old Zig-zag Path.

PLATES XII. to XV. illustrate the section on the Leigh Woods side; they are arranged in descending order of the strata, from South to North.

PLATE XII. The 'Point' and Quarry 5.
The slope above the tunnel is mainly composed of the 'Concretionary Beds' (uppermost S_2), capped by the massive basal beds of the Lower *Dibunophyllum*-zone (D_1).
Quarry 5 exhibits the upper part of the Upper *Seminula*-zone (S_2).

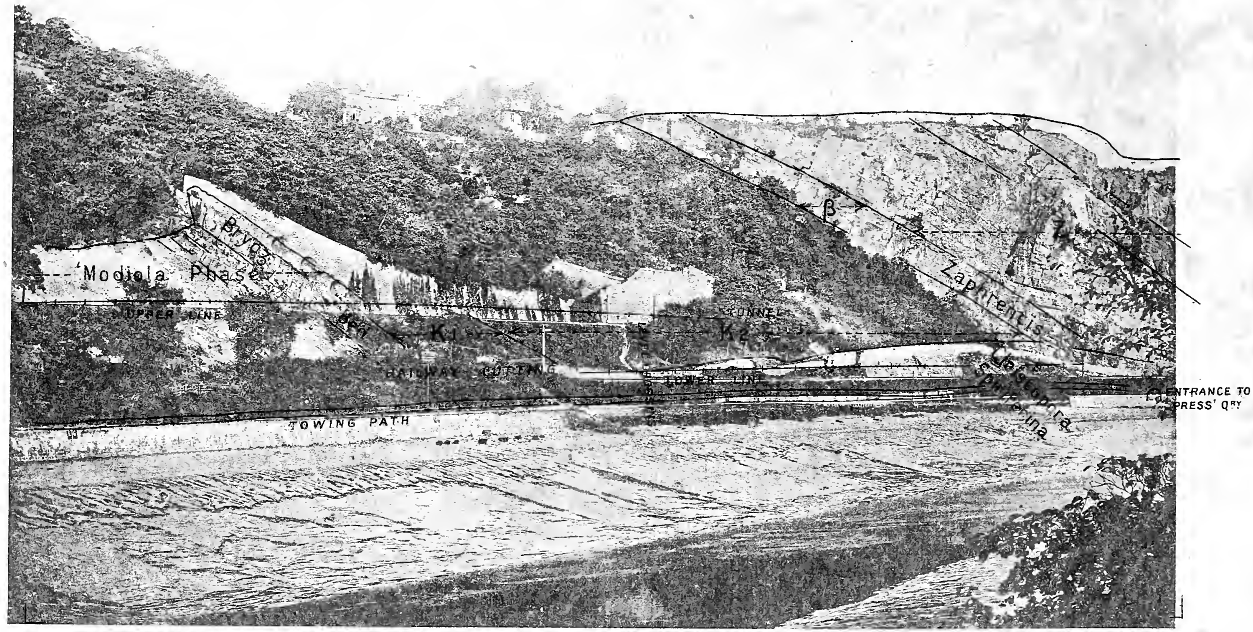
PLATE XIII. Quarry 5 and Quarry 4.
The *Seminula*-zone (S).
In Quarry 4 (to the right), the '*Seminula*-oolite' (lower S_2) rests upon the upper part of the Lower *Seminula*-zone (S_1).

PLATE XIV. Quarry 3 and part of Quarry 2.
In Quarry 3 (to the left), the massive *Caninia*-oolite (C_1) is capped by *Caninia*-shales (C_2) and is underlain by the *laminosa*-dolomites (C_1).

PLATE XV. Quarry 2 and Quarry 1.
In Quarry 2 (to the left), a capping of *laminosa*-dolomites (base of C_1) rests upon the Upper *Zaphrentis*-zone (γ and Z_2).
In Quarry 1 (to the right), all the beds included in the plate belong to the Lower *Zaphrentis*-zone (Z_1). Lower beds (β and K_2) are however exposed at the base of the Quarry, immediately north of the beds represented in the plate.

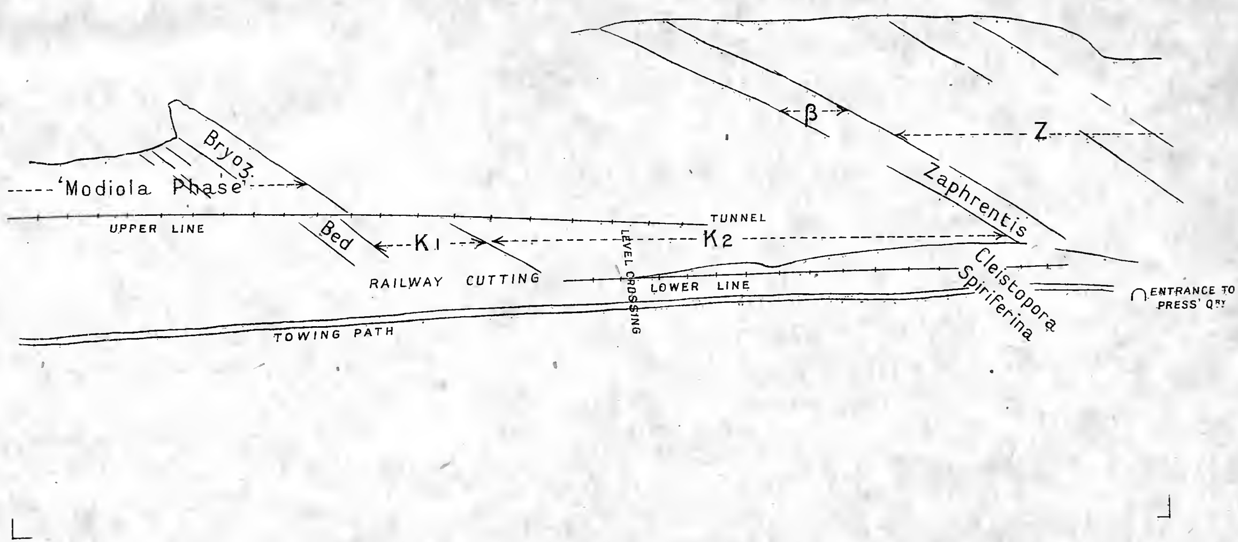
PLATE XVI. Sketch Map of the Avon Gorge; accompanied by Horizontal and Vertical Sections, illustrating the Lithological and Zonal succession. [Reproduced from *Quart. Journ. Geol. Soc.*, vol. 61, Pl. 27, by kind permission of the Council of the Geological Society.]

Plate 1.



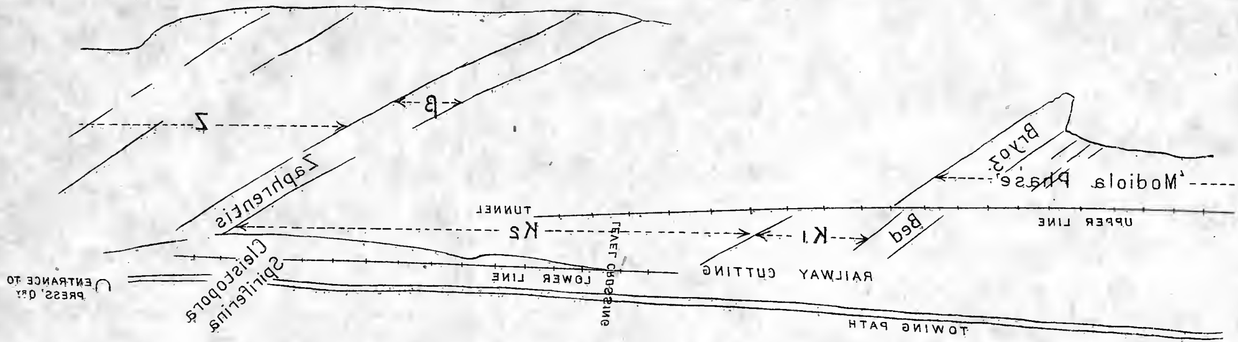
'Modiola Phase
Bryoz
UPPER LINE
K1
K2
TUNNEL
β
Zaphrentis
RAILWAY CUTTING
LOWER LINE
TOWING PATH
ENTRANCE TO
PRESS' Q^RY

Plate 1.



Bryoz.
'Modiola Phase'
UPPER LINE
TUNNEL
Bed
K1
K2
β
Z
Zaphrentis
Cleistopora
Spiriferina
RAILWAY CUTTING
LEVEL CROSSING
LOWER LINE
TOWING PATH
ENTRANCE TO PRESS' Q^RY

Plate I.


Z
β
Zaphrentis
K2
K1
Bed
Bryozoa
'Modiola Phase'
TUNNEL
UPPER LINE
LEVEL CROSSING
Cleistopora
Spiriferina
ENTRANCE TO PRESS' Q'RY
LOWER LINE
RAILWAY CUTTING
TOWING PATH

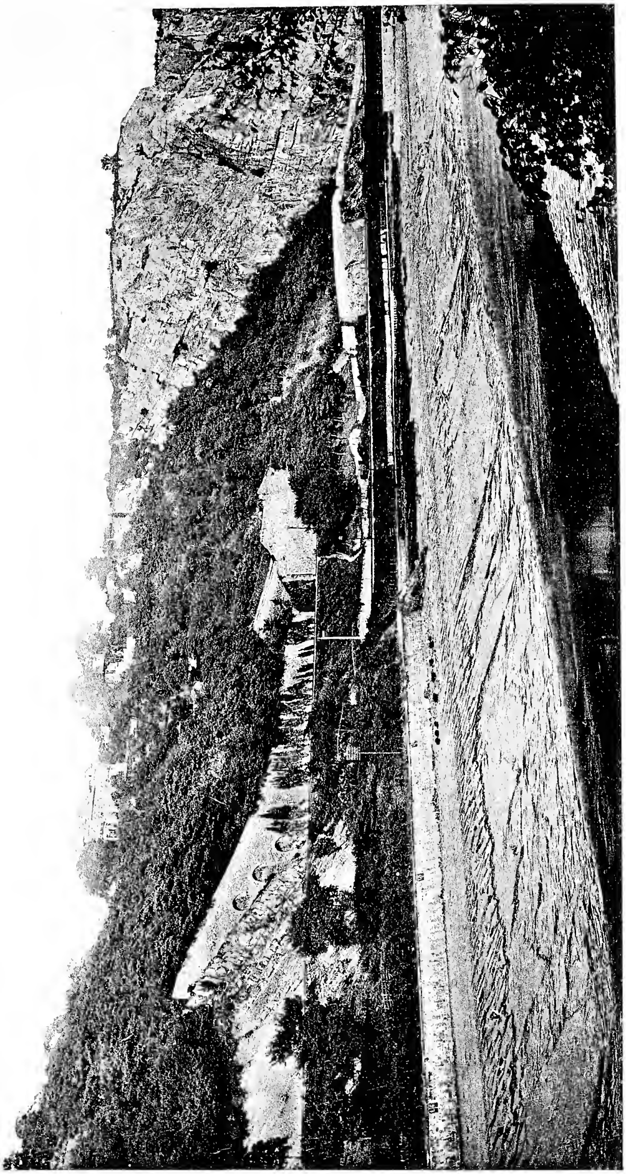


Plate 2.

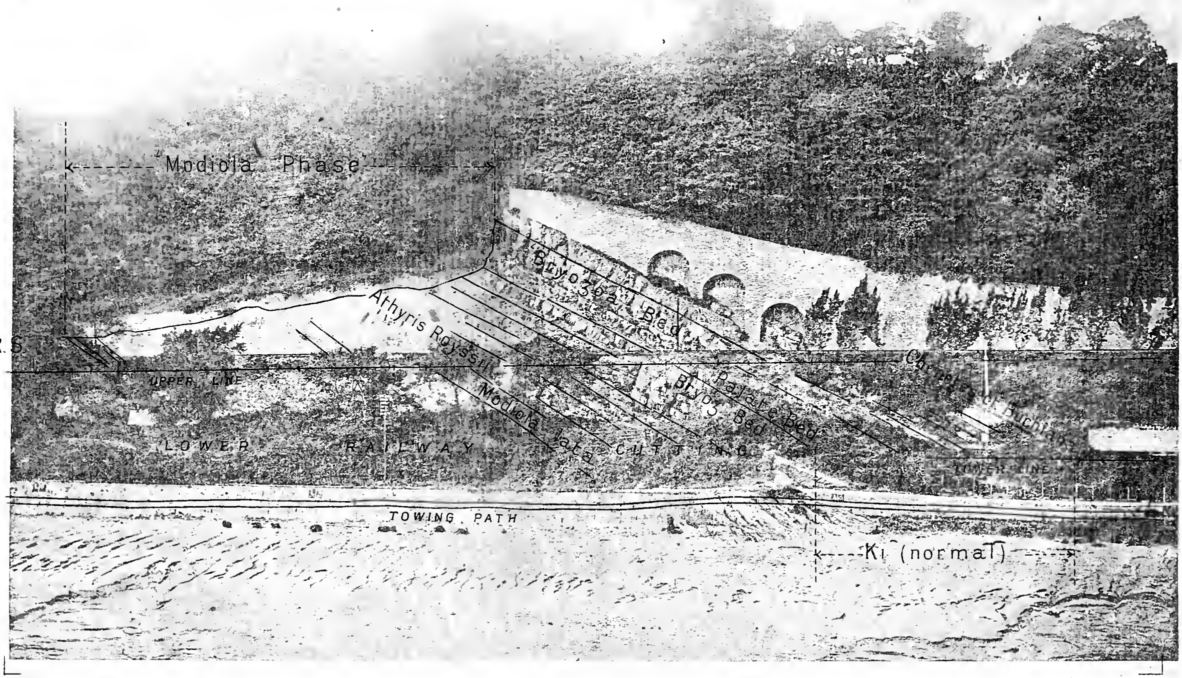
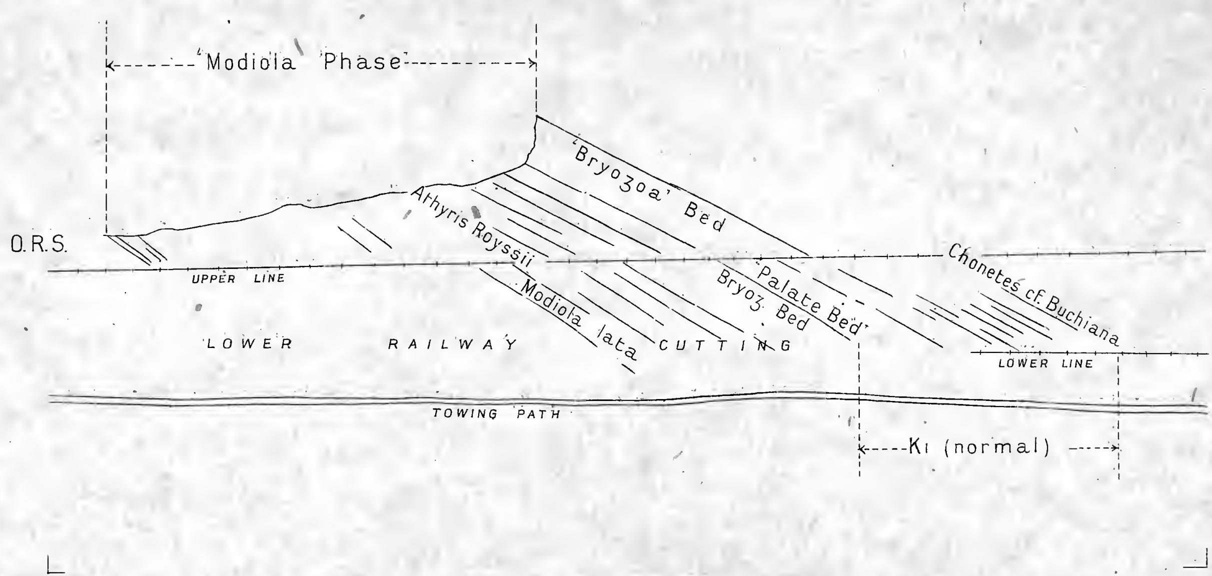
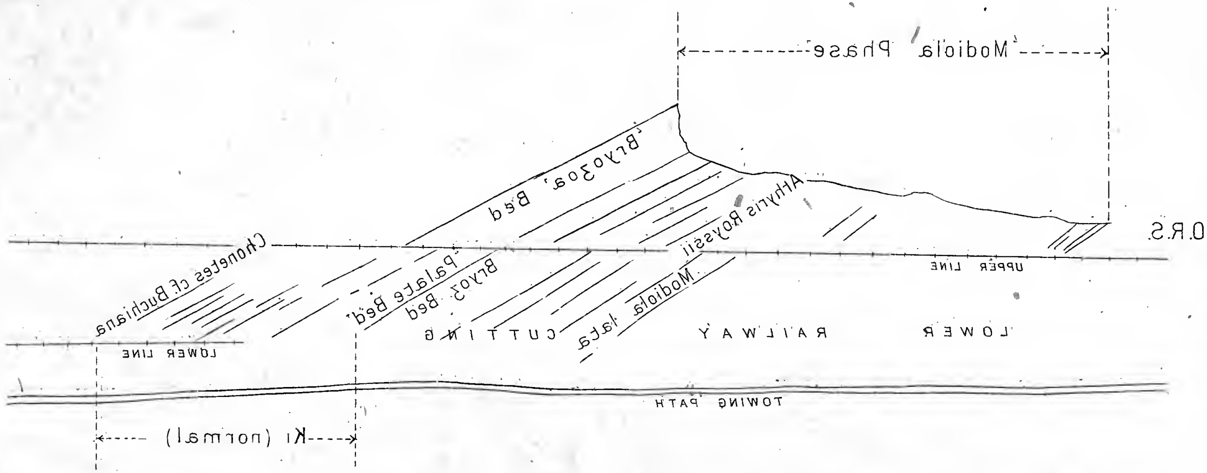

Modiola Phase
O.R.S.
Athyris Royssii
Bryozoa Bed
Palate Bed
Bryos Bed
Modiola lata
UPPER LINE
LOWER RAILWAY CUTTING
LOWER LINE
TOWING PATH
K1 (normal)

Plate 2.



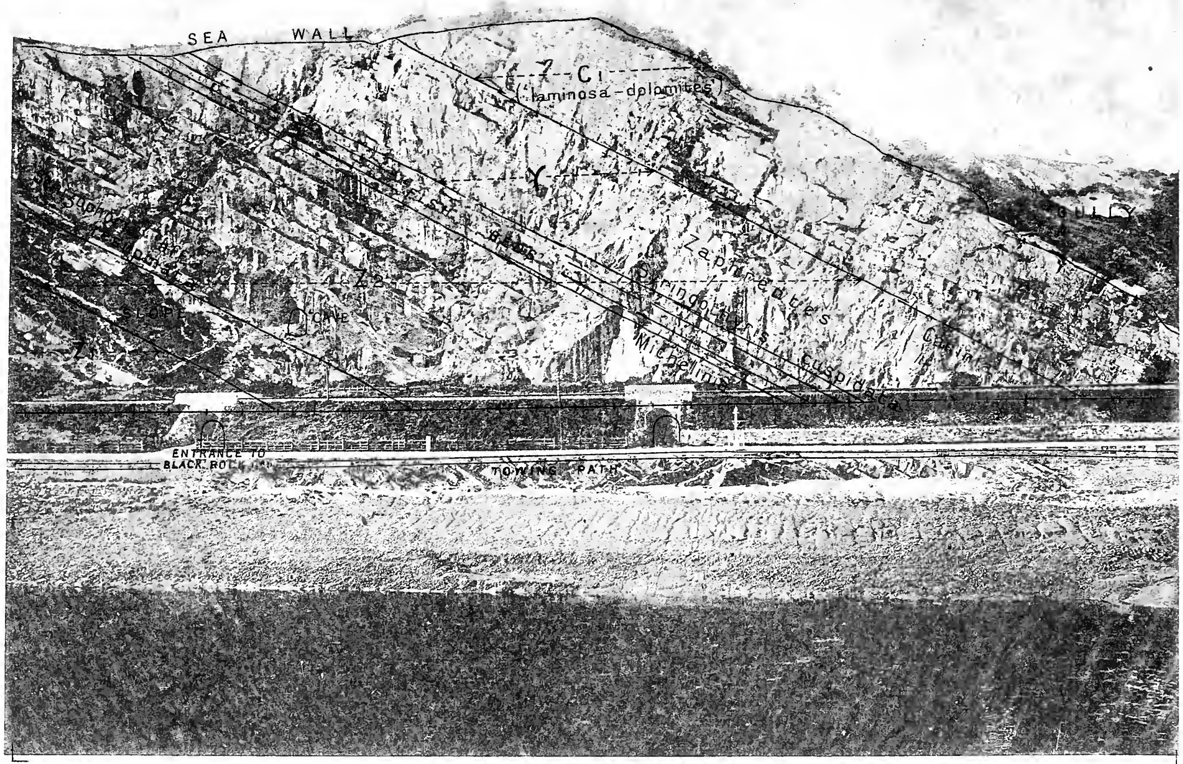
'Modiola' Phase
O.R.S.
'Bryozoa' Bed
Athyris Royssii
'Palate Bed'
Bryoz. Bed
Chonetes cf. Buchiana
Modiola lata
UPPER LINE
LOWER RAILWAY CUTTING
LOWER LINE
TOWING PATH
K1 (normal)

Plate 2.



Modiola Phase
'Bryozoa' Bed
Athyris Royssii
O.R.S.
Chonetes cf. Buchiana
Palate Bed
Bryoz. Bed
Modiola lata
UPPER LINE
LOWER LINE
LOWER RAILWAY CUTTING
TOWING PATH
K1 (normal)

Plate 3.


SEA WALL
C1
(laminosa-dolomites)
GULLY
Zaphrentis
Syringothyris
Cuspidata
Michelinia
Z2
CAVE
SLOPE
Z1
ENTRANCE TO
BLACK ROCK
TOWING PATH

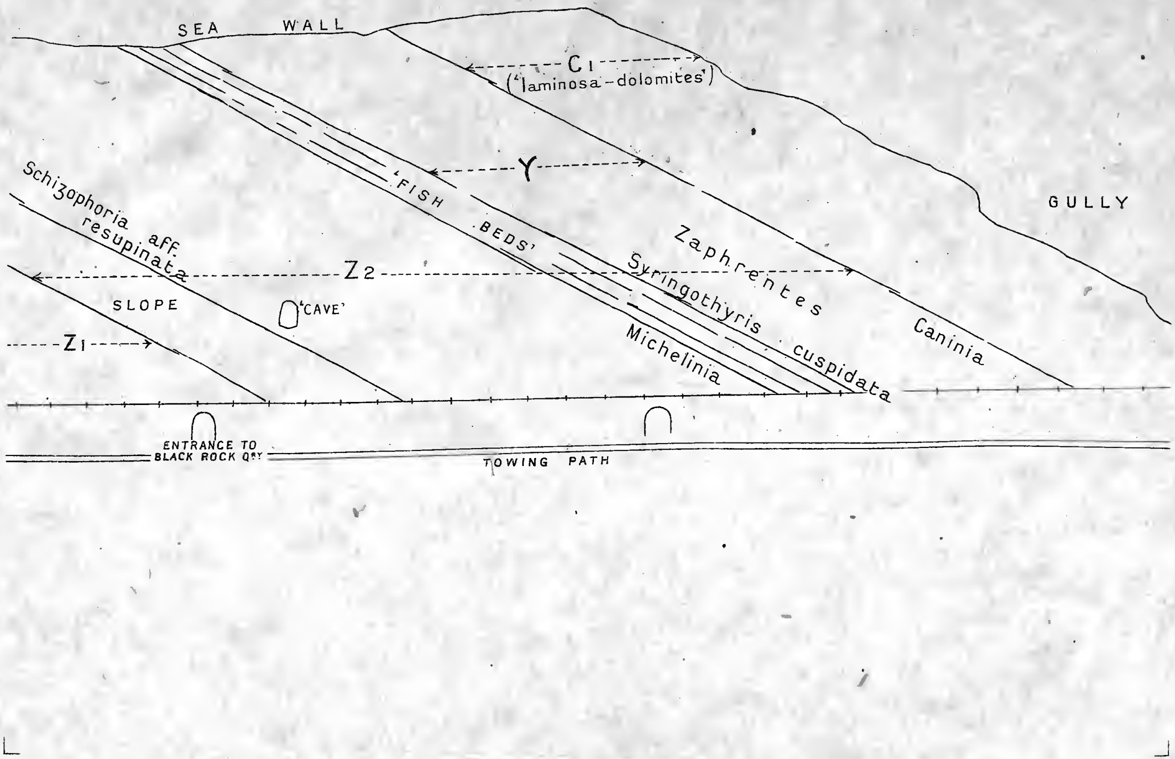
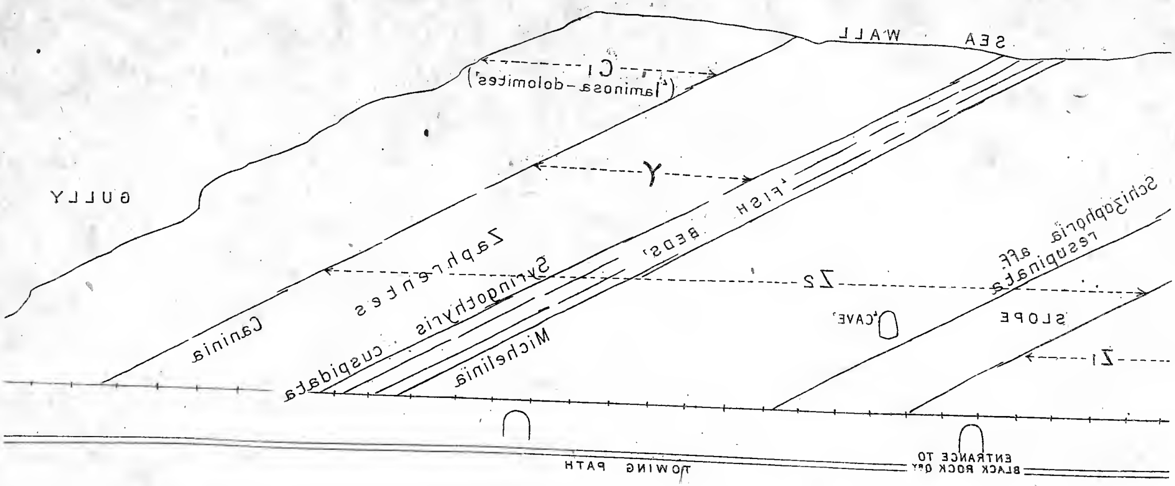
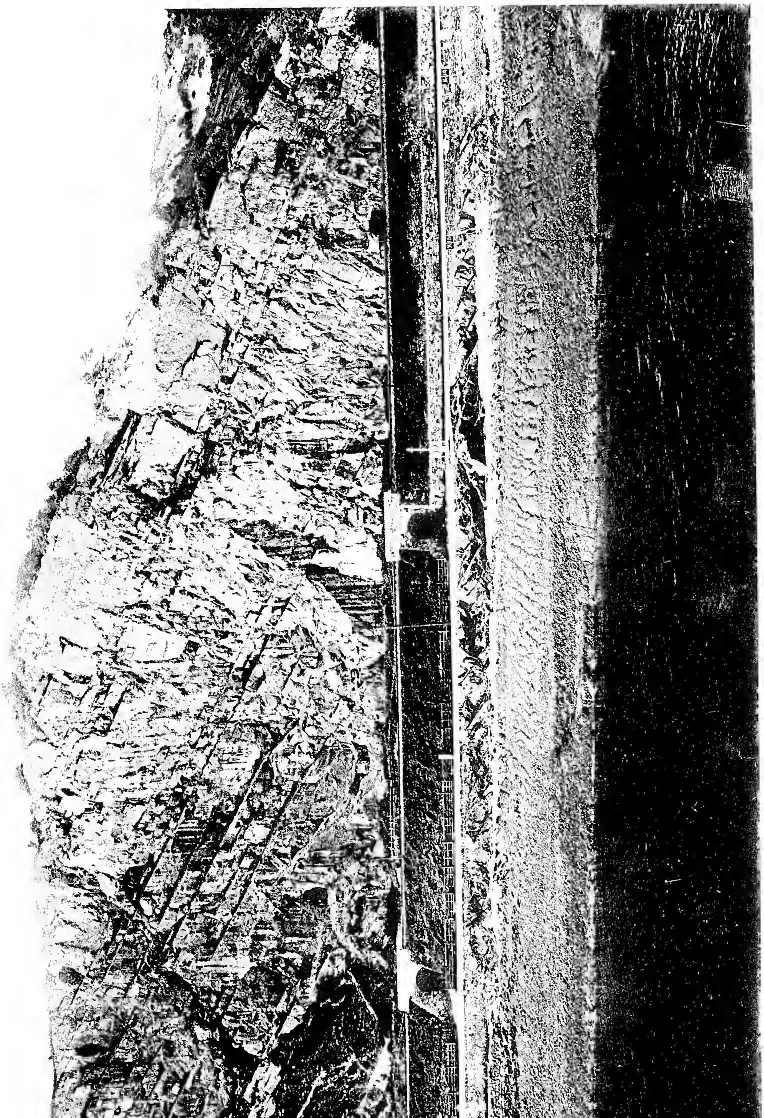
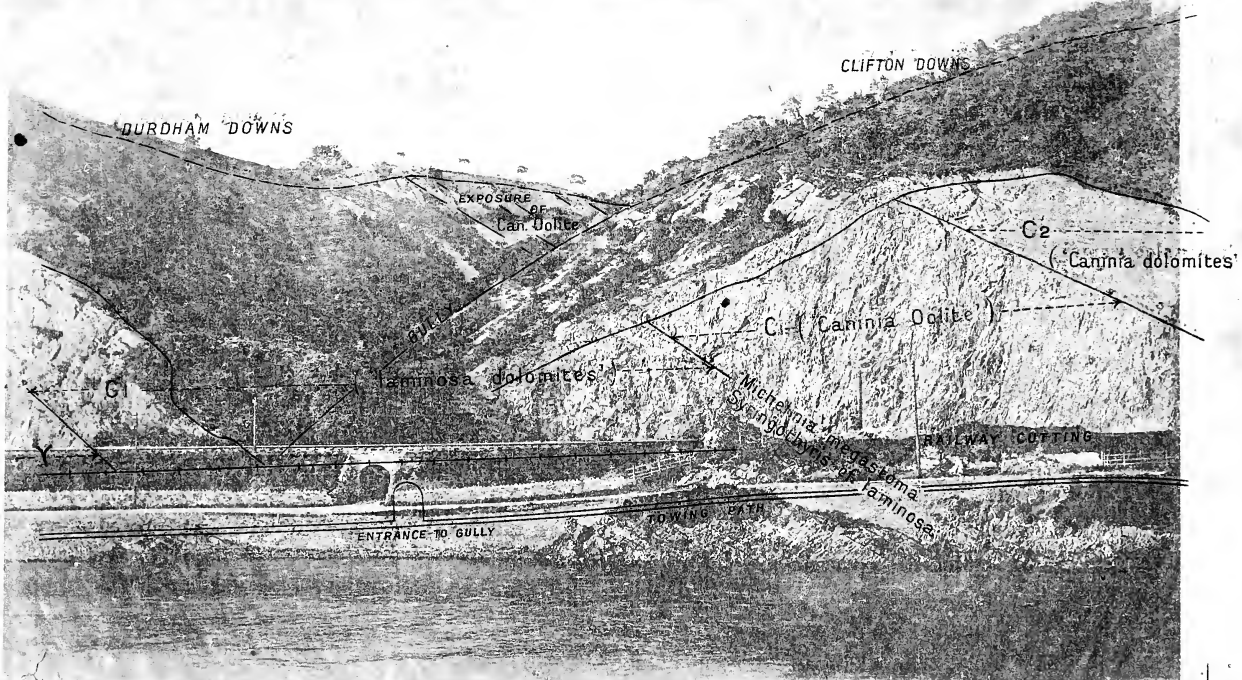

SEA WALL
C1
('laminosa-dolomites')
GULLY
Y
'FISH BEDS'
Schizophoria aff. resupinata
Z2
Zaphrentes
Syringothyris cuspidata
Caninia
SLOPE
'CAVE'
Z1
Michelinia
ENTRANCE TO BLACK ROCK Q^{RY}
TOWING PATH

Plate 3



GULLY
SEA WALL
C1
('laminosa-dolomites')
Y
Z2
Z1
Caninia
Zaphrentes
Syringothyris cuspidata
Michelinia
'FISH BEDS'
Schizophoria aff. resupinata
'CAVE'
SLOPE
TOWING PATH
ENTRANCE TO BLACK ROCK QRY




DURDHAM DOWNS
CLIFTON DOWNS
EXPOSURE OF Can. Oolite
GULLY
C2
('Caninia dolomites')
C1 ('Caninia Oolite')
C1
('laminosa dolomites')
Michelinia megastoma
Syringothyris cf. laminosa
RAILWAY CUTTING
TOWING PATH
ENTRANCE TO GULLY
Y

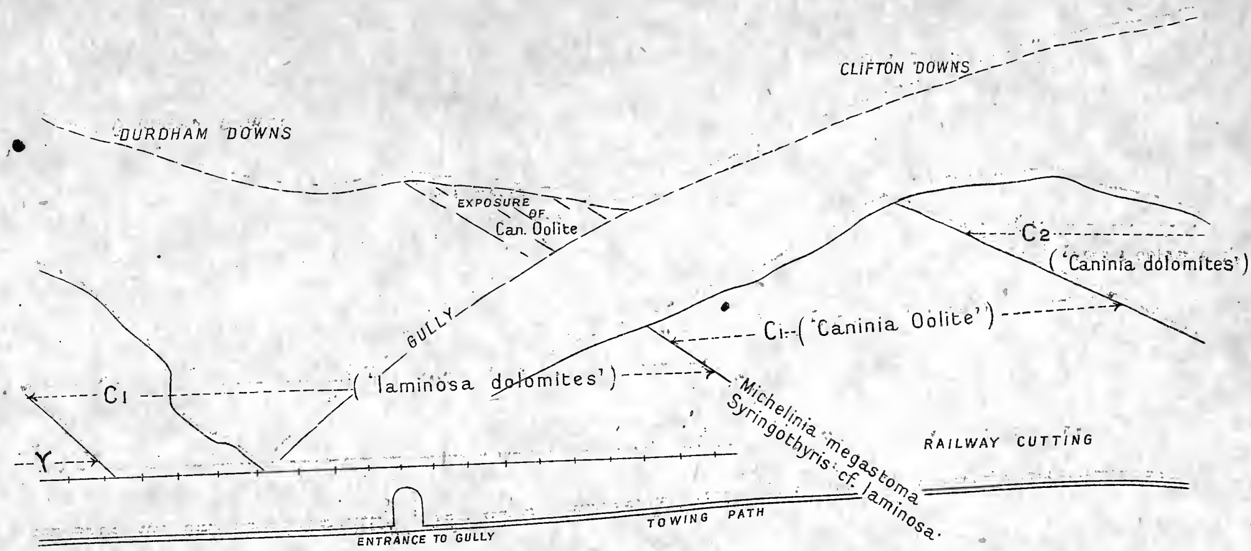
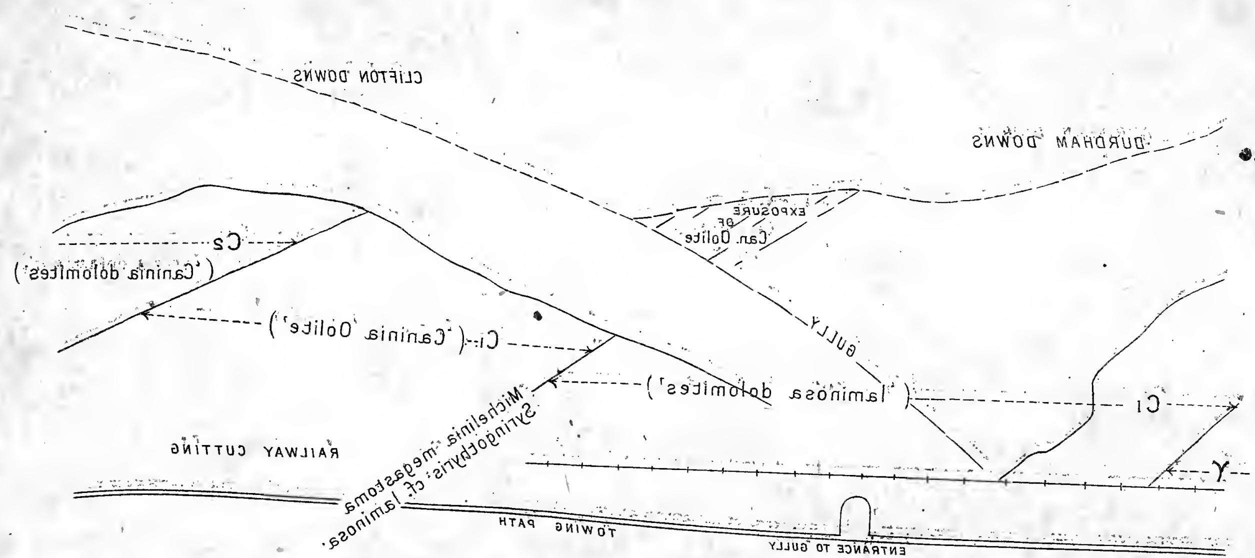

DURDHAM DOWNS
CLIFTON DOWNS
EXPOSURE OF Can. Oolite
GULLY
C2
('Caninia dolomites')
C1-('Caninia Oolite')
C1
('laminosa dolomites')
Michelinia megastoma
Syringothyris cf. laminosa.
Y
RAILWAY CUTTING
TOWING PATH
ENTRANCE TO GULLY

Plate 4


CLIFTON DOWNS
DURDHAM DOWNS
EXPOSURE OF Can Oolite
GULLY
C2
('Caninia dolomites')
C1 ('Caninia Oolite')
'Michelinia' megastoma
Syringothyris cf. laminosa.
('laminosa dolomites')
C1
Y
RAILWAY CUTTING
TOWING PATH
ENTRANCE TO GULLY

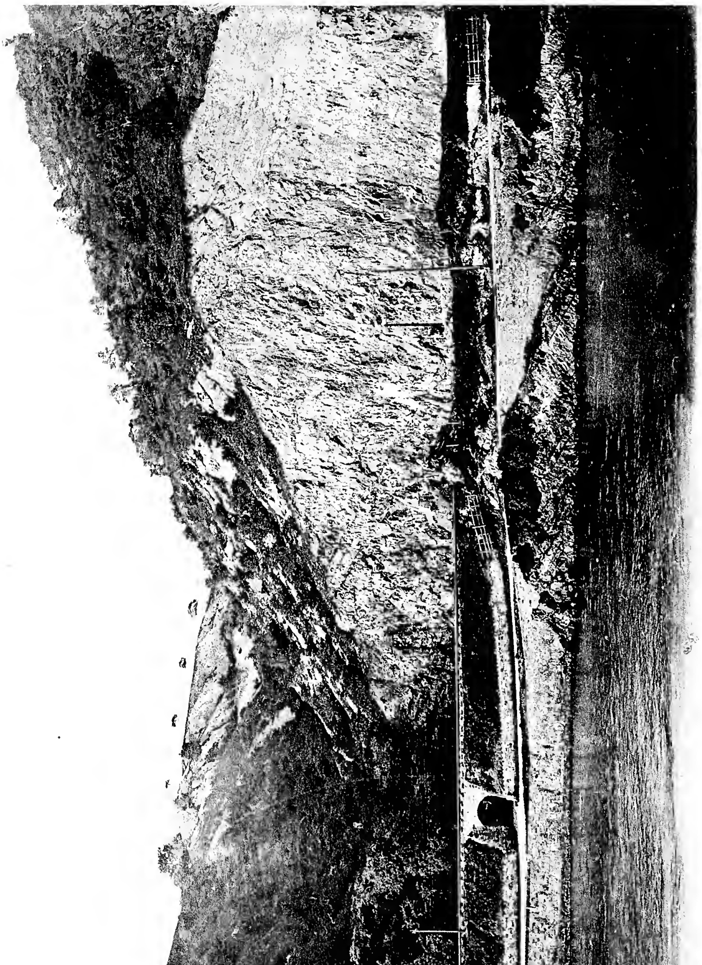


Plate 5.

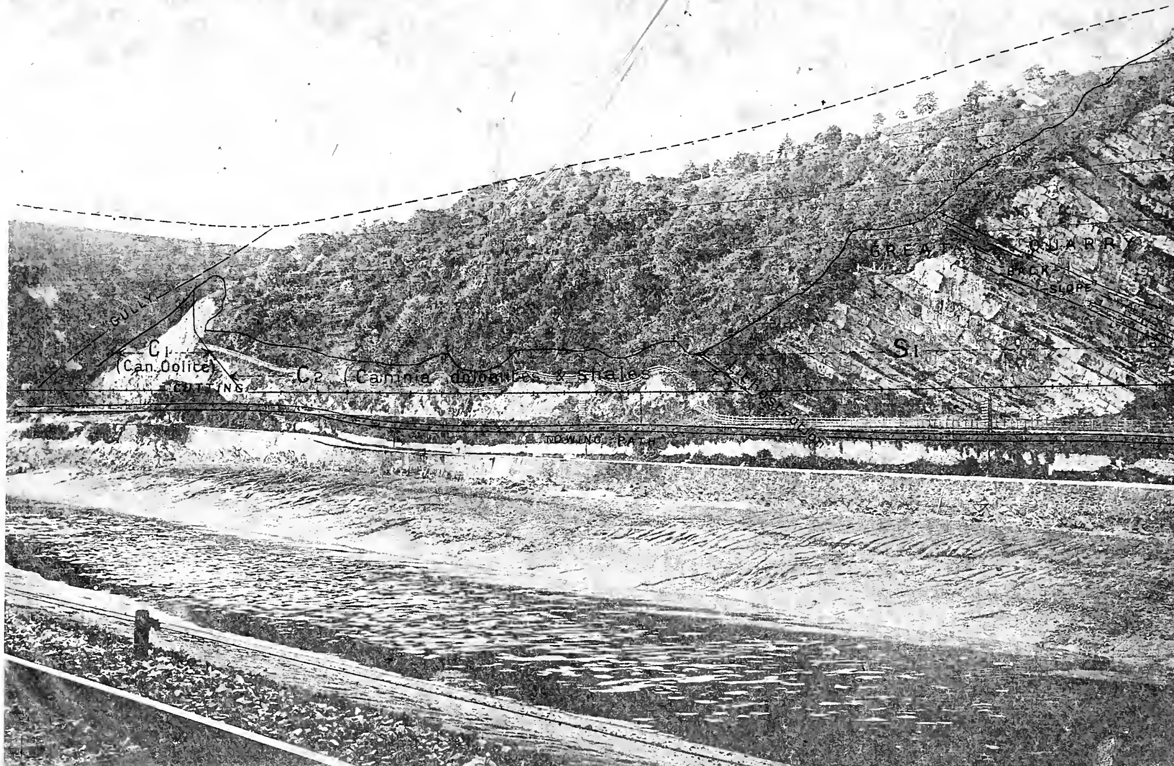

GULLY
C1
(Can. Oolite)
CUTTING
C2 (Caninia dolomites & shales
GREAT QUARRY
BACK SLOPE
S1
TOWING PATH

Plate 5.

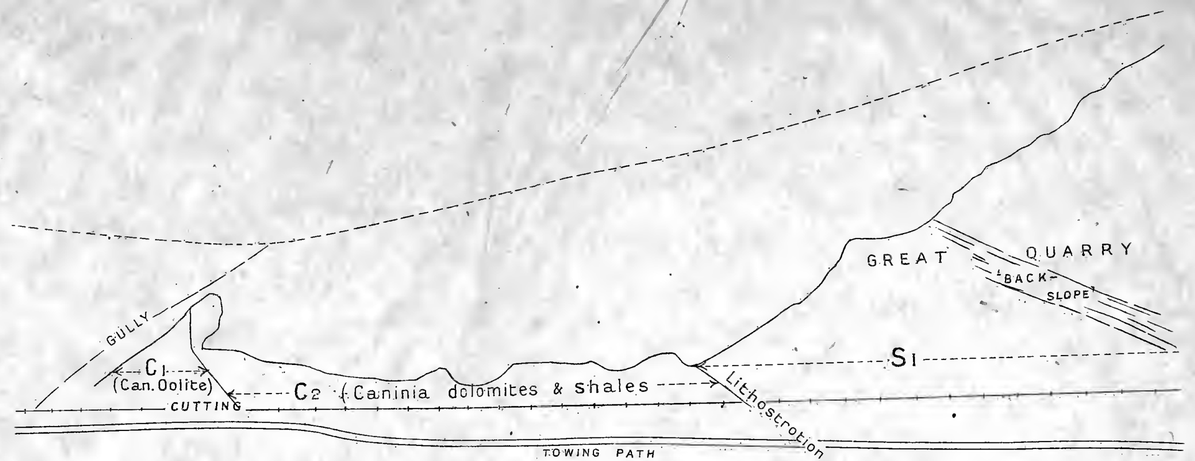
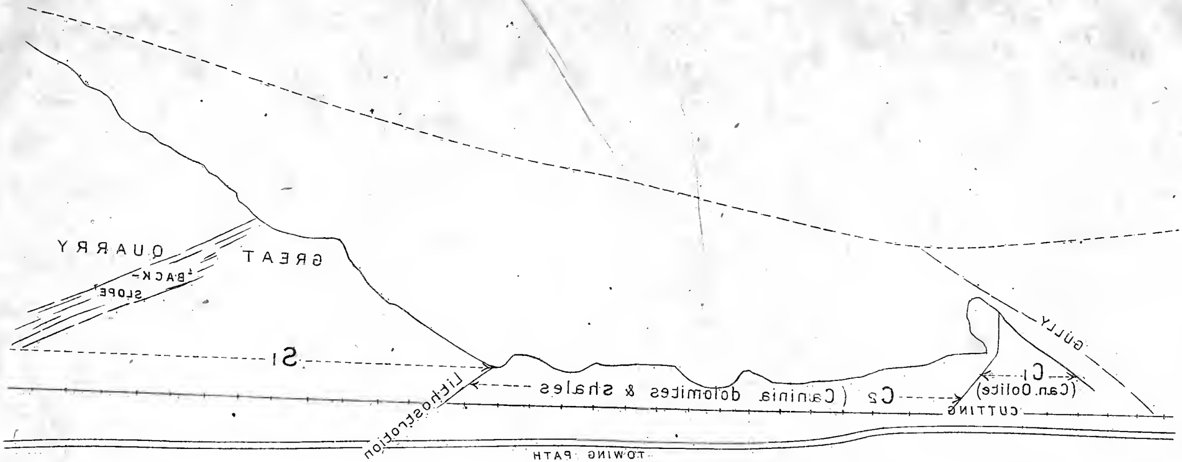

GREAT QUARRY
'BACK-SLOPE'
S1
Lithostrotion
C2 (Caninia dolomites & shales
C1
(Can. Oolite)
GULLY
CUTTING
TOWING PATH

Plate 5



GREAT QUARRY
'BACK-SLOPE'
S1
Lithostrotion
C2 (Caninia dolomites & shales)
C1 (Can. Oolite)
GULLY
CUTTING
TOWING PATH

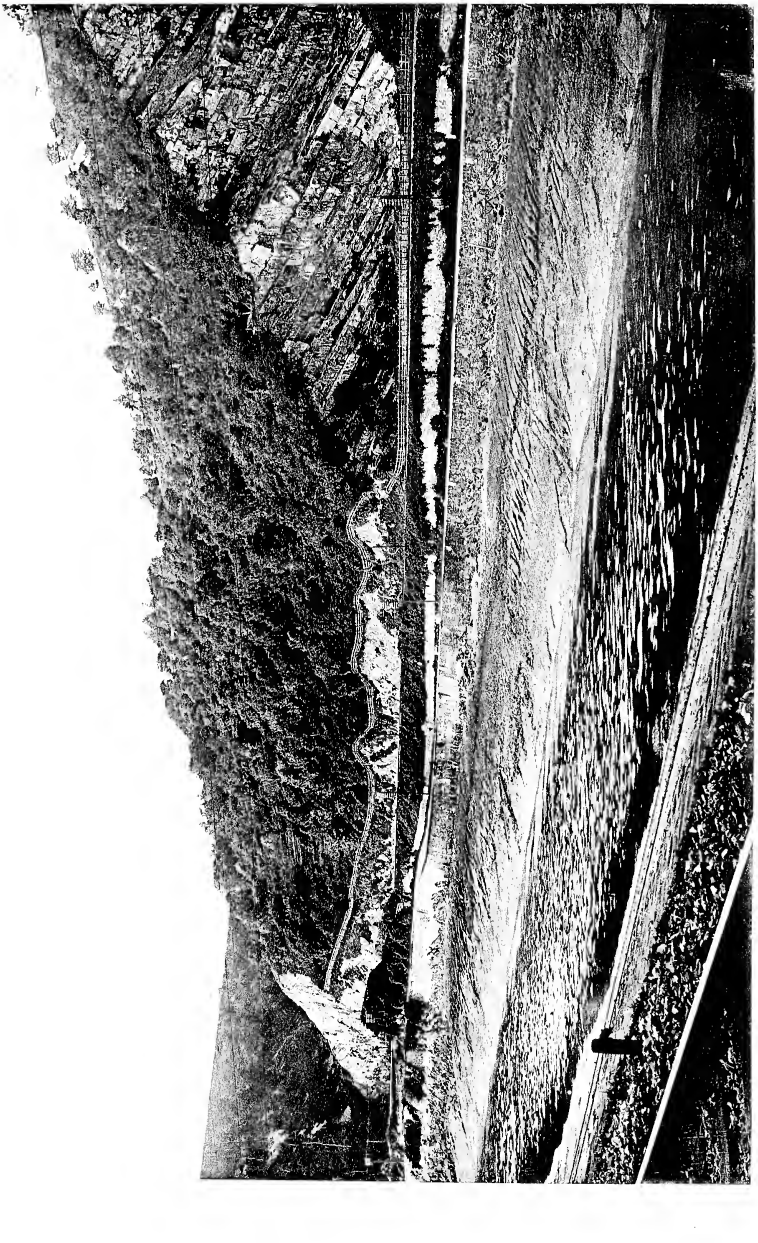


Plate 5^a

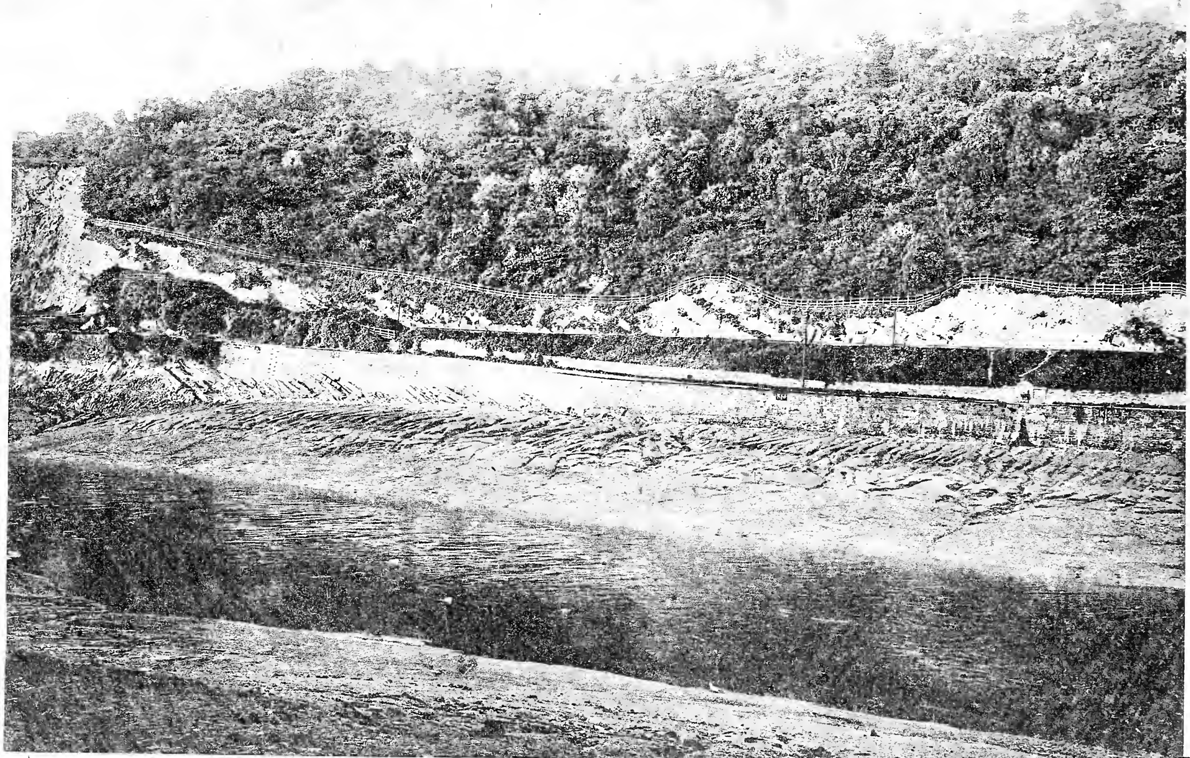


Plate 5ª.

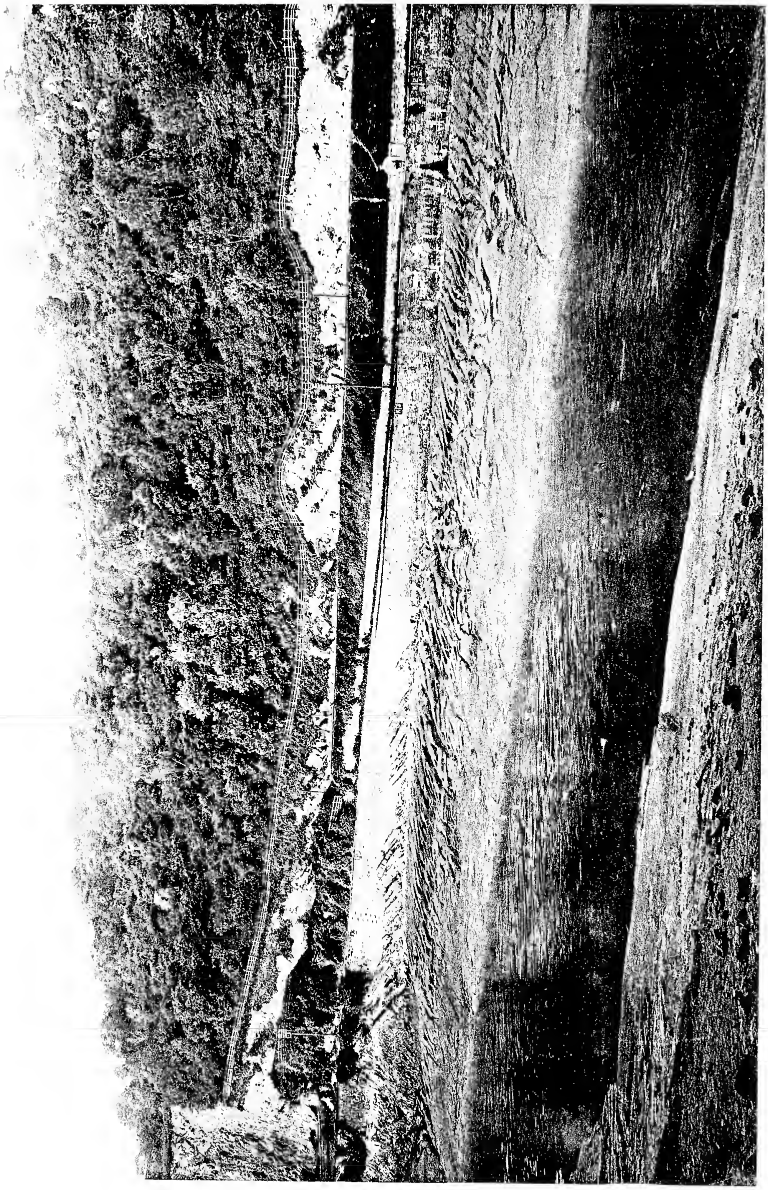


Plate 6

Plate 6.

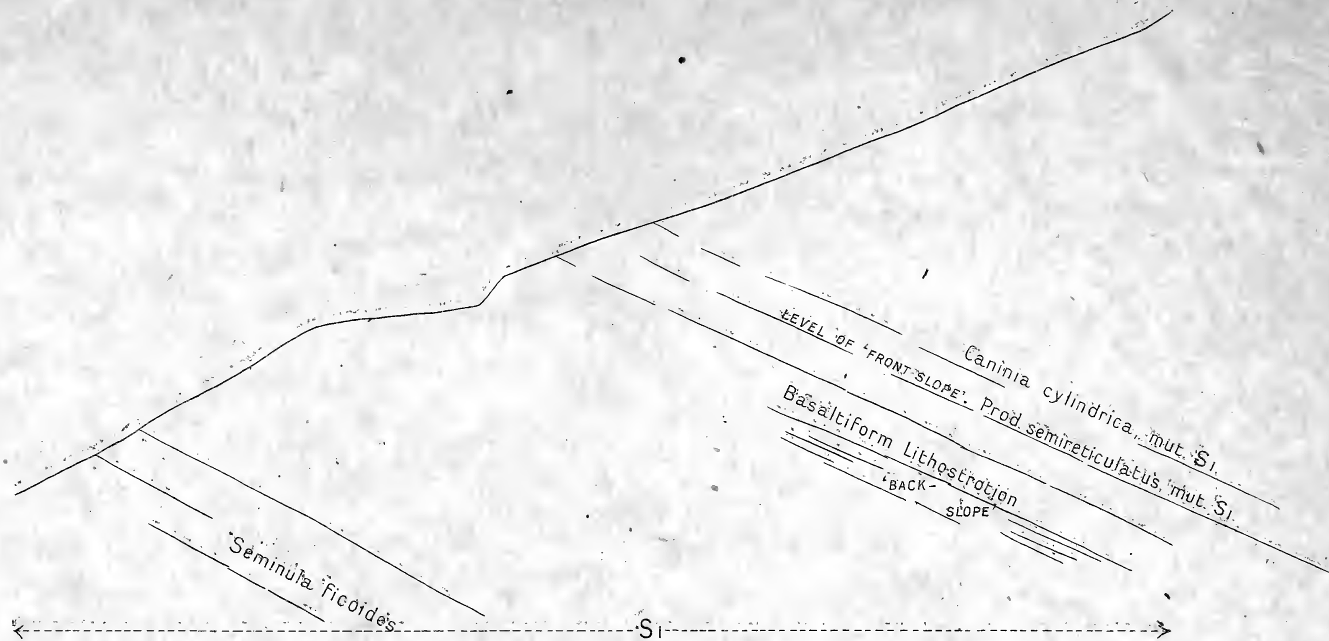
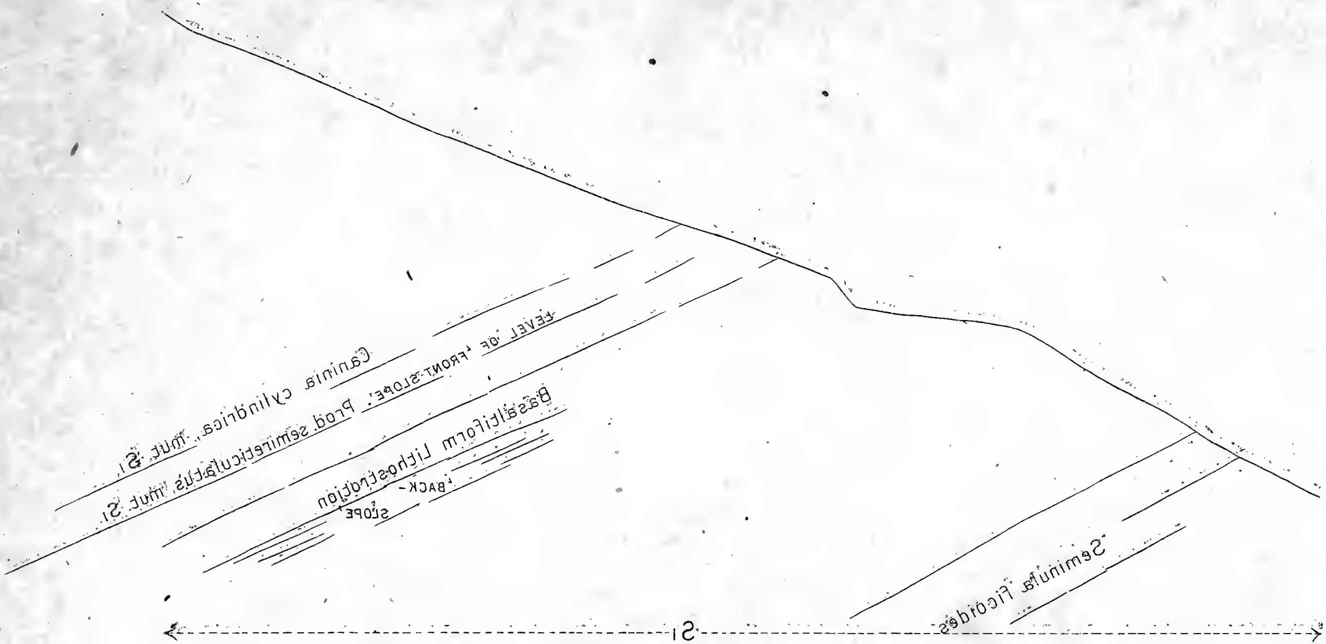

Caninia cylindrica, mut. S1.
LEVEL OF 'FRONT SLOPE'. Prod. semireticulatus, mut. S1.
Basaltiform Lithostrotion
'BACK-SLOPE'
Seminula ficoides
S1

Plate 6.


Caninia cylindrica, mut. S1
LEVEL OF 'FRONT-SLOPE'. Prod semireticulatus mut. S1
Basaltiform Lithostrotion
'BACK-SLOPE'
Seminula ficoides
S1

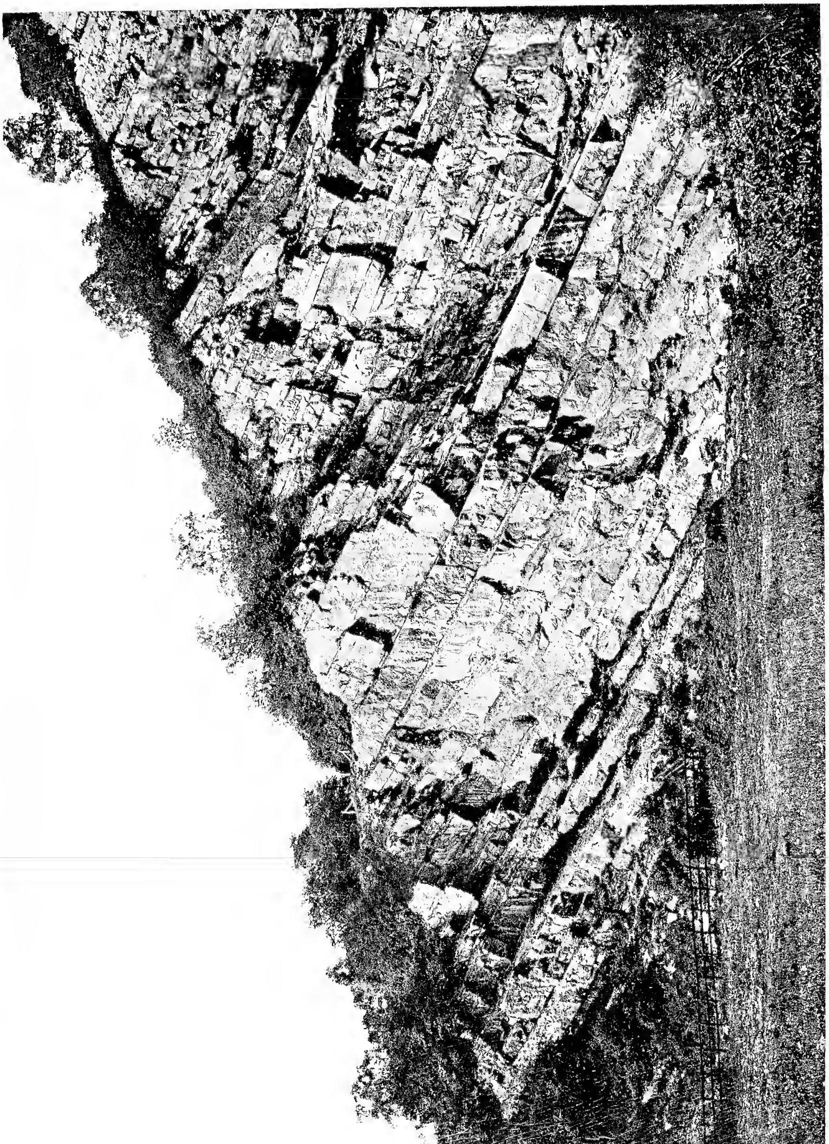


Plate 7.

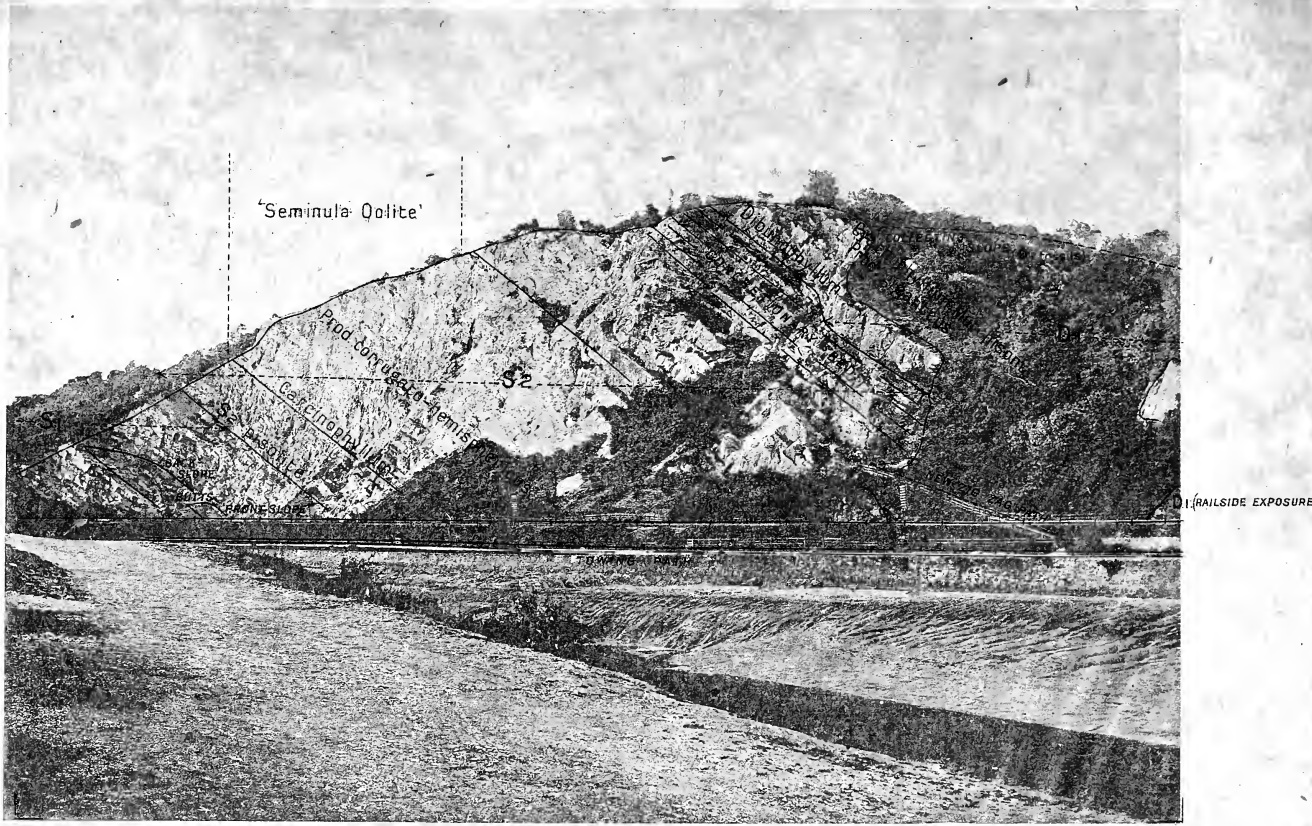

'Seminula Oolite'
S1
S2
Prod. corrugato-hemisphericus
Carcinophyllum
S2 Pisolite
BACK SLOPE
BUTTS
FRONT SLOPE
Dibunophyllum
D1
TOWING PATH
D1 (RAILSIDE EXPOSURE)

Plate 7.

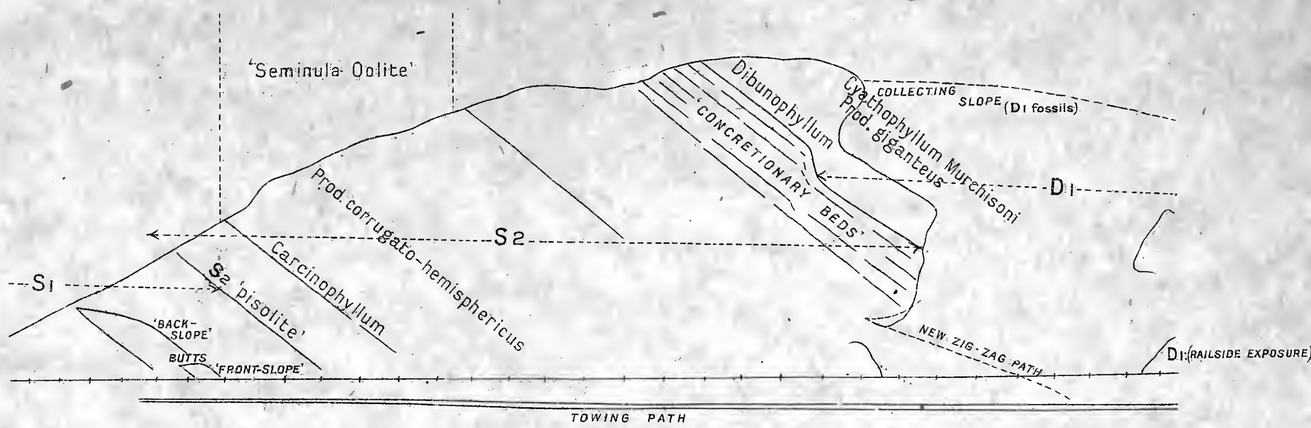
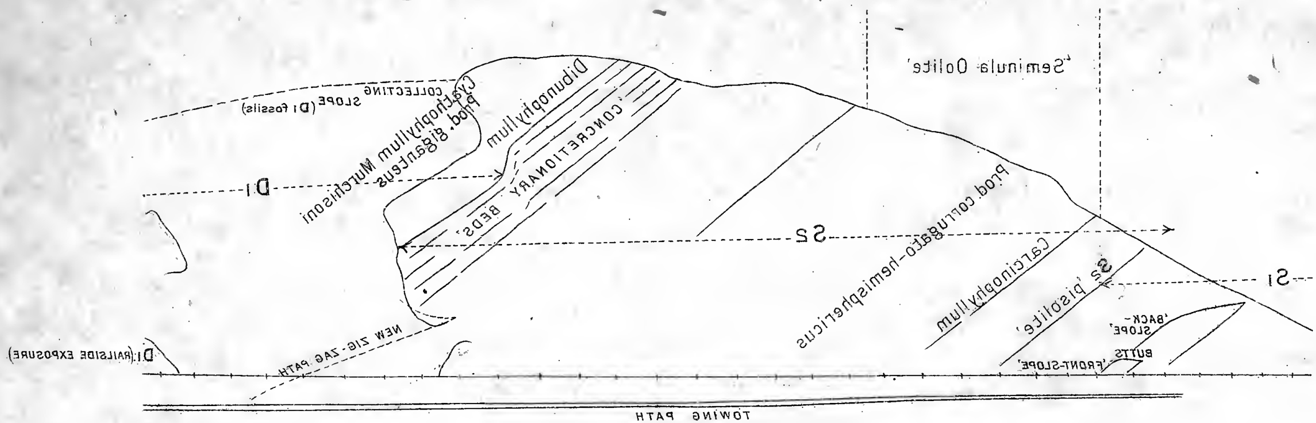

'Seminula Oolite'
Dibunophyllum
Cyathophyllum Murchisoni
Prod. giganteus
COLLECTING SLOPE (D1 fossils)
D1
'CONCRETIONARY BEDS'
S2
S1
Prod. corrugato-hemisphericus
Carcinophyllum
S2 'pisolite'
'BACK-SLOPE'
BUTTS
'FRONT-SLOPE'
NEW ZIG-ZAG PATH
D1 (RAILSIDE EXPOSURE)
TOWING PATH

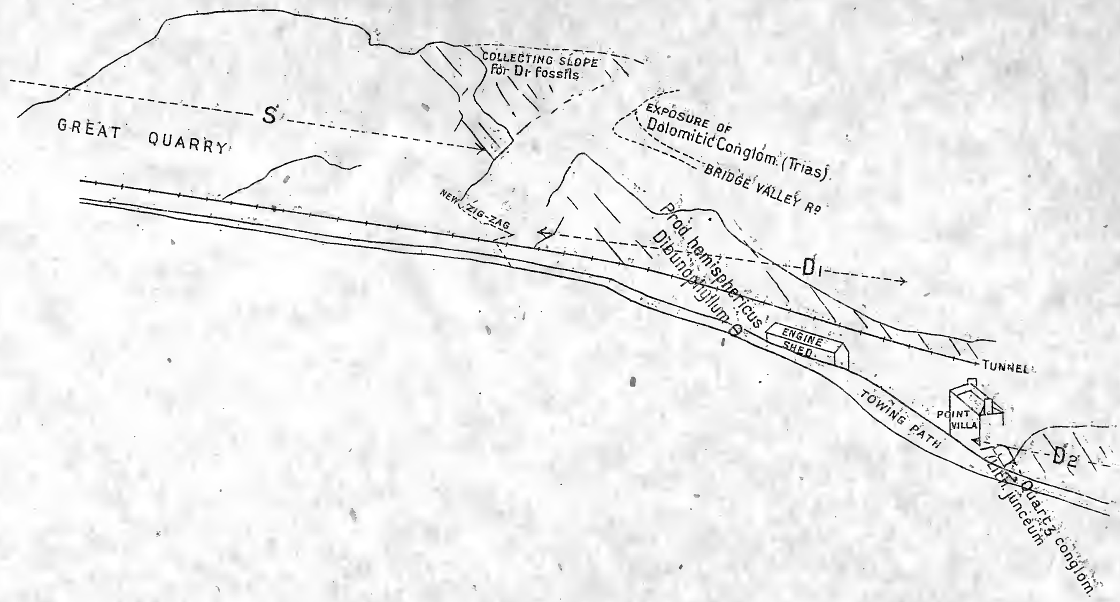
Plate 7



'Seminula Oolite'
Dibunophyllum
'CONCRETIONARY BEDS'
Cyathophyllum Murchisoni
Prod. giganteus
COLLECTING SLOPE (D1 fossils)
D1
S2
Prod. corrugato-hemisphericus
Carcinophyllum
S2 'pisolite'
S1
'BACK-SLOPE'
BUTTS
'FRONT-SLOPE'
NEW ZIG-ZAG PATH
D1 (RAILSIDE EXPOSURE)
TOWING PATH

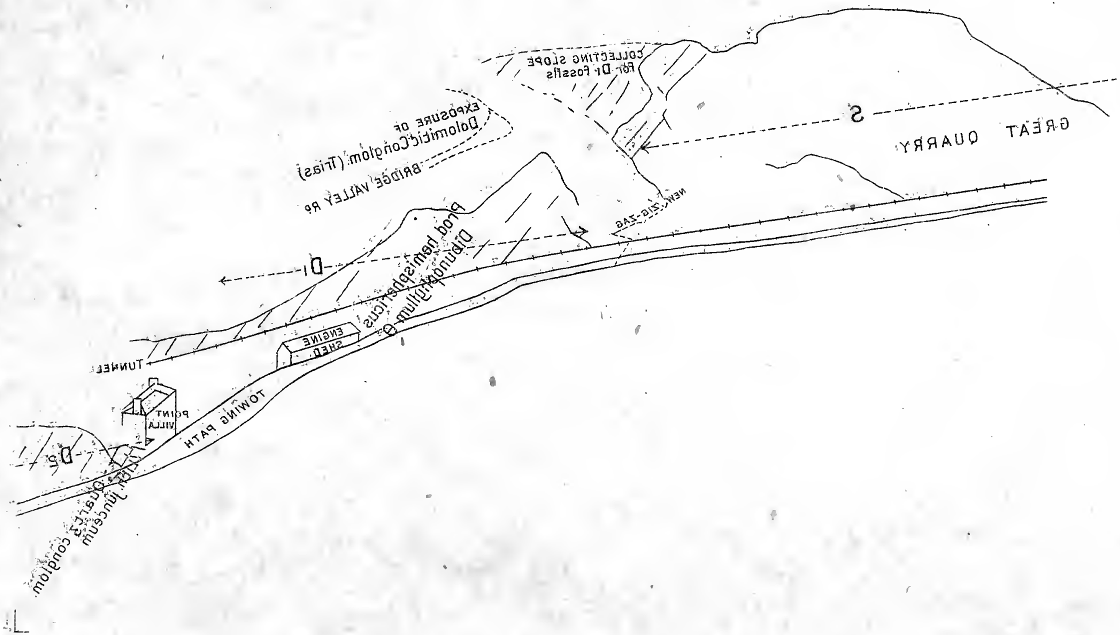

GREAT QUARRY
S
EXPOSURE OF
BRIDGE VALLEY RD
ENGINE SHED
TUNNEL
TOWING PATH

Plate 8.



COLLECTING SLOPE
For D1 fossils
EXPOSURE OF
Dolomitic Conglom. (Trias)
BRIDGE VALLEY Rd
S
GREAT QUARRY
NEW ZIG-ZAG
Prod. hemisphericus
Dibunophyllum θ
D1
ENGINE SHED
TUNNEL
TOWING PATH
POINT VILLA
D2
Lith. junceum
Quartz conglom.

Plate 8



COLLECTING SLOPE for D1 fossils
EXPOSURE OF Dolomitic Conglom. (Trias)
BRIDGE VALLEY Rd
S
GREAT QUARRY
NEW ZIG-ZAG
Prod hemisphericus
Dibunophyllum
D1
ENGINE SHED
TUNNEL
POINT VILLA
TOWING PATH
D2
Quartz conglom.
juncea

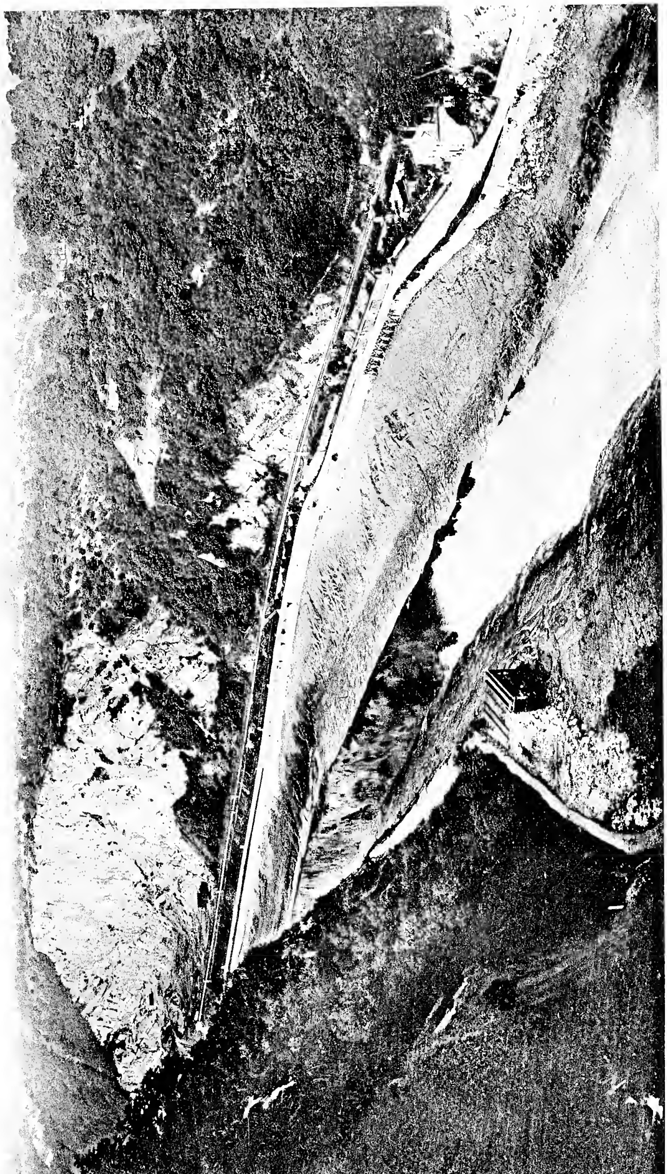


Plate 9.

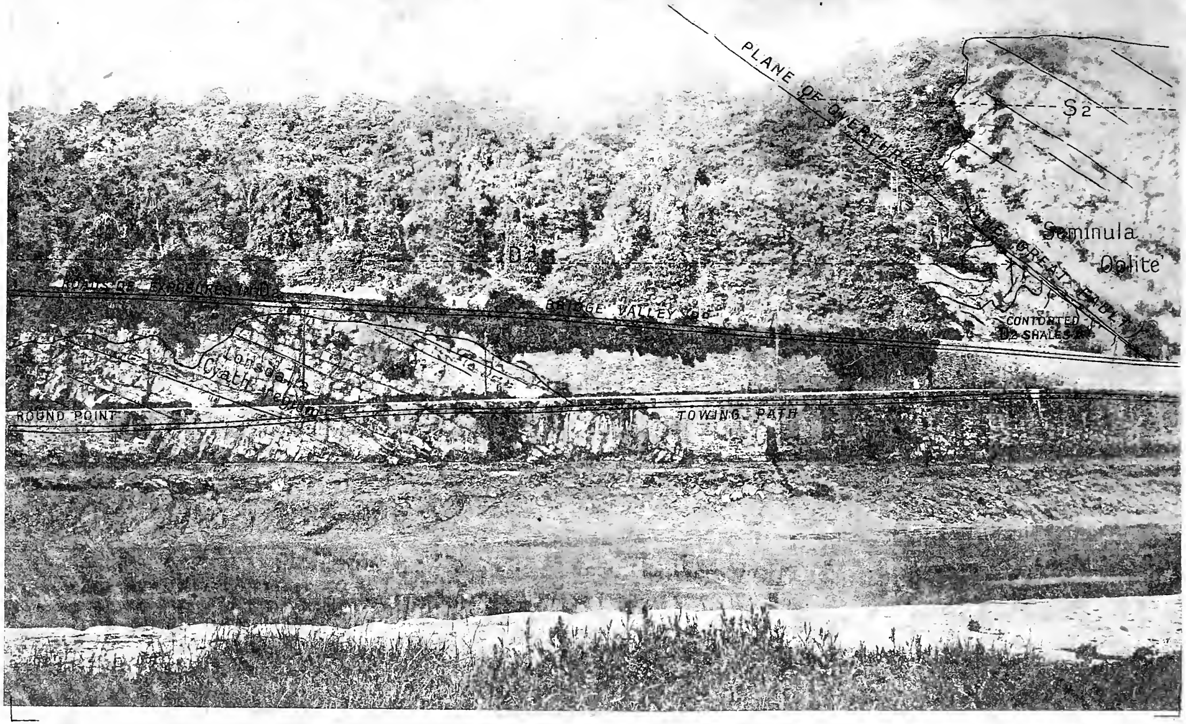

PLANE OF OVERTHRUST
THE GREAT FAULT
S2
Seminula
Oolite
CONTORTED
D2 SHALES
D2
BRIDGE VALLEY
Lonsdaleia
Cyath. region
ROUND POINT
TOWING PATH

Plate 9.

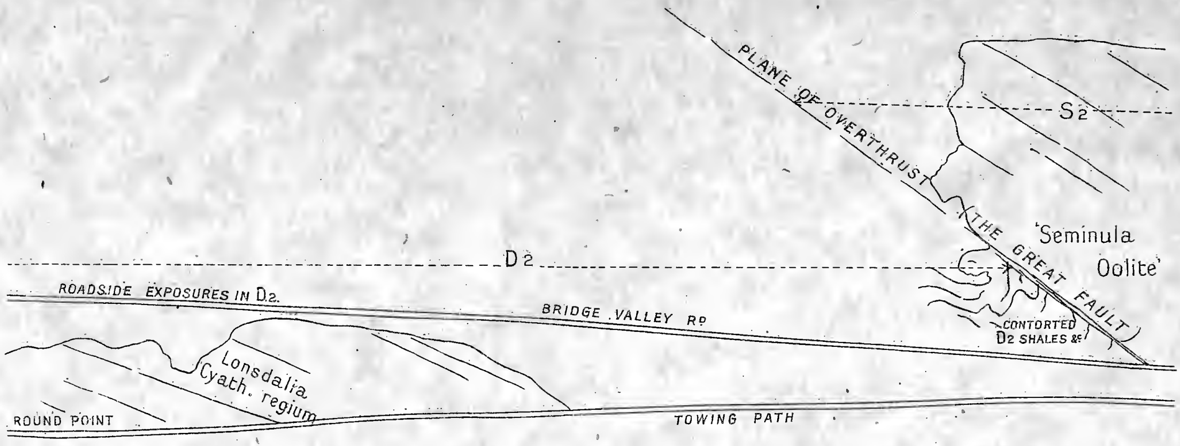
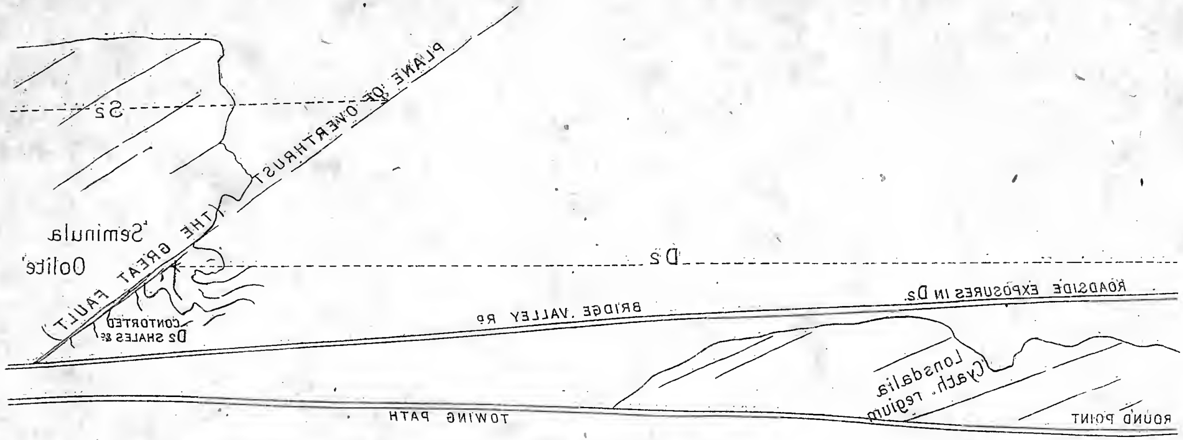
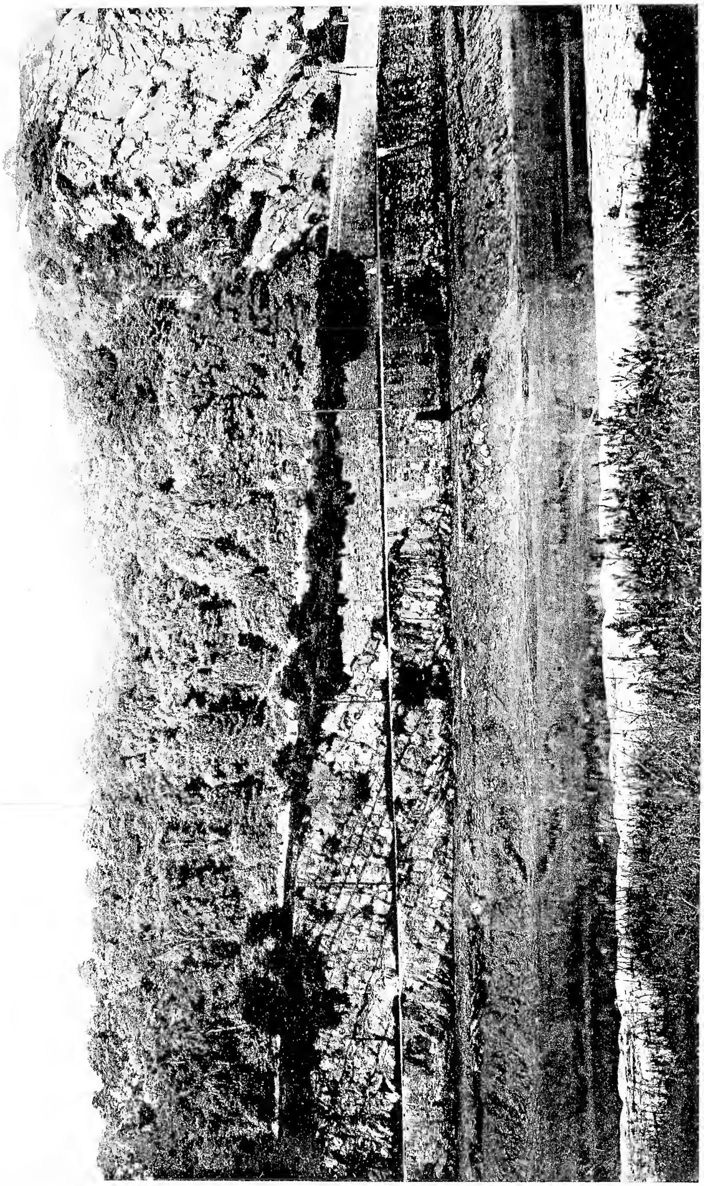
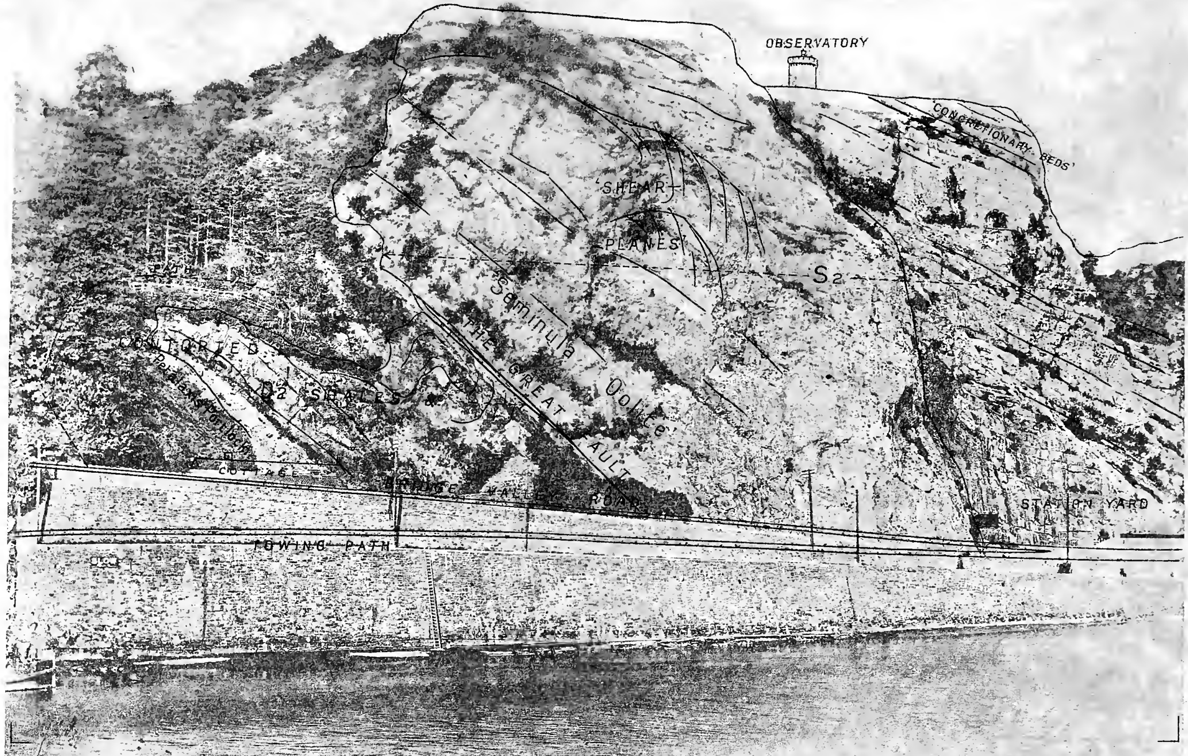

PLANE OF OVERTHRUST
(THE GREAT FAULT)
S2
'Seminula
Oolite'
D2
CONTORTED
D2 SHALES &c
ROADSIDE EXPOSURES IN D2.
BRIDGE VALLEY RD
Lonsdalia
Cyath. regium
ROUND POINT
TOWING PATH

Plate 9.



PLANE OF OVERTHRUST
S2
THE GREAT FAULT
'Seminula
Oolite'
CONTORTED
D2 SHALES &c
D2
ROADSIDE EXPOSURES IN D2
BRIDGE VALLEY RD
Lonsdalia
Cyath. regium
TOWING PATH
ROUND POINT




OBSERVATORY
'CONCRETIONARY BEDS'
'SHEAR PLANES'
S2
Seminula Oolite
THE GREAT FAULT
CONTORTED
D2 SHALES
BRIDGE VALLEY ROAD
TOWING PATH
STATION YARD

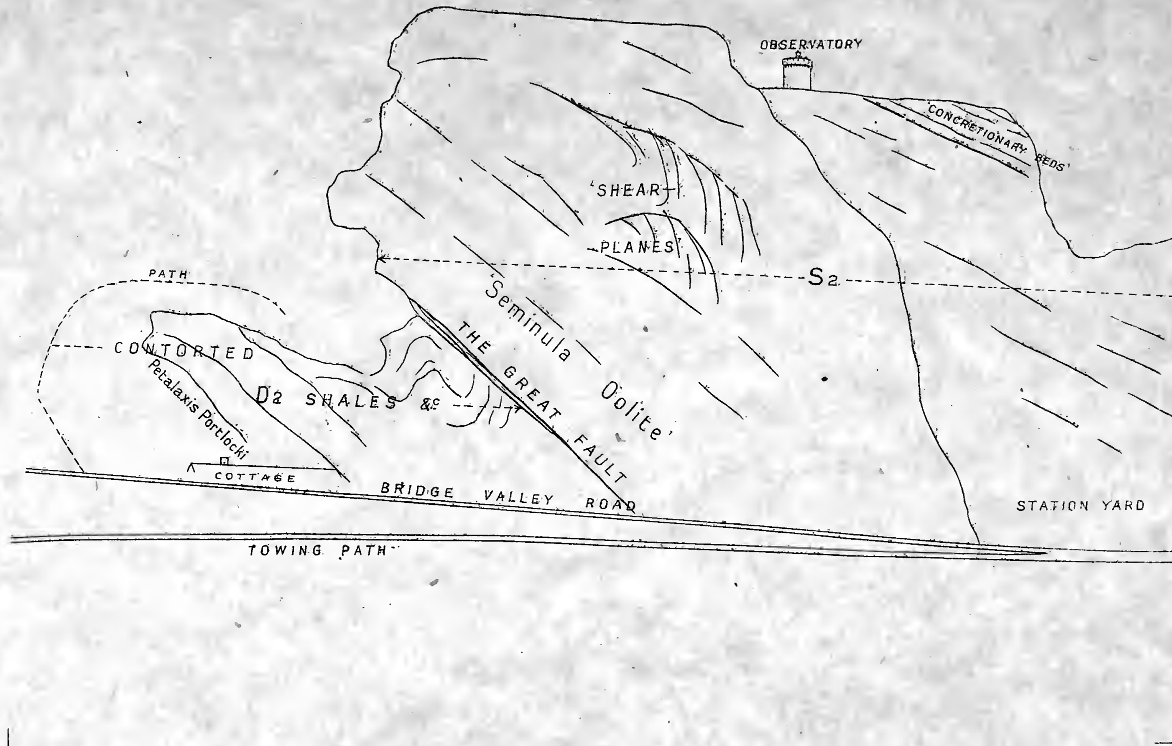
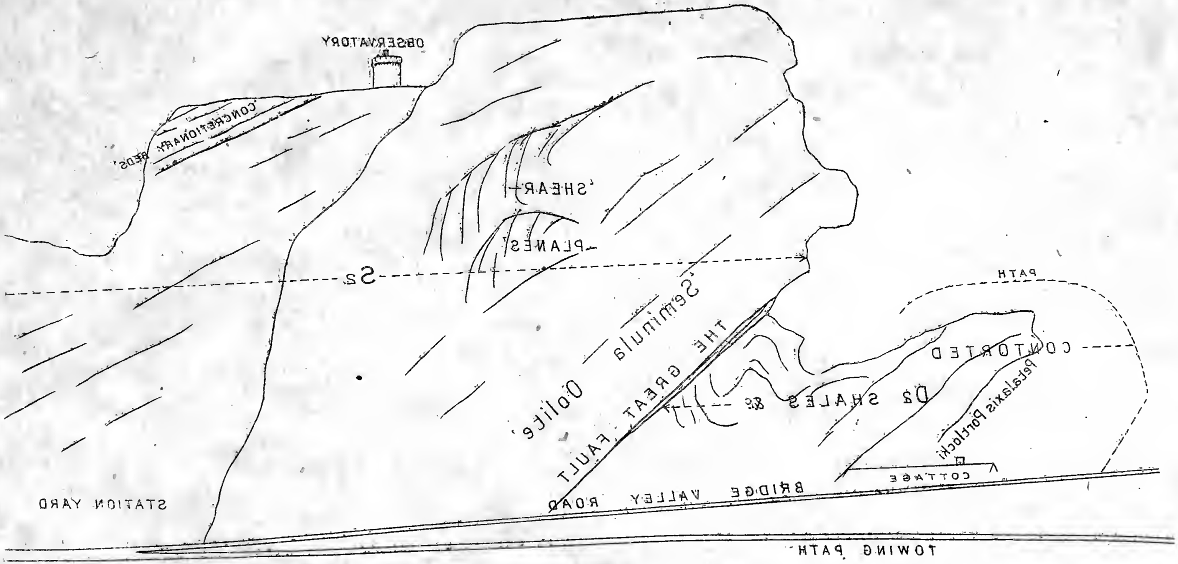
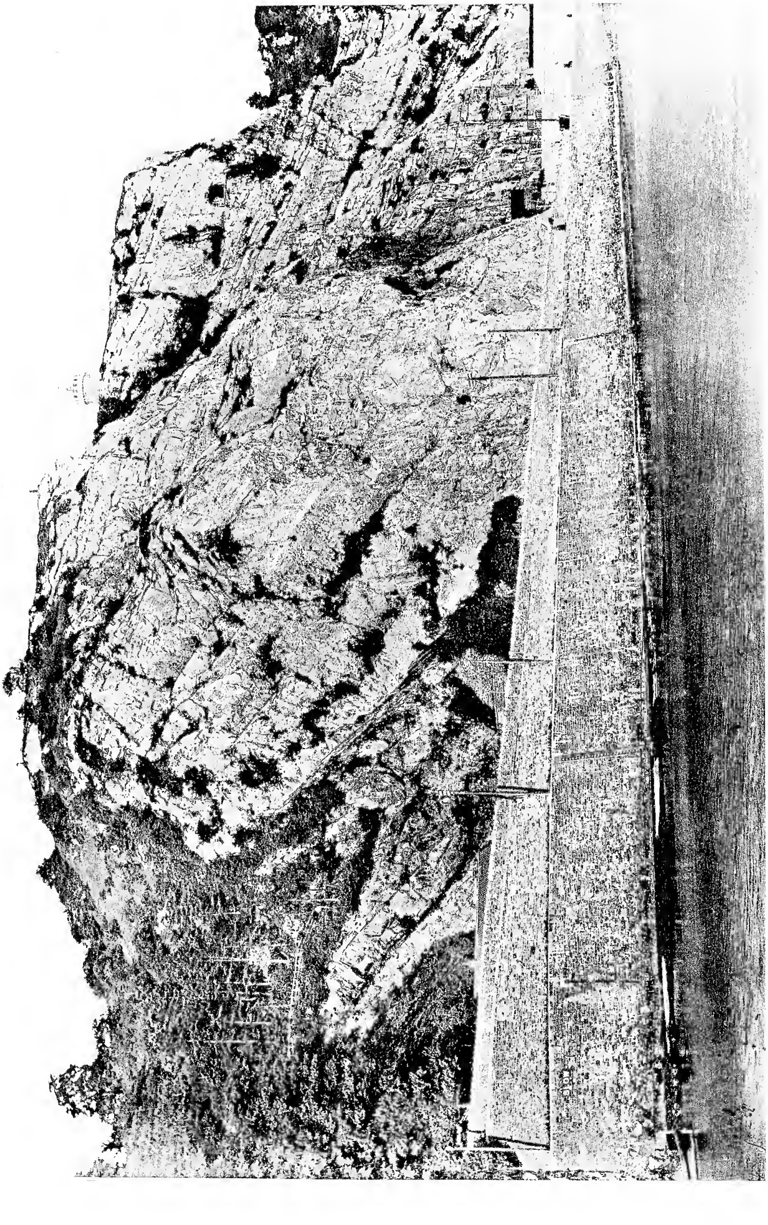

OBSERVATORY
'CONCRETIONARY BEDS'
'SHEAR
PLANES'
S2
'Seminula Oolite'
THE GREAT FAULT
PATH
CONTORTED
D2 SHALES &c
Petalaxis Portlocki
COTTAGE
BRIDGE VALLEY ROAD
STATION YARD
TOWING PATH

Plate 10.


OBSERVATORY
'CONCRETIONARY BEDS'
'SHEAR PLANES'
S2
'Seminula Oolite'
THE GREAT FAULT
D2 SHALES &
CONTORTED
Petalaxis Portlocki
PATH
COTTAGE
STATION YARD
BRIDGE VALLEY ROAD
TOWING PATH



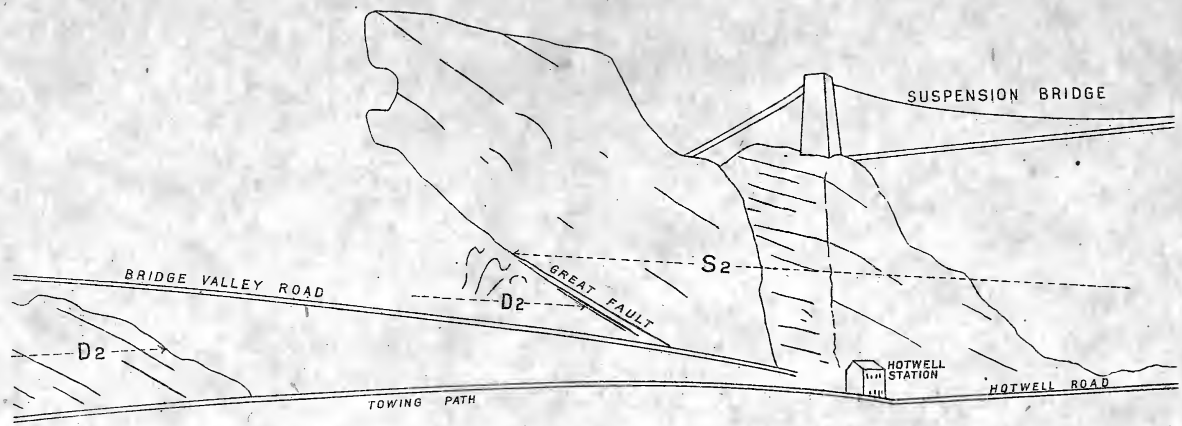
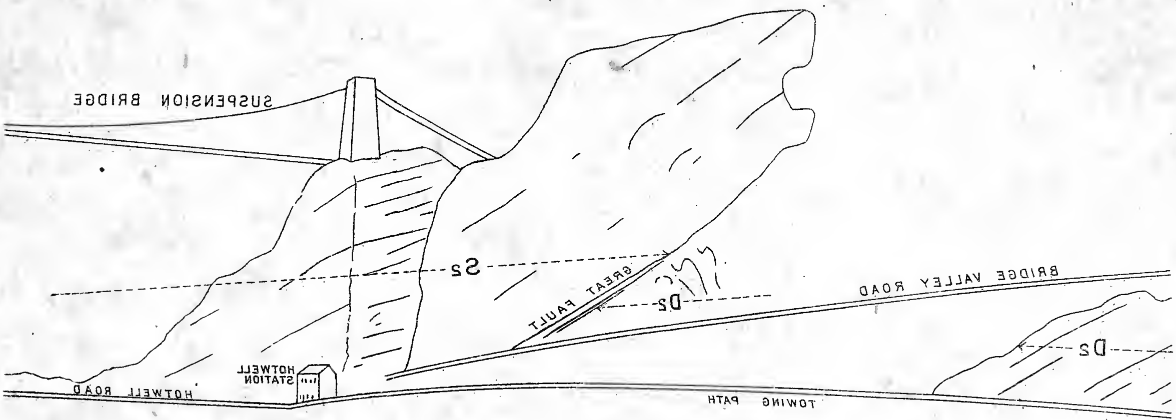
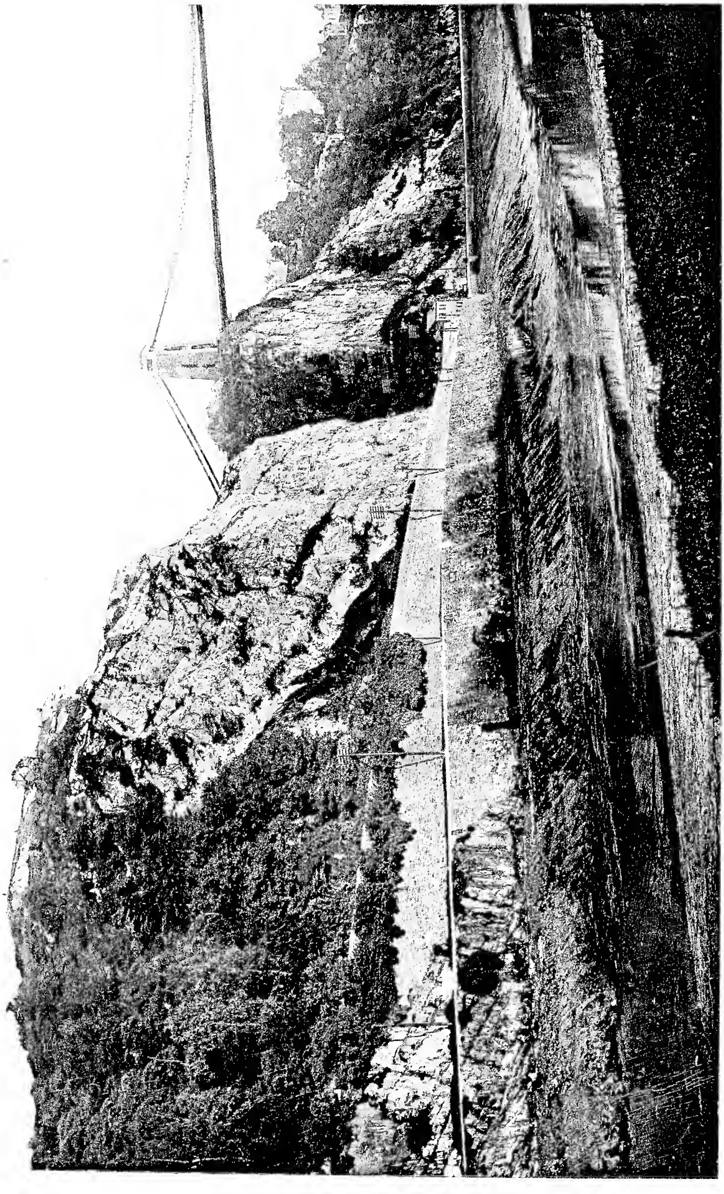

SUSPENSION BRIDGE
S2
GREAT FAULT
D2
BRIDGE VALLEY ROAD
D2
HOTWELL STATION
HOTWELL ROAD
TOWING PATH

Plate II.


SUSPENSION BRIDGE
S2
GREAT FAULT
D2
BRIDGE VALLEY ROAD
D2
HOTWELL STATION
HOTWELL ROAD
TOWING PATH



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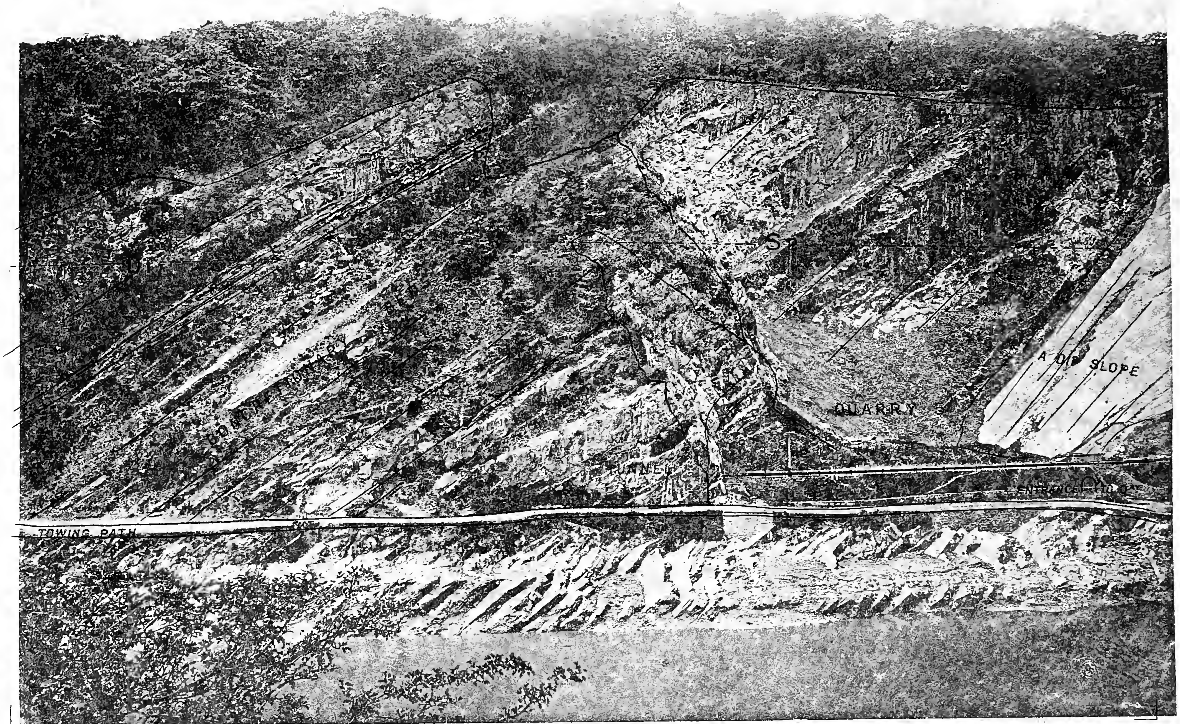

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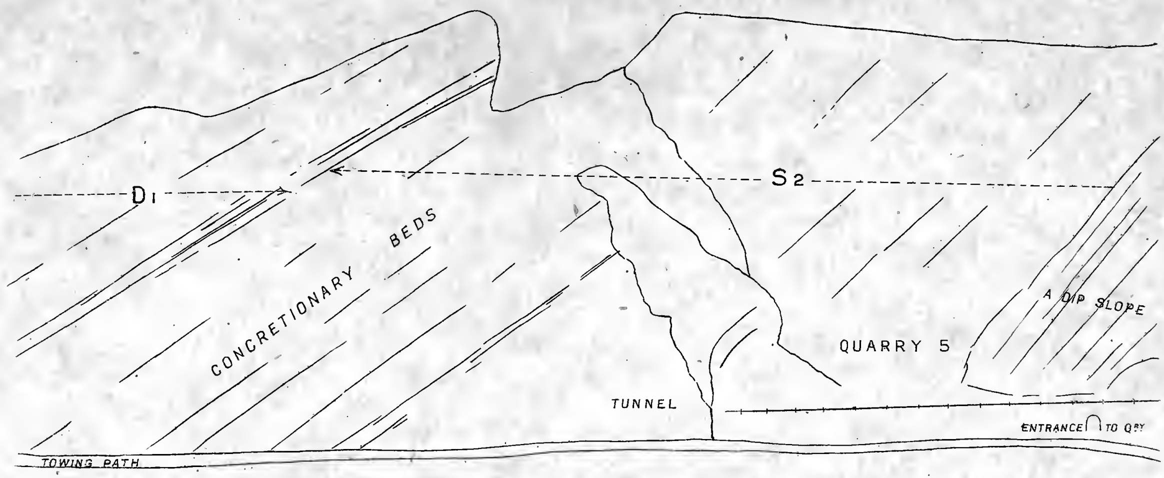
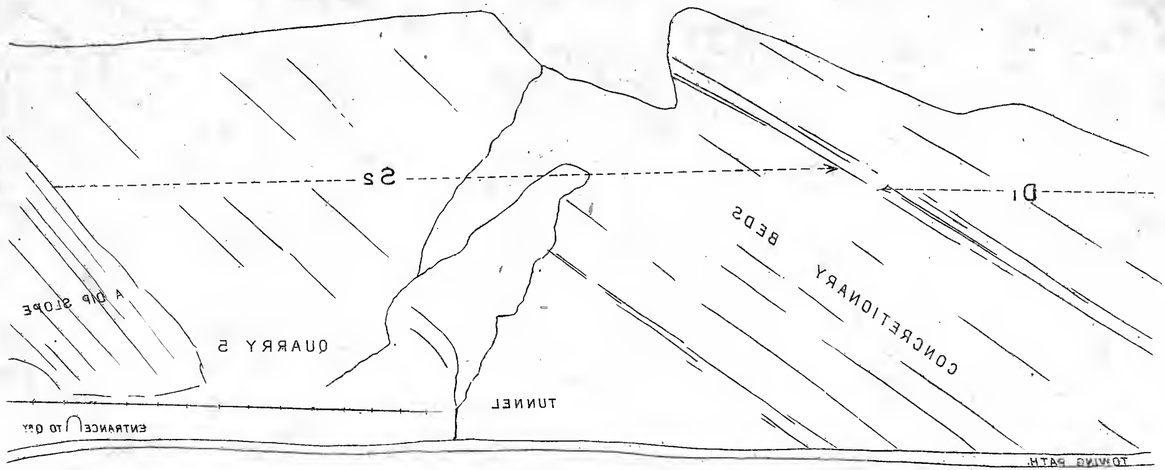
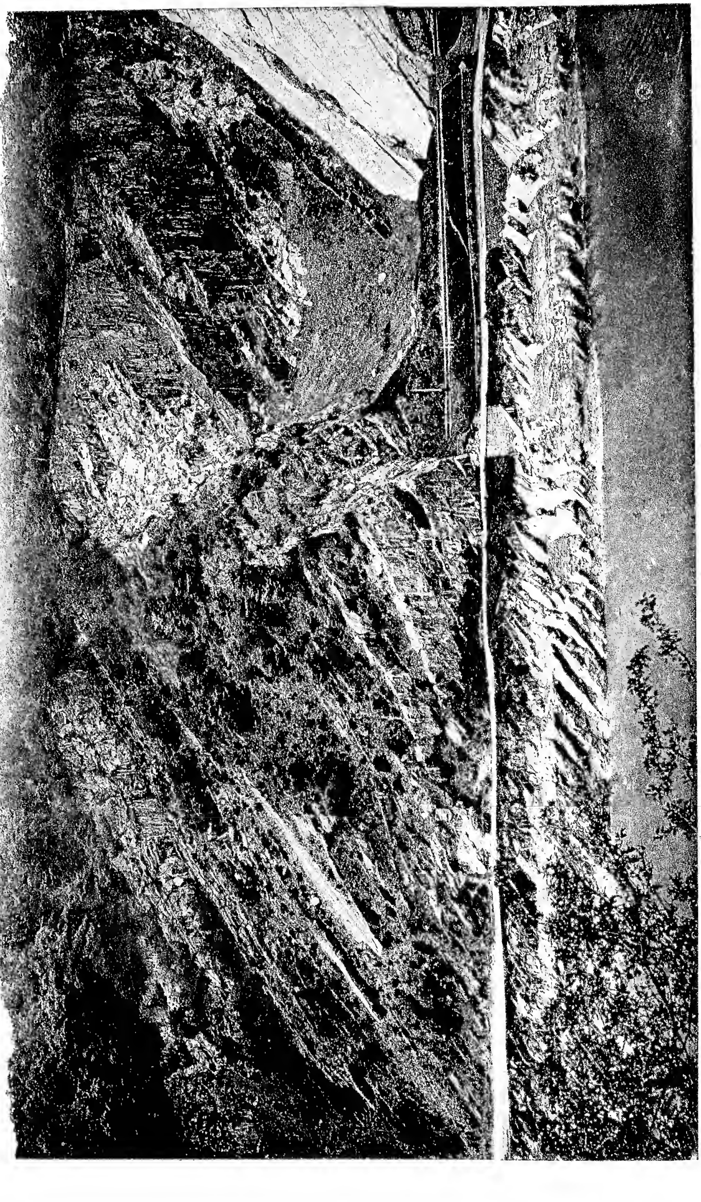

S2
D1
CONCRETIONARY BEDS
TUNNEL
QUARRY 5
A DIP SLOPE
ENTRANCE TO Q'RY
TOWING PATH

Plate 12.


S2
D1
A DIP SLOPE
QUARRY 5
TUNNEL
ENTRANCE TO QRY
CONCRETIONARY BEDS
TOWING PATH.



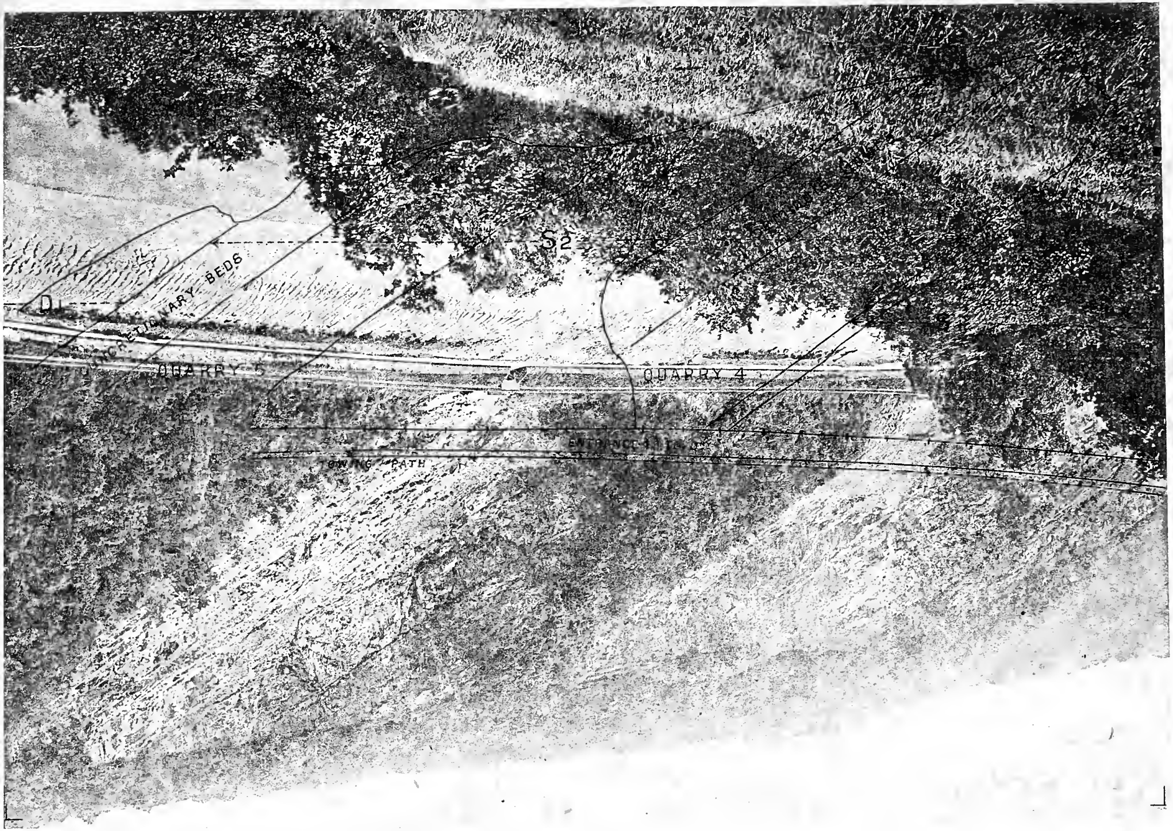
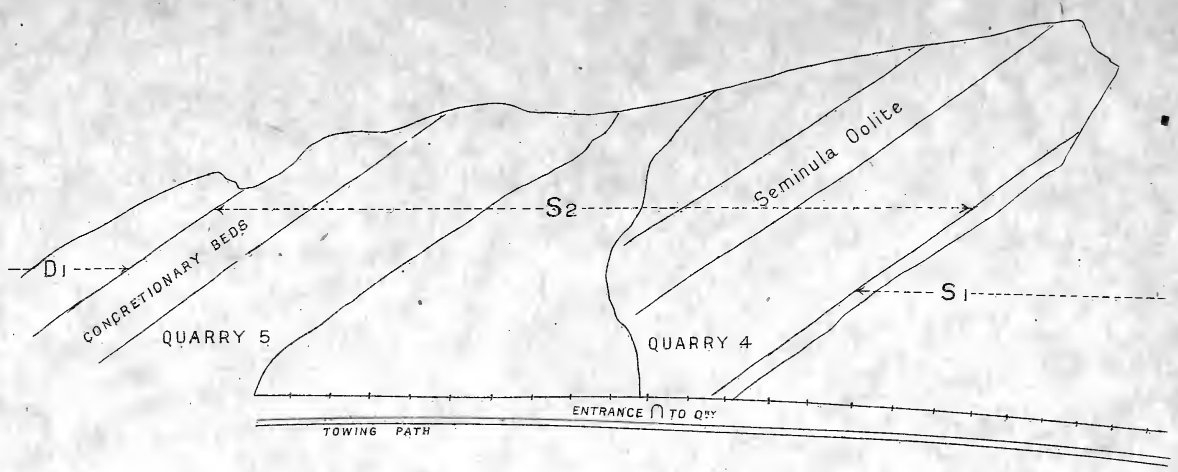
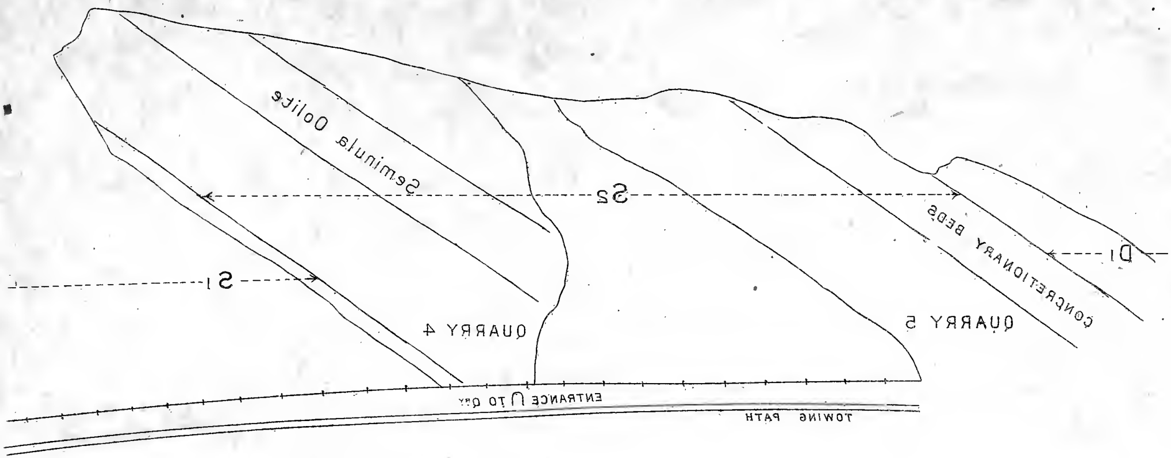

D1
S2
BEDS
QUARRY 5
QUARRY 4
ENTRANCE
TOWING PATH

Plate 13



D1
CONCRETIONARY BEDS
QUARRY 5
S2
Seminula Oolite
QUARRY 4
S1
ENTRANCE TO QRY
TOWING PATH

Plate 13


Seminula Oolite
S2
S1
D1
CONCRETIONARY BEDS
QUARRY 4
QUARRY 5
ENTRANCE TO QRY
TOWING PATH

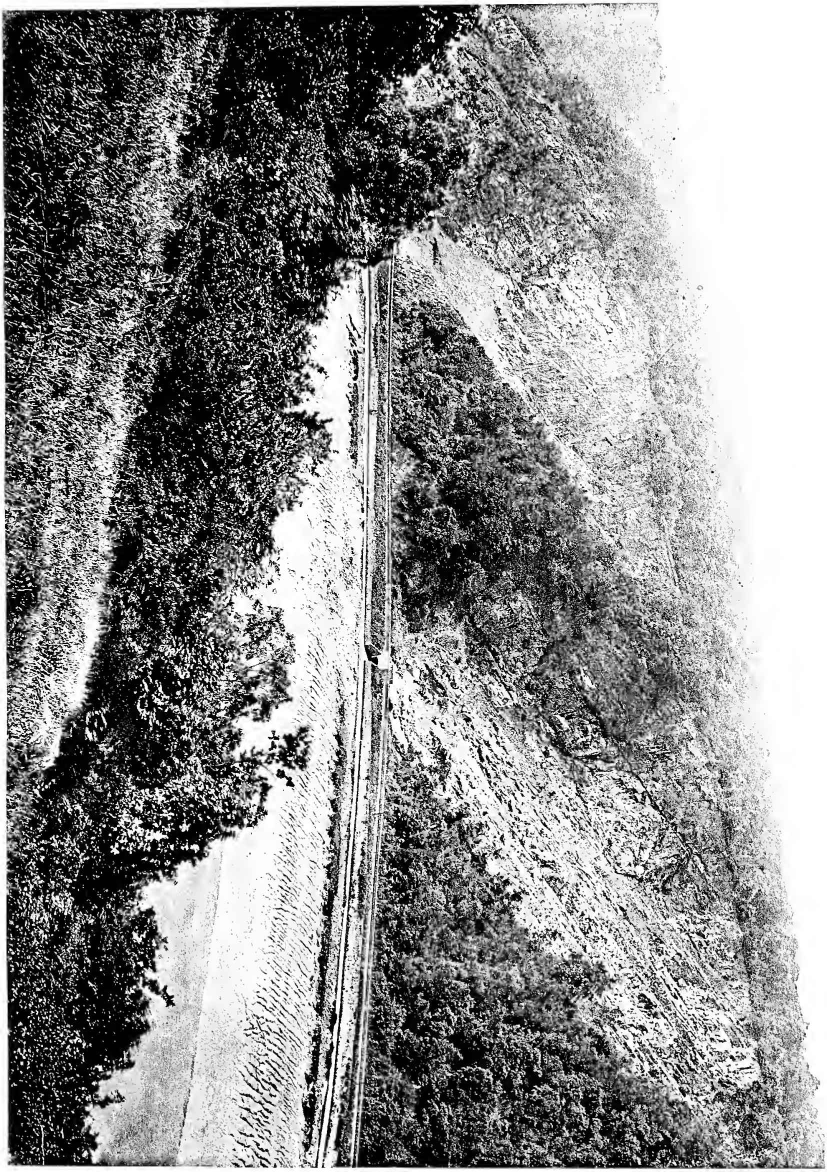
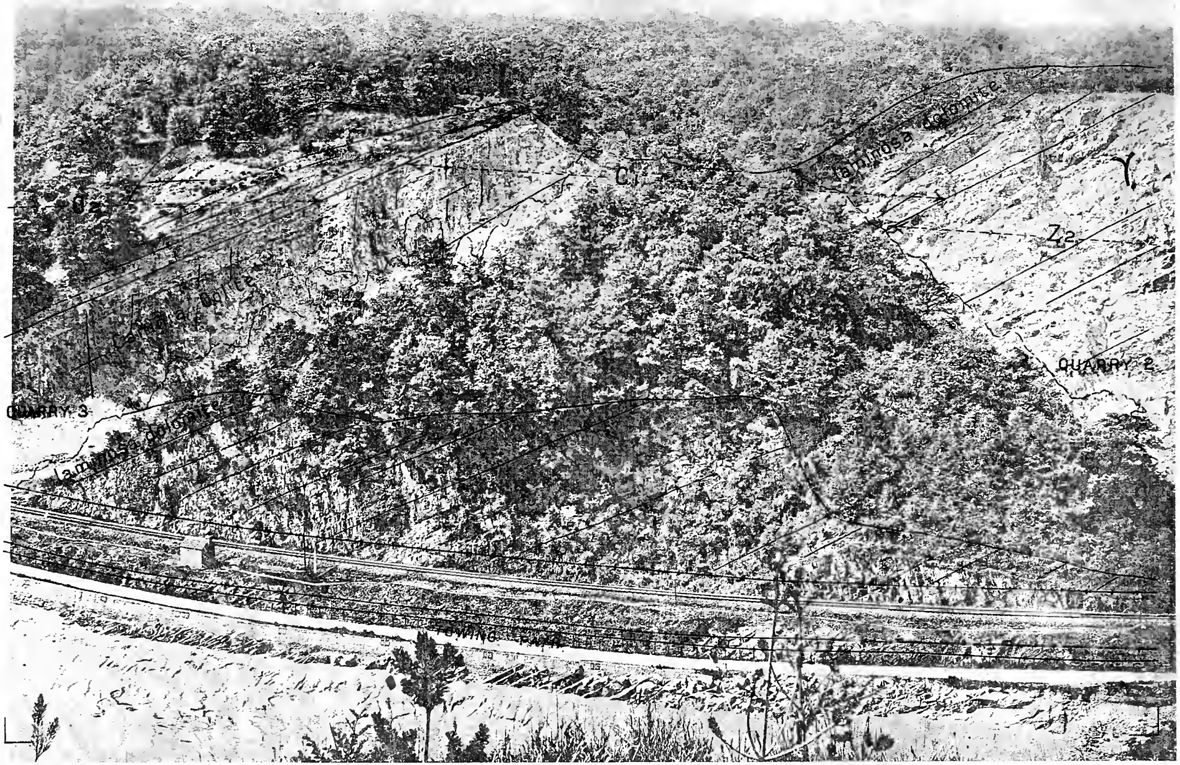


Plate 14



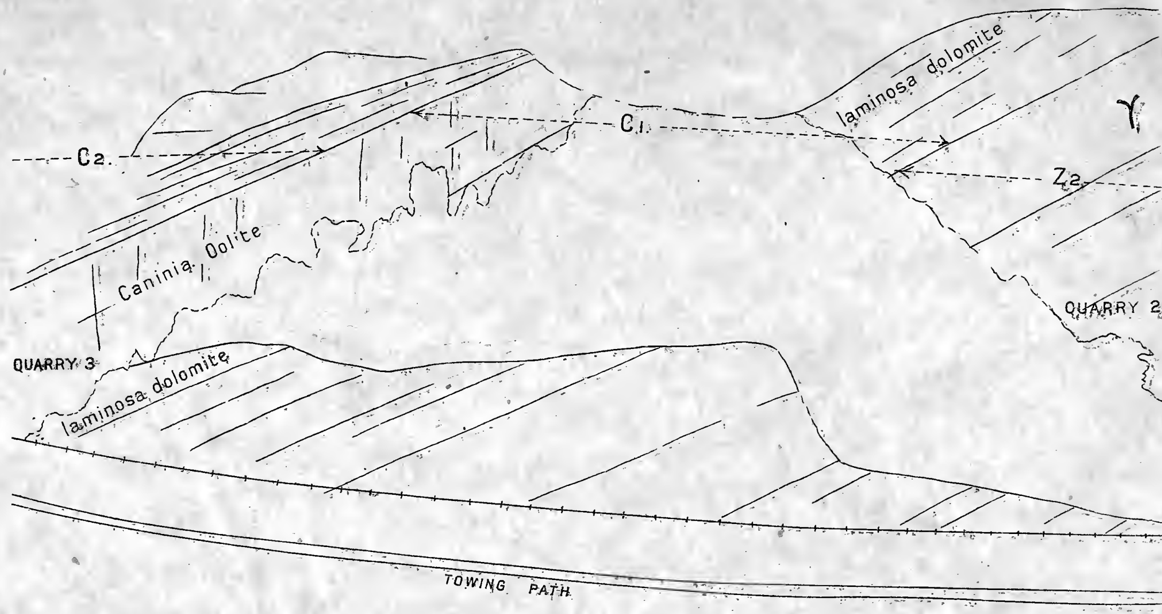
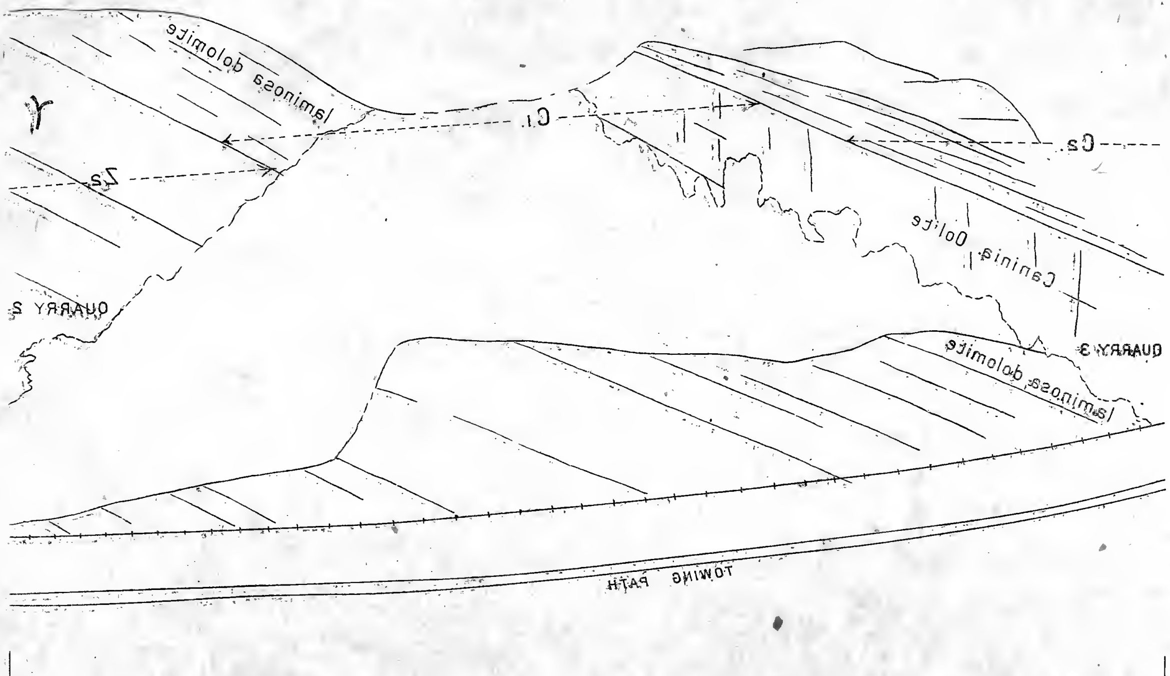

C2.
C1.
Z2
laminosa dolomite
γ
Caninia Oolite
QUARRY 2
QUARRY 3
laminosa dolomite
TOWING PATH

Plate 14



laminosa dolomite
Y
Zs
Cl.
Cs.
Caninia Oolite
QUARRY 2
QUARRY 3
laminosa dolomite
TOWING PATH

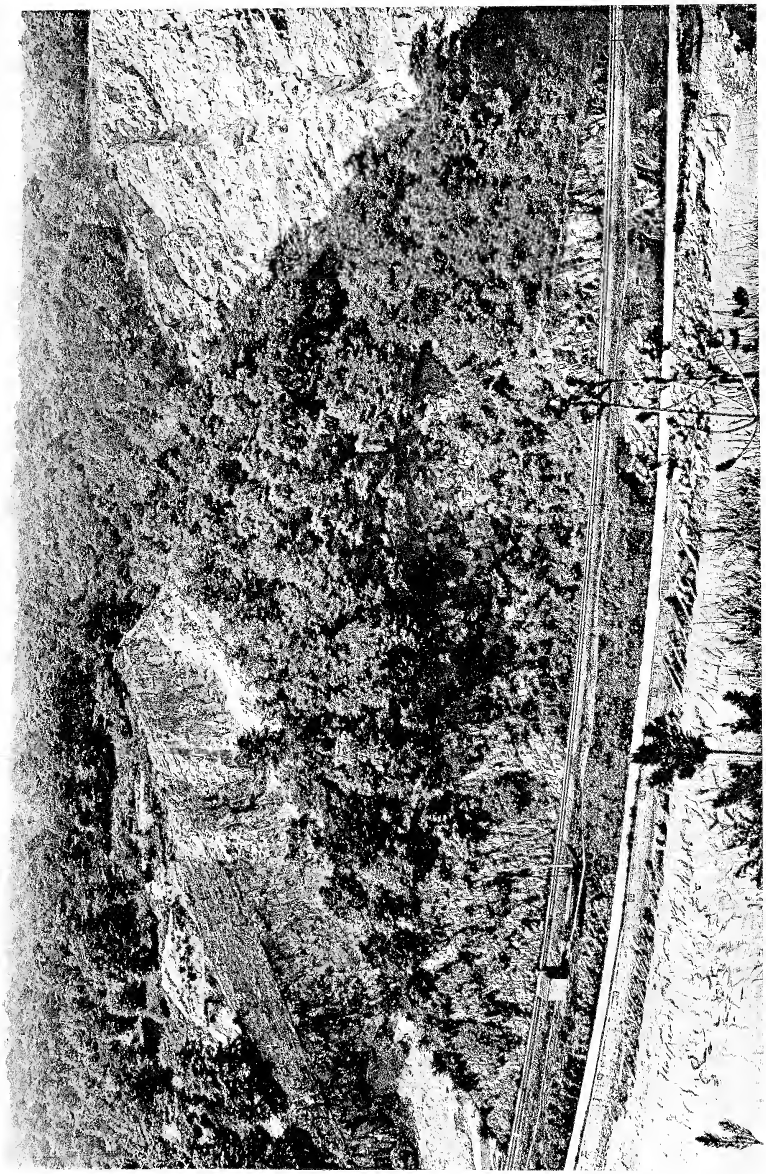
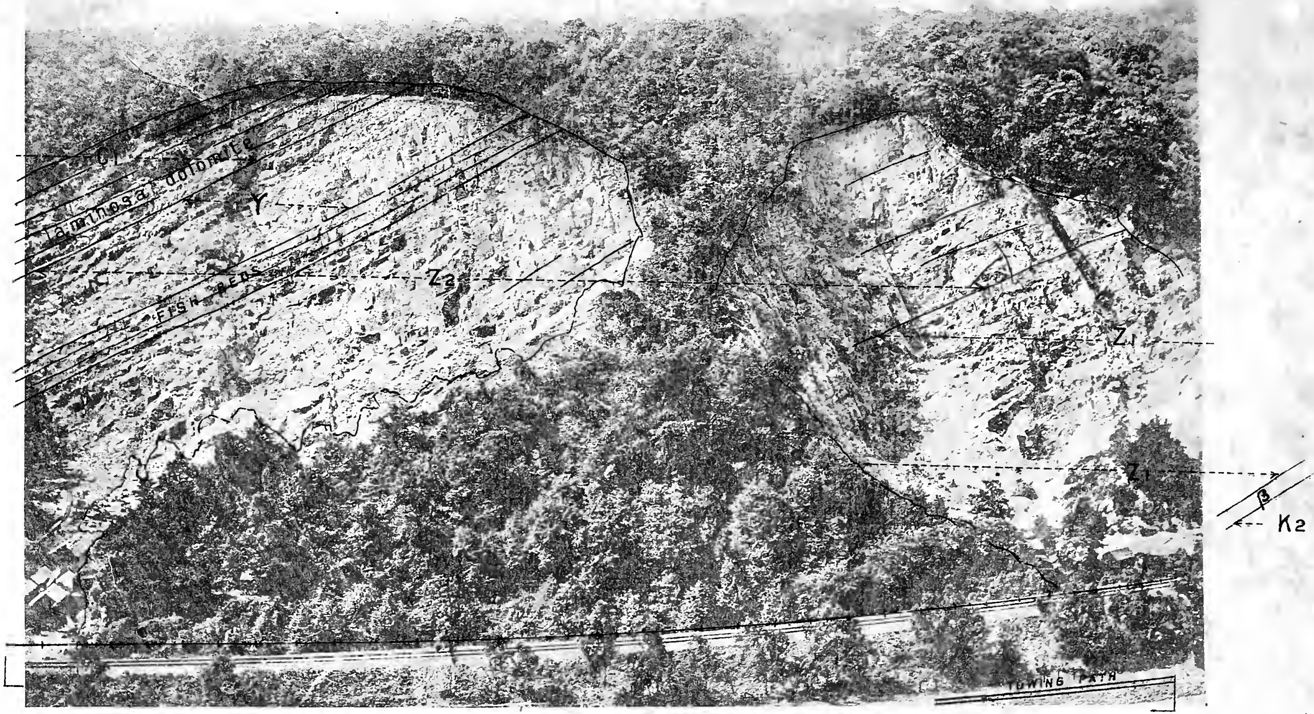


Plate 15



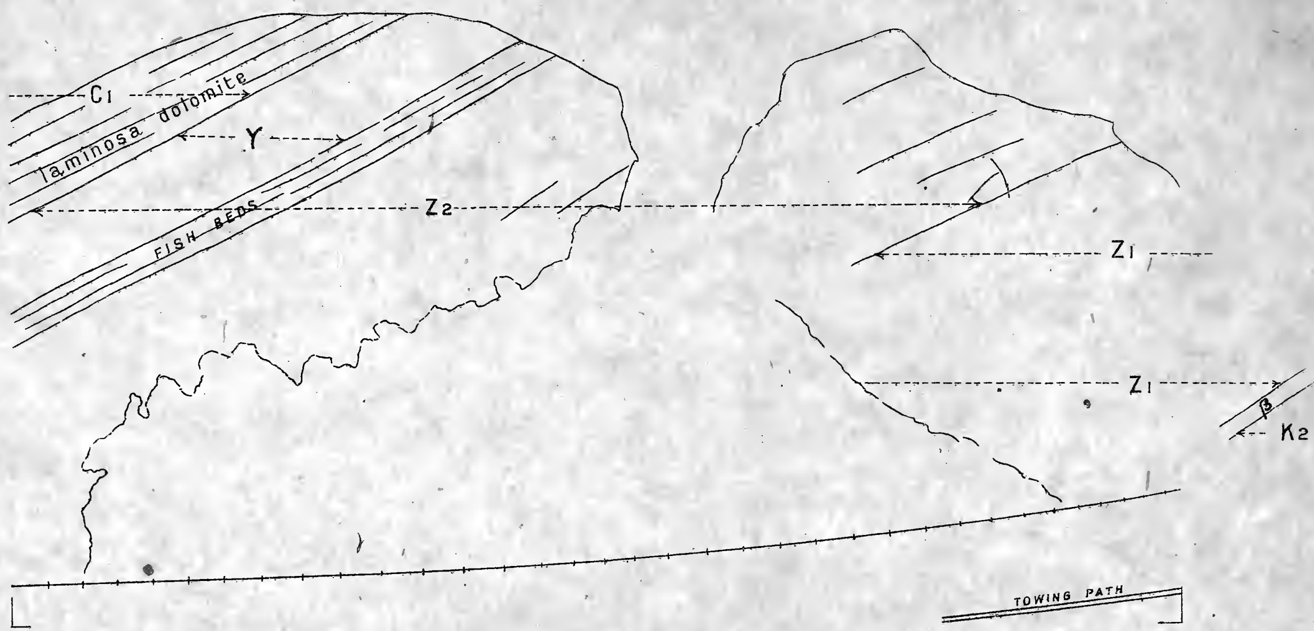
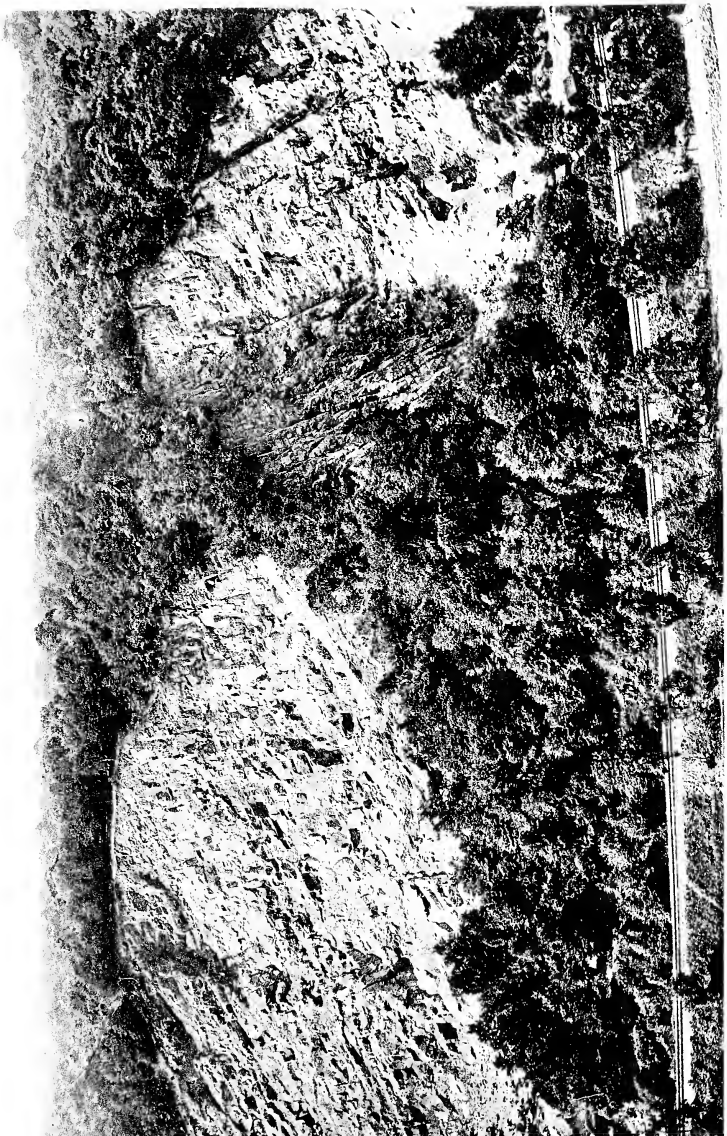
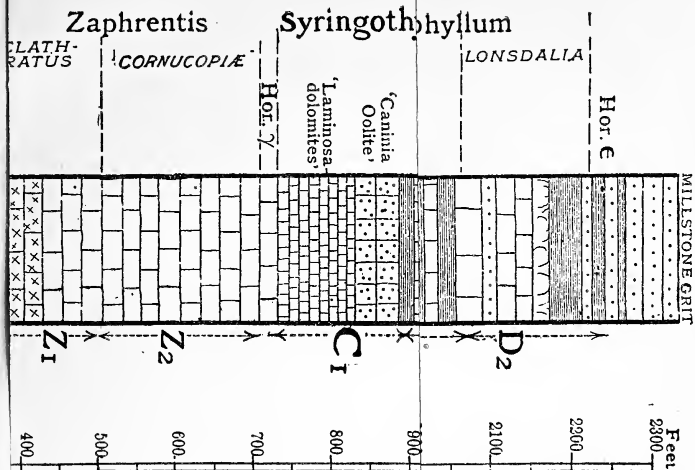

C1
laminosa dolomite
Y
Z2
FISH BEDS
Z1
Z1
β
K2
TOWING PATH

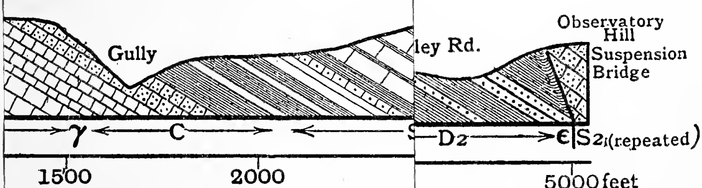
Plate 15

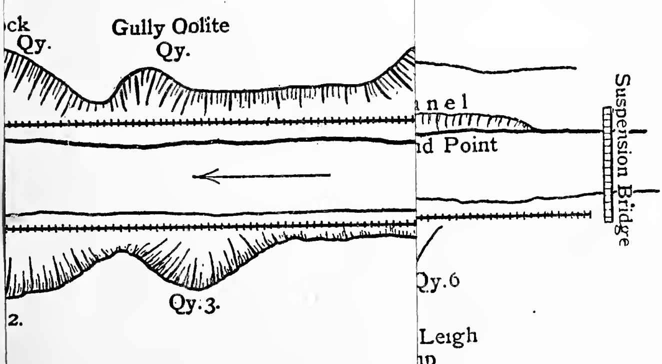




THE A

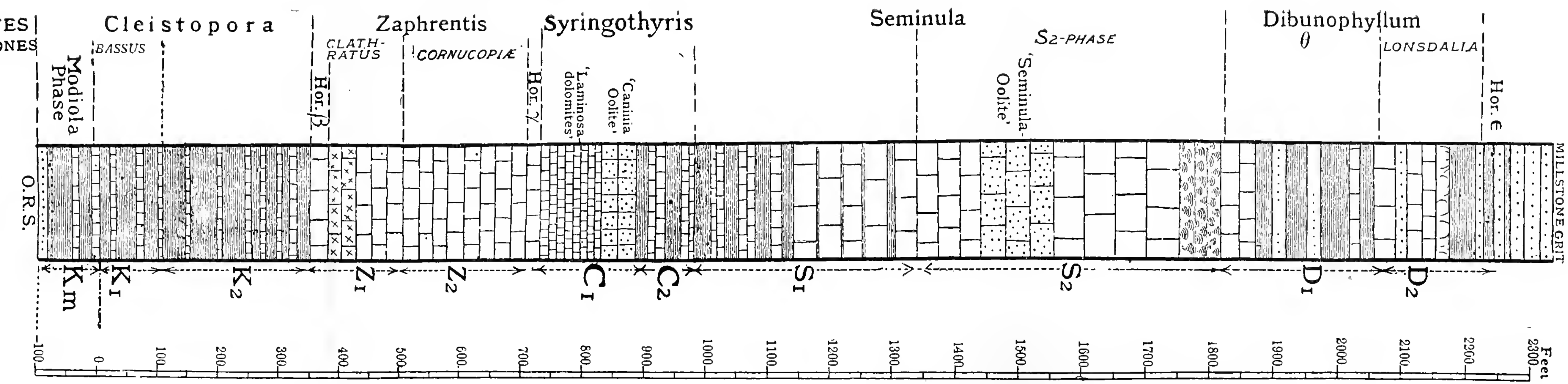
Horizontal S





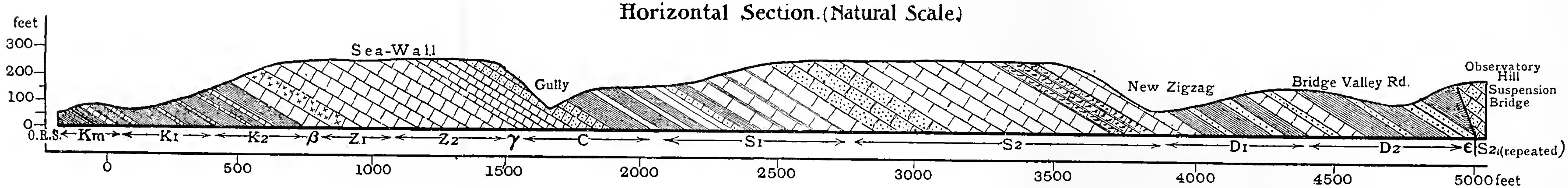
Sketch Ma

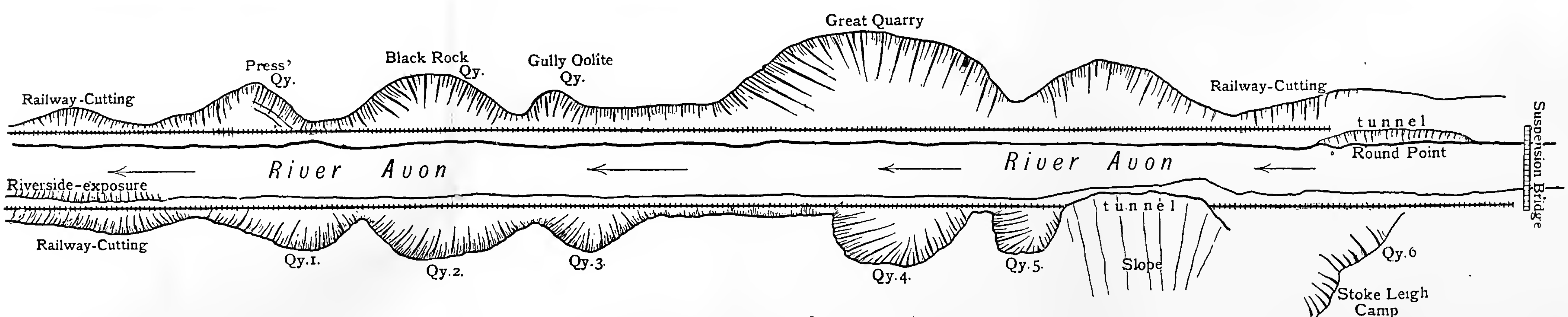
VERTICAL SECTION
Showing the Thickness and Lithic Characters of the ZONES and SUBZONES in the AVON Sequence.



THE AVON GORGE

Horizontal Section. (Natural Scale.)





Sketch Map of Quarries.

Report of Meetings

For the year ending December 31, 1905.

GENERAL.

MR. C. K. RUDGE chose "Some Animals from a Devon-tide Pool" as the subject of his Presidential lecture on January 26.

The subjects brought before the Society at the General Meetings were as follows :—

Feb. 9. Professor S. H. Reynolds, M.A., F.G.S., on "A Sketch of the Geological History of the Bristol District."

Mar. 2. Mr. F. B. Stead, M.A., on "The Deep Sea and its Fauna."

Apr. 6.—Mr. R. C. Cann Lippincott on "Göethe's explanation of the production of Colour by Colourless Semi-transparent Media"; and Mr. J. H. Priestley, B.Sc., on "Some Relations between Plants and Ants."

May 4.—Mr. G. Munro Smith, M.R.C.S., on "The Domestic Cat."

Oct. 5.—Mr. J. H. Priestley, B.Sc., on "Plants as Parasites."

Nov. 2.—Mr. J. W. White, F.L.S., on "The Botany of the Balearics."

Dec. 7.—Mr. O. C. M. Davis, B.Sc., on "Some Experiments with Gases."

Messrs. Davis' and Lippincott's papers were illustrated by experiments, the others by lantern slides.

BOTANICAL SECTION.

THE discovery of a new British grass in North Somerset was referred to in my last Report. The story of its identification savours of romance. In the year 1726 Dillenius, Sherardian

Professor of Botany at Oxford, accompanied by Dr. Brewer, made a two months' journey through the West of England and Wales in search of plants, visiting the Mendips, Cheddar, Uphill and " Brent " [Brean] Down. In the still extant description of this journey written by Dillenius he notes the discovery at Uphill and Brean Down of a new grass which he calls " *Spartium montanum radice bulbosa et fungosa.*" Later, he identified it by means of A. Scheuchzer's description in the *Agrostographia*, published in 1716, with the species therein named " *Gramen valesianum tenuifolium, panicula spicata, viride argentea, splendente.*" This identification by Dillenius was correct, and testifies to his skill in diagnosis as much as his detection of the growing plant does to his keenness as a field-botanist. However, the specimens he gathered somehow became separated from his label and memorandum, and so remained unremarked in the Sherardian Herbarium for close upon two centuries. Meanwhile nearly every British botanist of note, generation after generation, came to Brean Down for its rare plants and heeded not this Koeleria growing abundantly about the rocks. Although the facilities we possess for botanical exploration are so great in comparison with those at the command of our forefathers, and the advances of science have been so prodigious since the days of Ray and Dillenius, yet it must be owned that in critical acumen and intellectual vigour the people of to-day can claim no superiority over those who laid the foundations of our knowledge. It was not until 1904 that Mr. G. Claridge Druce, of Oxford, when preparing a memoir of Dillenius and an account of his herbarium, looked through a packet of odds and ends, saw the unlabelled specimens in one place and the empty sheet with memo. in another, surmised that they were related to each other, and fitted them together again. Mr. Druce now wanted proof that he was right in so doing; and, although in October, the next week-end found him on the way to Weston. Without much difficulty he succeeded in finding the plant with dried flower-stems growing in considerable quantity on exposed limestone slopes. Thus all doubt of the existence in Britain of *K. vallesiaca* was removed, and Mr. Druce can be congratulated on a very smart bit of work.

The grass is indeed readily recognizable at any period by its curious root stock. This bears a dense tuft of short, stout shoots, most of which are barren. The whole plant is frequently without a flower-stem: sometimes only one shoot flowers—seldom more than three. Each shoot is separately enveloped at the base in a fine fibrous network, closely interwoven and of some thickness; the whole forms a compact tuft often several inches in diameter firmly wedged among stones or anchored in a crevice of rock by plentiful long strong root-fibres. On digging up specimens I have several times noticed, in more than one locality, white patches of the mycelium of a fungus upon the fibrous sheathing, the health of the plant apparently not being thereby affected. This suggests the origin of Dillenius' phrase "*gramen montanum fungosum*," or the latter adjective may have had reference to the filamentous matting which is so conspicuous a character. The leaves differ from those of *cristata* and the panicles are continuous and not more or less interrupted.

The nomenclature of the genus Koeleria is very much involved. For reasons that need not be gone into here it is at present doubtful if the name *vallesiaca* can be retained for this species. It may have to be known as *K. suberosa* Persoon; or possibly take the new title of *K. splendens* Druce.

Finding in a friend's collection a good specimen of the new grass gathered many years ago on Worle Hill (it was of course labelled *cristata*), Mr. Bucknall and I went there and found an abundance. It grows on several parts of that hill. Mr. Bucknall has also found many plants (mostly barren) on stony ground high up on Crook's Peak, and a larger quantity towards the base of its southern slope. These North Somerset localities are at present the only ones known in Great Britain.

JAMES W. WHITE, F.L.S.,
Hon. Secretary.

GEOLOGICAL SECTION.

THE Section at present numbers sixty-one members, showing an increase of four on 1904.

I regret to have to report the loss by death of A. Capper Pass, Esq., who was a member and President of this Section for a great many years. Prof. S. H. Reynolds, M.A., F.G.S., was re-elected President, and Mr. B. A. Baker, Hon. Sec. for 1905.

There have been nine meetings of the Section, when the following papers were read :—

Jan. 19.—Exhibition Meeting.

Feb. 16.—"The Carboniferous Limestone of South-West Gower," by W. B. Gubbin, M.D.

Mar. 23.—"The recent Volcanic Eruptions in the West Indies," by the President (Prof. S. H. Reynolds, M.A., F.G.S.).

April 20.—"On the Sectional Structures and Geological Range of the Carboniferous Rocks in the Bristol and Somerset Coalfields, and their possible extension in adjoining Districts," by J. McMurtrie, F.G.S.

May 18.—"Notes on the Geology of Malvern," by the President (Prof. S. H. Reynolds, M.A., F.G.S.).

June 15.—"The Carboniferous Limestone of the Weston super-Mare district," by T. F. Sibly, B.Sc.

Oct. 19.—"A Visit to the Dolomite Alps," by the President (Prof. S. H. Reynolds, M.A., F.G.S.).

Nov. 16.—"The Avonian Sequence," described from lantern slides from photographs taken by the President, by Dr. A. Vaughan, B.A., F.G.S.

Dec. 21.—Exhibition Meeting.

There was an average attendance of seventeen at each meeting, which shows a falling off of five as compared with last year.

The Financial Report shows a total receipt of £6 12*s*. 10*d*., including a balance of £1 10*s*. 4*d*. brought forward from last year. The expenditure has been £3 17*s*. 10*d*., leaving a balance of £2 15*s*. The Report again shows some progress of the Section, but it was pointed out by the President and myself at the last meeting of the year that it is only a few of the members who read papers at the meetings year after year, and much the same thing occurs at the Exhibition Meetings. It is hoped that more members will contribute papers, however short, this year. I do not think the members of this Section can be aware of the privilege they have of using the Society's Library in the room at 20, Berkeley Square, and reading the many very interesting geological books and magazines to be found there, as the library is not used as much as it might be. Any member of the Society can use the room, although not a member of the Literary and Philosophical Club.

B. A. BAKER,

Hon. Secretary.

ENTOMOLOGICAL SECTION.

MARCH 14.—A paper prepared by Mr. R. M. Prideaux was read by the President on "A few Notes on Scale Transference in Lepidoptera and the nature of the wing colouring revealed by the process." The paper was illustrated by examples prepared by Mr. Prideaux, the wing scales of the specimens treated being transferred, and thereby reversed, to a cardboard support. This process resulted in a marked change of appearance in the case of those species where the colour resulted from structural and optical conditions.

April 18.—Mr. G. C. Griffiths exhibited a large number of British and foreign Lepidoptera including many rare species, amongst them being *Papilio Crœsus, P. Victoriæ, P. Lyœus,* and *Druyria autimachus.*

Nov. 14.—Mr. H. J. Charbonnier exhibited specimens of *Serycomyia borealis, Syrphus labiatorium* and *Chilosia illustrata* from Lynmouth and *Ischyrosyrphus glaucis, Chrysotoxum arcuatum, Syrphus compositarium* and *S. umbellatarum* from Cheddar.

Mr. G. C. Griffiths showed two specimens of *Ephyra pendularia* var. *subroseata,* Shropshire; also examples of *Agrias sardana-*

palus, Peru; *Papilio paradosea*, New Guinea; *P. ascanius*, Brazil; *P. cacicus*, Colombia; and *Œtheoptera Victoriæ*, New Hebrides.

The Hon. Secretary exhibited specimens of *Megachile centumadaris*, *Odynerus parictum*, *Oxycera pardalina*, and *Amblyteles palictarius*, from Braunton; *Megachile maritima*, *Cerceris interrupta* and *Colletis succincta*, from Crantock; also *Moredon equestris* (dark variety) from Bristol.

CHARLES BARTLETT,
Hon. Secretary.

June 25, 1906.

FOURTH SERIES, VOL. I., Part III. (issued for 1906). Price 2s.

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A Bone Cave at Walton, near Clevedon.

By Sidney H. Reynolds, M.A., F.G.S.

THE ridge of high ground running from Portishead to Clevedon is composed as regards its seaward portion of Old Red Sandstone overlain unconformably by Dolomitic Conglomerate, while its landward portion consists of Carboniferous limestone in which several quarries have been opened. Two of these lie one on either side of Holl lane which leaves the main Portishead and Clevedon road below Walton Castle. The horizon exposed is the Caninia oolite of Dr. Vaughan's nomenclature.

In the western quarry the rock is quarried for lime-burning, in the eastern quarry a thick series of superficial deposits is banked up against the hillside which here is decidedly steeply inclined. The thickness of these superficial deposits is variable, but sometimes as much as 20 ft. They are described by Mr. H. N. Davies, F.G.S., in a communication appended to this paper. In places they contain numerous shells of a small snail, *Hygromia hispida Linn.*, and a few of *Succinea putris*, *Linn.* These were identified for Dr. Male by Mr. A. S. Kennard. Very numerous teeth, jaws, and limb-bones of small rodents also occur in the superficial deposits. The quarrying of the superficial material for gravel led, during the latter part of 1905, to the discovery of a small cave, measuring about eighteen feet in width by eight in height and ten in depth. This cave was full of a highly ossiferous cave-earth, and similar material was banked up against the slope of the cliff round the mouth of the cave.

The finding of these bones was first noted by Mr. G. E. Male, of Clevedon, who with his brother, Dr. H. C. Male, collected a large series, many of which are now in the Jermyn Street Museum. But before Mr. Male learnt of the existence of the cave several cart-loads of bones were put upon the new light railway between Clevedon and Portishead.

Having obtained permission from Messrs. J. Coles and Son, the lessees of the quarry, I commenced in January, 1906, to work the deposit on behalf of the Bristol Museum, and some 500 specimens were obtained, which are now preserved in that institution. These, however, hardly represent a tithe of those which actually occurred, as in addition to those destroyed before Mr. Male's first visit, great numbers have been taken away by local collectors.

When I first visited the cave its major portion had already been cleared of cave-earth to within 20 ins. of the bottom. The bones obtained by me were found in :—

(1) The 20 in. of cave-earth on the floor of the cave.

(2) A mass banked up against the limestone and blocking a fissure on the right side of the cave.

(3) A mass filling up the left side of the cave and banked up against the limestone to the left of its mouth.

The following is a list of the species found by various collectors in the Walton cave. Mr. E. T. Newton, F.R.S., has most kindly identified the bones of birds, while he, Dr. Forsyth Major, and Mr. Martin Hinton have all examined collections of the rodent remains.

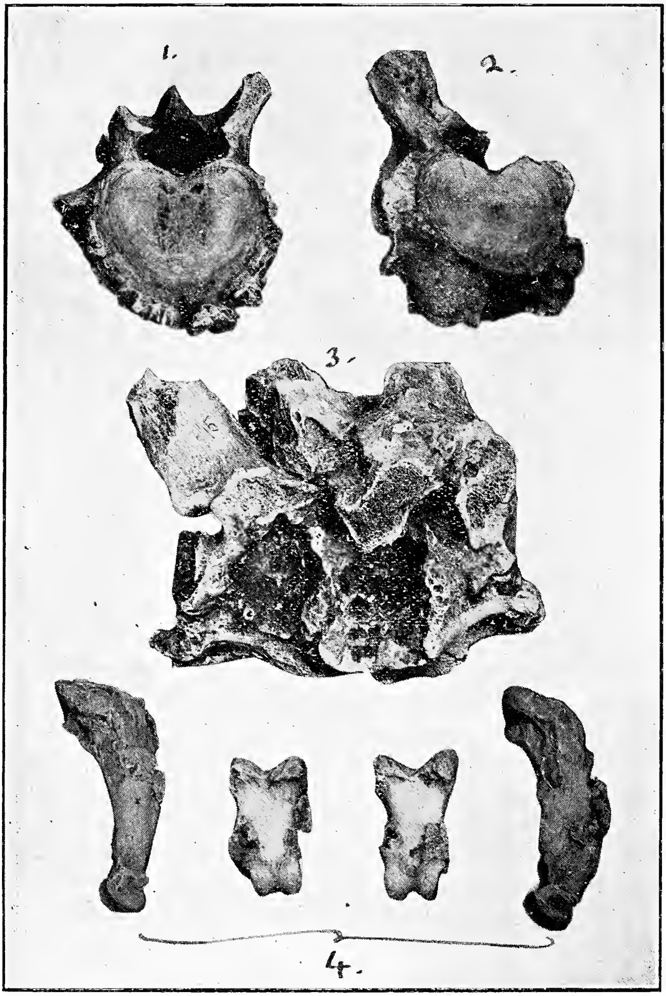
MAMMALIA.	
UNGULATA.	
Horse	*Equus caballus* Linn.
CARNIVORA.	
Bear	*Ursus arctos* Linn.
Wolf	*Canis lupus* Linn.
Fox	*C. vulpes* Linn.
Arctic Fox ?	*C. lagopus ?* Linn.
RODENTIA.	
Field Vole ?	*Microtus agrestis ?* Linn.
	M. ratticeps Keyserling and Blasius.
Alpine Vole	*M. nivalis* Martins.
	M. gregalis Pallas.
	M. Malei M. Hinton.
Rabbit	*Lepus cuniculus* Linn.
AVES.	
Eagle	*Haliaetus albicilla* Linn.
Buzzard	*Buteo ? vulgaris* Leach.
Wheatear	*Saxicola œnanthe* Linn.
Skylark	*Alauda arvensis* Linn.
Robin	*Erithacus rubecula* Linn.
Redwing	*Turdus iliacus* Linn.
Thrush	*Turdus musicus* Linn.
Blackbird	*Turdus merula* Linn.
Raven	*Corvus corax* Linn.
Greenfinch	*Ligurinus chloris* Linn.
Swift	*Cypselus apus* Linn.
Ringed Plover	*Aegialitis hiaticula* Linn.
Golden Plover	*Charadrius pluvialis* Linn.
Turnstone	*Strepsilas interpres* Linn.
Dunlin ? or Sandpiper ?	*Tringa ?* or *Totanus ?*
Godwit ? or Greenshank ?	*Limosa ?* or *Totanus ?*
Whimbrel ?	*Numenius phaeopus ?* Linn.
Heron	*Ardea cinerea* Linn.
Common Gull	*Larus canus* Linn.
Cormorant	*Phalacrocorax carbo* Linn.
Wild Duck	*Anas boschas* Linn.
Wigeon ?	*Mareca penelope ?* Linn.
Pintail ?	*Dafila acuta ?* Linn.
Goose	*Bernicla leucopsis* Bechstein.
PISCES.	
Four vertebræ	

Some account of the specimens follows—

UNGULATA.

Horse *Equus caballus.*

The bones of horses are the most abundant met with, being slightly more numerous than those of bears. Perfectly preserved



Bones of Bears affected by osteo-arthritis, from Walton, near Clevedon.

1 and 2. Lumbar vertebræ. 3. Thoracic vertebræ.
4. Phalangeal bones.

(Nos. 1 and 2 are in the Bristol Museum collection, the remainder in the Male collection).

specimens of the tibia, humerus, and radius were obtained, together with numerous teeth, vertebræ, and bones of the manus and pes. An associated series of cervical vertebræ, and two associated sets of bones of one of the extremities were found. The dimensions of the bones indicates considerably smaller individuals than in most of the modern breeds of horses. The teeth were in all stages of wear, from examples which had not cut the gums to examples worn down to the roots. The best preserved femur has a maximum length of 25·5 centimetres, and the best preserved tibia of 30 centimetres.

CARNIVORA.

Bear *Ursus arctos.*

About 150 bones of bears were collected and identified for the Bristol Museum. These included three nearly perfect left femora, four perfect tibiæ, several broken but large humeri, one belonging to Dr. Male having a maximum diameter across the distal end of as much as 15·45 centimetres; the corresponding measurement of the largest humerus in the Taunton Museum is 16·8 centimetres. The maximum length of the best preserved femur in the Bristol Museum collection is 44 centimetres, as compared with 52·5 centimetres in the case of the largest at Taunton; the largest tibia from the Bristol series measures 34·8 centimetres, as compared with 36·5 centimetres, the length of the largest of the Taunton specimens. The large Taunton specimens referred to above were found in the Banwell cave. Many detached teeth were found in various stages of wear, and several more or less well preserved mandibular rami. One of these, belonging to Mr. G. E. Male, is of a very aged individual which had not merely lost $\overline{\text{p.m. 4}}$ and $\overline{\text{m. 1}}$, but had the alveoli of these comparatively large teeth completely closed up; on the other hand it is noteworthy that the alveolus for the small tooth $\overline{\text{p.m. 1}}$ is present, and there are traces also of that for $\overline{\text{p.m. 2}}$. In aged individuals both these teeth are often lost, and their alveoli are closed up. A jaw belonging to the Bristol Museum retains the alveolus for $\overline{\text{p.m. 1}}$, but shows no trace of the alveoli for $\overline{\text{p.m. 2}}$ and $\overline{3}$. No examples were met with showing unworn crowns of $\overline{\text{p.m. 1}}$ and $\overline{\text{m. 1}}$—the most useful teeth for deciding whether a particular specimen should be attributed to *Ursus spelæus* or *Ursus arctos*, but the retention of $\overline{\text{p.m. 1}}$ points to the probability of the specimens belonging to the latter species.

By far the most noteworthy feature of the Bear's bones is their remarkably diseased character. Dr. Male sent some bones to Mr. S. G. Shattock, of the Royal College of Surgeons, who replied "I should regard the disease shown by the pieces of the spinal column of the Bears as a very pronounced form of osteo-arthritis affecting the costal articulations and heads of the ribs. The amount of destruction is unusual, but in animals this is at times a marked feature as shown by the bones in the College collection." This peculiarity is shown not merely by the vertebræ, but by most of the phalangeal bones, and occasionally by the limb-bones, as in the

A 2

case of a very large humerus belonging to Dr. Male. Specimens in the Bristol Museum show these features equally well with Dr. Male's specimens (see plate).

Wolf *Canis lupus.*

By far the commonest of the larger bones next to those of the horse and bear were those of the wolf. Several skulls were met with, but in too crumbling a state to be extracted whole. Several nearly perfect mandibular rami were found showing remarkable variation in size. The largest in the Bristol Museum collection measures 16 centimetres from the posterior edge of the condyle to the posterior edge of the alveolus for the canine, while one belonging to Dr. Male, which was clearly that of an adult individual, from the fact that $\overline{\text{m. 2}}$ was fully developed, measures only 12·15 centimetres from the posterior edge of the condyle to the posterior edge of the canine. The Bristol Museum collection includes many limb-bones and vertebræ, and among them three perfect examples of the axis.

Fox *Canis vulpes.*

Bones of the fox were not very common, but are represented in Dr. Male's and the Bristol Museum collections.

? Arctic Fox *Canis lagopus.*

Mr. E. T. Newton thinks that some vertebræ from Clevedon, in the collection of Dr. Male, may be attributable to the Arctic Fox on account of their small size. They are the 10th, 11th, 12th, and 13th dorsal, and the last lumbar. He is also of opinion that half a metatarsal bone and a portion of a small lower jaw in the Bristol Museum collection may belong to the same species.

Rodentia.

While the bones of the larger mammals were found only in the cave-earth, the remains of rodents, while occurring in the cave earth, were more abundant in certain of the superficial deposits, their presence in both pointing to the conclusion that both deposits are of the same general age.

Rabbit *Lepus cuniculus.*

This species is represented by humeri in Dr. Male's collection, but its remains are very rare, and in view of its burrowing habits much caution must be exercised in admitting it as a member of the fauna. Its absence would be quite in accord with the evidence pointing to the considerable antiquity of the Clevedon cave, and as pointed out by Sandford,[1] the rabbit is one of the rarest members of the early cave fauna.

A very large number (some hundreds) of jaws, teeth, and limb-bones of Voles have been found in the Clevedon deposits, and are now in the collections of Dr. Male, the Jermyn Street Museum, the British Museum, and the Bristol Museum. The greater part of these,

[1] Q. Journ. Geol. Soc., vol. xxvi. (1870), p. 128.

Mr. Newton refers to *Microtus ratticeps* and *Microtus gregalis.* The latter species, however, varies much, and some of the forms approximate to *Microtus nivalis ;* while one or two, he thinks, may represent the last-named species. Mr. Martin Hinton, in a paper recently read before the Geologists' Association, definitely refers some of these forms to *Microtus nivalis* (see p. 190). There is one jaw which, Mr. Newton thinks, may be doubtfully referred to *Microtus agrestis :* but it is just possible that this is a modern importation.

A goodly number of the limb-bones in Dr. Male's collection and others in the Bristol Museum are, it seems, too large to be referred to either of the species of Voles which have been recognised among the Clevedon remains ; Mr. Newton, however, finds that they agree with the limb-bones of the Norway Lemming *(Myodes lemmus),* but as no corresponding jaws or teeth have been found, he hesitates to include that species in the Clevedon list. Mr. Martin Hinton thinks these limb-bones may belong to the new nivaloid Vole which he has recently described as *Microtus Malei.*

AVES.

Although a considerable number of species of birds have been identified by Mr. Newton, as shown in the list on p. 184, each species is represented by only a small number of detached bones. The bones of birds were all found in the cave-earth, not in the superficial deposits.

With the exception above noted of the finding of an associated series of the limb bones of a horse, all the bones occurred in a scattered and jumbled state, and clearly must have been washed into their position by water. There is, however, no fissure in the rock through which they could have been introduced, and this fact, together with that of the occurrence, banked up round its present mouth, of bone-bearing material identical with that occupying the cave, shows that the present cave is but a reduced remnant of a former larger one.

It is a noteworthy fact that the remains of Hyænas which occurred so abundantly in the Mendip caves at Wookey and Uphill are entirely absent at Walton, and the fauna as a whole shows a poverty as compared with that of the Mendip caves.

The only indications of the presence of man found are certain fragmentary bones collected by Mr. F. Beale, of Clevedon, from the superficial deposit at the mouth of the cave; these were sent to Prof. Boyd Dawkins, to obtain his opinion as to whether they showed marks of cutting or splitting by human agency. His reply was that he could see no marks of cutting on any of them, but he identified a portion of a human femur "of the usual Neolithic type," and other fragments. The small number and fragmentary state of these bones, and the existence of some uncertainty as to their association, render it unsafe to base any strong conclusions upon them. The probable presence of the Arctic Fox, and possibly of the Lemming, and as pointed out by Mr. Hinton, the character of the voles, all point to the cave being of very considerable antiquity, according to Mr. Hinton (see p. 191) it dates from the Middle Pleistocene.

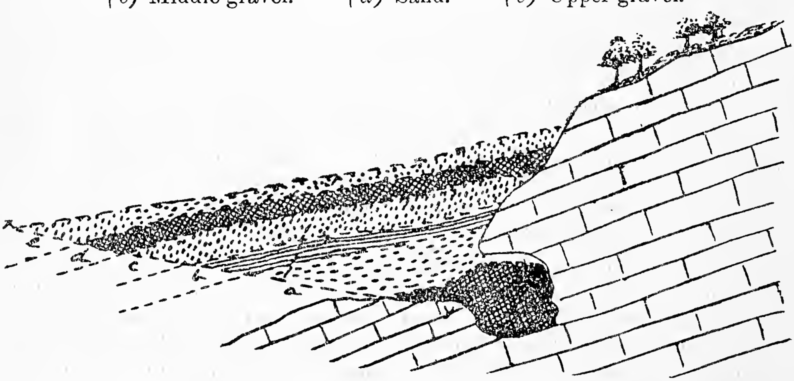
Supplementary Notes on the Clevedon Bone Cave and Gravels.

By H. N. Davies, F.G.S.

THE beds of gravel which mask the face of the low cliff on the south side of Walton Hill, Clevedon, also concealed the small cave at their base until December, 1905, when quarrymen in the employ of Mr. Coles, a contractor, exposed the mouth of the hole. Bones had been continually found in the lowest bed of gravel in the neighbourhood of the cave. I only saw fragmentary specimens, as the better and more perfect ones had been dispersed before I arrived on the spot on Wednesday, January 3rd, 1906. I found the cave filled with cave earth almost to the roof. In the upper portion of this deposit there were many small subangular stones and much coarse grit, as if the gravel which had lain against the cliff had also penetrated the cave. In a section of the gravel beds on the left hand side of the short roadway leading down to the cave Mr. Coles directed my attention to some very small bones and teeth, which were to be found in large numbers at a certain level in the basement gravel. I traced this interesting band quite round the outside quarried face of the gravel; and in a spot about twenty yards from the cave I found also an accumulation of small land-snail shells. Neither bones nor shells were found in the *finer* portion of the gravel bed but amongst *course deposit* of partially water-worn limestone debris.

Taking the deposits from the bottom beds upwards we have :—

(a) Lower gravel very coarse about the middle of the bed. *(b)* Clay. *(c)* Middle gravel. *(d)* Sand. *(e)* Upper gravel.



Diagrammatic section of the Walton bone cave and associated deposits.

The Carboniferous Limestone Beds dip to the south-east at an angle of about 40°. The gravels, clay and sand, dip at an angle of 35° near the cliff, but at the distance of a few yards the dip becomes less, the gravels thin out, and the sand and clay are continued under the surface soil of the valley. The portion outside the dotted line in the diagram has been quarried away near the cave, and the line *x y* shows the inclined cartway from the road to the cave.

In the lower gravel *(a)* about 3 feet above the cartway the rodent remains occurred. I collected two perfect skulls, and a large number of lower jaws, teeth, and long bones; and these, with specimens of bird bones and the small snail shell, I forwarded to Dr. A. Smith Woodward, of the Natural History Museum, South Kensington, for identification. Other specimens were also sent to Mr. Allen, of the Jermyn Street Museum. Dr. Forsyth Major for Dr. A. Smith Woodward, and Mr. E. T. Newton for Mr. Allen, kindly examined the specimens, and the reports of both experts substantially agree.

1.—A large number of the jaws belong to
Microtus gregalis (recorded by Alston and Blackmore as *Arvicola nivalis).* Most of the limb-bones also belonged to this small rodent.

2.—A small number of jaws belong to
Microtus ratticeps.

3.—The bird bones are those of a wader, but were not identified. Some have been returned to Mr. E. T. Newton for further examination.

4.—Mr. B. B. Woodward identifies the shells as belonging to *Hygromia rufescens.*

I also obtained, through the kindness of Mr. Coles, portions of the lower jaws of *Ursus arctos* and *Canis lupus* from the cave earth which had been cleared out during my enforced absence in London.

Note on the occurrence of the Alpine Vole (*Microtus nivalis*) in the Clevedon Cave Deposit.

By Martin A. C. Hinton.

THE occurrence of remains referable to the group of Alpine Voles (of which *Microtus nivalis* is to be regarded as the type) in the Clevedon cave deposit is of great interest. The group is known to have had a much more extensive range in late Pliocene and early Pleistocene times than it at present possesses. At the present day it is found inhabiting the mountain peaks of Southern Europe and Asia from heights of 3000 or 4000 feet to levels far above the snow line. Its frequency increases as we ascend, and in the Alps we find it living most abundantly in such situations as are covered for nine or ten months in the year with snow. It must be borne in mind, too, that these little mammals actually live under the snow covering throughout this long period.

In 1902 Dr. C. I. Forsyth Major first detected a vole of this group among the voles from the Upper Freshwater Bed of West Runton, a deposit of late Pliocene Age. The voles with which this ancient member of the group is associated are all southern forms. The only section of the High Terrace Drift of the Thames Valley which has yielded a tolerably representative fauna has also afforded us with remains of some of these southern rodents, although, unfortunately, the *nivalis* group was not obtained. In the still later Middle Terrace Drift of the Thames, to which the well known Grays and Crayford Brickearths belong, numerous forms of the *nivalis* group have now been found. At Clevedon, too, we have several forms of *nivalis* comparable with the existing recent races or species known as *M. leucurus* and *M. petrophilus*, and besides these a very large and distinct nivaloid vole to which I have given the name of *M. malei*. A full account of these discoveries will be found in my paper, lately published in the Proceedings of the Geologists' Association, vol. xx., p. 39.

It might reasonably be argued from the remarkable habitat of this group of voles that at the time it so abundantly peopled the South of England the climate was an extremely severe one. But notwithstanding the fact that this view seems to be supported by the occurrence in Britain at about the same time of other Alpine and Arctic species, I think this conclusion is really a false one. We must consider not merely this Alpine and Arctic element, but the whole of the fauna and flora preserved in the deposits mentioned above. In the two older deposits, that of West Runton and the High Terrace Drift, the mammals are practically all southern forms, while in the Middle Terrace Drift the occurrence of the Hippopotamus and Ape (an animal most intolerant of cold), to mention only two species, teach us that the climate must have been a genial one. Therefore *M. nivalis* was originally an animal with a temperate habitat, and the real question to be solved is as to why it should now chose to live in the vicinity of perpetual snow.

This problem is of course intimately connected with that concerning the origin of Alpine and Arctic faunas. During the time represented by the Middle Terrace, England was invaded by many species of Rodentia which could only have come from Siberia and Eastern Europe. As these immigrants arrived *M. nivalis* gradually disappeared from Britain and retreated from the plains of Central and Southern Europe towards the mountains. Thus in slightly newer deposits such as the Ightham Fissure where the new Siberian forms occur very abundantly the *M. nivalis* group and the other old southern forms have completely vanished. On the lower mountain slopes the old forms, such as *M. nivalis*, were able to hold their own against the new comers, but the early frosts of such regions would be detrimental to such a species. It would learn from experience that security from the frost could only be had from an early covering of snow, and so it would quickly colonize the summits. This view is confirmed by many well known observations upon the Arctic and Alpine flora, and these questions are fully discussed in my recent paper. A great deal of valuable evidence on these points will be found in Dr. Scharff's "History of the European Fauna," with whose conclusions I very largely agree. I have argued that it is not necessary to invoke large changes in climate in order to account for the differences in the distribution of animals and plants which have been brought about since Pleistocene times, and my work among the drifts of the South-east of England as a geologist entirely confirms this view which I have based primarily upon palæontological and distributional researches.

The occurrence of the *M. nivalis* group at Clevedon shows that deposit to be not later than the deposits of the Middle Pleistocene period, and it supplies us with the western limit of the Pleistocene range of the group.

The Effect of Electricity upon Plants.

By J. H. Priestley, B.Sc.

DURING the last two years several attempts have been made in this locality to apply electricity as a stimulus to plant growth; in some cases these experiments have been upon an unusually large scale, and, as the subject is clearly one of great importance, it has been thought advisable to place the results upon record, and at the same time to give an account of further experimental work recently carried out in the Botanical Garden and Laboratories at the College. It is also intended to discuss some suggested explanations of the physiological action of the current.

The experiments upon a large scale which are to be described have all been the work of Mr. J. E. Newman, who has carried them out at Bitton, near Bristol, and at Gloucester, in 1905, and at Bevington Hall, near Evesham, during 1906.

I am much indebted to Mr. Newman for keeping me so closely in touch with his work, and for allowing me to embody his results in this paper.

Historical. The earliest work upon this subject with which I am acquainted is that of the Scotch physician, Mambray, in Edinburgh, and apparently about the same time Jallabert, in Geneva, carried out experiments upon the subject.

The success that they met with apparently caused the Abbé Nollet[1] to take up the subject in 1749. His experiments consisted in suspending iron plates upon steel chains hanging from a dry silk cord. Upon these insulated metal plates he kept animals and plants, the whole series of trays being charged from a somewhat cumbrous influence machine requiring the continuous efforts of three men to drive; he found that maize and mustard thus electrified germinated in every case more rapidly than control plants.

The Abbé Bertholon[2] (1783) greatly enhanced the practical interest of the subject by suggesting that atmospheric electricity was an important factor in the environment of the plant. He applied his idea practically by constructing various types of an apparatus he called the electro-vegetometre.

This consisted of a head of metallic points raised in the air in the manner of a lightning conductor and connected by a flexible conductor to a moveable iron bar terminating in a series of discharge points just over the plants to be electrified.

Atmospheric electricity is then collected by the upper end of the structure and discharged on to the plants from the lower end, the whole of the conducting structure being insulated by suitable wood

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[1] Abbé Nollet. Researches sur les causes particulieres des phenomenes electriques. Freres Guerin, Paris.

[2] Abbé Bertholon. De l'Electricite des vegetaux.—Didot Jeune, Paris.

supports. Bertholon states that the use of this apparatus was invariably accompanied with an improvement in the appearance of the vegetation and with an increase in the fertility of the plants, etc.

Grandeau[1] (1879) attempted to demonstrate the importance of atmospheric electricity by showing that when the plant was protected by means of a wire cage its development was greatly retarded.

In Grandeau's work, and in that of his pupil, Leclerc, the comparisons between the protected and control plants were not merely qualitative, but measurements of size, of gain in weight, and quantitative analysis of the plants were made. In this way they satisfied themselves that leaf and stem development was considerably retarded by the protection with a metallic network.

On the other hand Ch. Naudin, about the same time, published experiments carried out in the same manner, in which the plants left exposed to the open air had not grown so well as the ones protected beneath a wire cage.

The application of atmospheric electricity to stimulate plant growth has been a fairly common practice in France since Bertholon's time, some modification of what is termed the Geomagnetifère system being adopted.

A lightning conductor is raised in an exposed position to collect atmospheric electricity, and this is connected with wires running through the earth under the plants it is desired to stimulate. With this method good results are claimed, though Lord Kelvin's suggestion is perhaps worthy of note, viz., that possibly the value of the treatment lies in the upturning of the earth necessary to plant the wire.

M. Pinot de Moira has used the system for several years in his garden in Clifton, always with favourable results ; he has also shown me rows of peas planted beneath a wire cage which were far less advanced than the control rows outside the cage.

Recently a great deal of work has been carried on in France, at the station for Agricultural Chemistry established at Meudon, by Professor Berthelot,[2] who has tried the effect of the silent discharge, and particularly of atmospheric electricity upon plants.

He compared the growth of plants at the top of a 28 metre tower with that of plants growing at the foot, and considered that greater growth at the higher level was largely due to the potential gradient in the atmosphere. His explanation of the action of the current is mentioned later.

Electricity has been applied in a different way by Barrat in France, and Speschnew in Russia. In their experiments metal plates were sunk in the ground with a current passing through the soil between them, and apparently this stimulated the plants in this part of the soil to more vigorous growth than the plants on either side in the control plots.

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[1] Grandeau. Chimie et Physiologie appliquées a l'Agriculture et la Sylviculture.—Berger, Levrault, et Cie, Paris.

[2] Berthelot. Chimie Vegetale et Agricole. T.I.

Speschnew [1] obtained his current simply by using plates of different metal connected by a wire, the small earth current thus obtained apparently proving amply sufficient to produce a marked result.

Rawson and Le Baron [2] have used the same method at Arlington, Mass., quite recently. The plates of copper and zinc joined by a wire are sunk at either ends of forcing beds in the greenhouses, and are said to be very efficacious in bringing on lettuce at an early time, in fact they state that the lettuce thus electrified was ready for the market a week earlier than that in the control beds.

The potential difference between the plates was about 0·5 volts, and the current flowing varied from 0·4 to 15 milliamperes approximately. The results obtained with this method at College will be described later.

In many cases electricity has been artificially generated and then used to increase the plant's growth, either by a system of discharge on to the plants from above or by being passed through the soil in which the plants are growing.

Professor S. Lemstrom [3] used the method of overhead discharge in a great number of experiments which he has conducted and which were often upon a very large scale He usually employed an influence machine of special construction driven by some continuous source of power; one pole of this machine was earthed, while the other was connected to a system of wires stretching over the plants and studded with fine discharge points.

His results show a definite increase in yield in the case of many crops, whether the overhead wires were kept positively or negatively charged.

The current was applied sometimes at night, sometimes in the daytime with apparently equally satisfactory results.

Lemstrom points out that precautions have to be taken in using his method of electrification, as in dry weather the electric discharge may easily be given for too long a time, when its effects are deleterious, also the treatment should vary according to the plants experimented upon, strawberries, for example, usually showing a very marked increase, whereas beans with the same treatment may often show considerable retardation in development.

At the Clifton Laboratory Dr. E. H. Cook[4] has carried out experiments the results of which seem to point to an increased power of germination, either with the use of low tension currents (up to 20 volts and current passing up to 100 milliamperes) or with high tension discharge from a Wimshurst machine.

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[1] Referred to by R. Green, Phil. Trans. of the Royal Society.—Vol. 188, B. p. 188.

[2] The Electrician. —Vol. 57, p. 305. 1906.

[3] Lemstrom. Electricity in Agriculture and Horticulture.—The "Electrician" Series.

[4] E. H. Cook, D.Sc., F.I.C. British Association, Bristol Meeting.

Apart from the increase in rapidity of germination, Dr. Cook was unable to satisfy himself that the passage of the low tension current through the soil made any difference to the plant.

Using the overhead discharge from the Wimshurst (E.M.F. from 25,000 to 40,000 volts) or from an induction coil (E.M.F. approximately 45,000 volts) he obtained a continued increase in the rate of growth of the plant.

Asa S. Kinney,[1] in 1898, and Ahlfvengren,[2] a year later, both found that the germinating power of seeds is apparently increased by an electric current passing through them. Kinney concluded that the optimum voltage for this current was about 3 volts. Ahlfvengren suggested that this optimum varied for different plants, and, also, with changing conditions, varied for the same plant.

Results such as these would explain the different action of the current upon two different species, for one of them the voltage supplied may be optimum, whilst for the other it may approach the maximum, when it might exert a deleterious influence on the plant.

Lowenherz[3] seems to have come to similar conclusions; he also finds that the effect of the current on the plant is greatest during the period of germination. He is of opinion that the direction in which the current traverses the seed is of importance.

Other work upon the subject will be referred to when discussing the theoretical considerations involved in the practical application of electricity.

PRACTICAL APPLICATION OF ELECTRICITY.

Experimental.

BITTON.

Mr. J. E. Newman was able during the winter of 1904 to instal a small trial apparatus with the overhead discharge system at the Golden Valley Nurseries at Bitton, near Bristol. The installation was completed by the Spring, and, apart from occasional breakdowns, was running until the Autumn.

The breakdown were accounted for by the fact that the machine used to generate the necessary electric power was simply a small influence machine of the Wimshurst type, hardly suited to continuous running, and that the oil engine first employed to drive it was scarcely powerful enough.

The machine was working beneath a dust free case in a small shed upon the grounds, and its two terminals were connected,—one to the earth the other to a system of wires running out over the grounds and through seven out of the fifteen glasshouses. In the open the total area of experimental and control plots was about a thousand square yards. The wires ran at a height of some sixteen inches above the tops

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[1] Hatch Experimental Station. Massachusett's Agricultural College, 1897.

[2] Ahlfvengren. Ofversigt af Kongl Vetenskaps-Akademien Forhandlingar, Stockholm, 1898, No. 8 (Ref. Bot. Centralblatt. Bd. 79, p. 53. 1899).

[3] Lowenherz. Versuche uber Electrocultur. Botanisches Centralblatt, p. 523.

of the plants, or above the rows of tomatoes in the glasshouses, and upon these wires at intervals were twisted short pieces of fine wire with the free ends pointing downwards, and thus acting as discharge points.

The wires were supported on ordinary telegraph wire insulators, which proved satisfactory except in wet weather, when there was such a rapid leakage of the charge that there was practically no discharge on to the plants.

From March 7th up to July 26th the machine was running during 108 days for a period of 9·3 hours daily. Until May 20th the machine was running chiefly in the day time, and after that date it was running principally at night.

In all cases control plots were provided, which, apart from the electric treatment were, as far as practicable, under identical conditions. The crops from the electrified and control plots were gathered and estimated separately, usually by weighing.

The results of electrification in the case of the various crops grown is given in the following table :—

Cucumbers, 17 per cent. increase.

Strawberries (5 year plants), 36 per cent. increase.

,, (1 year plants), 80 per cent. increase, and more runners produced.

Broadbeans, 15 per cent. decrease, but ready for picking 5 days earlier.

Cabbages (Spring), Ready for picking 10 days earlier.

[1] Celery, 2 per cent. increase.

Tomatoes, No difference.

One point requires special mention in the case of the cucumbers grown in the houses. On May 8th a spot disease, of bacterial nature, appeared in all the cucumber houses, and unquestionably made far more headway in the unelectrified houses.

It seems probable that the ravages of the disease were largely inhibited by the electric discharge, for during one week when the influence machine broke down the disease progressed far more rapidly under the wires, and was again checked upon restarting the machine.[2]

The action of the electric discharge may be due to one of two causes, either the resisting properties of the host have been increased, or the attacking power of the parasite diminished.

Recent work by Massee,[3] by Ray,[4] and by Miyoshi[5] supports the view that the greater immunity of the treated cucumbers might be due

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[1] The small increase in the case of the Celery may be connected with the fact that in this case the wires used as discharge points were not so fine. As a consequence the amount of current flowing from the air to the ground was probably considerably less. In all the other cases fine wire was used for the discharge points.

[2] See also "Fruitgrower, Fruiterer and Florist," p. 106. August 17th, 1905.

[3] Massee. On the Origin of Parasitism in Fungi. Philosophical Transactions of the Royal Society. 197 B.

[4] Ray. Etude Biologique sur le Parasitisme. Comptes Rendus. Vol. 136, p. 566. 1903.

[5] Miyoshi. Ueber Chemotropismus der Pilzie. Botanisches Zeitung, p. 1. 1894.

to chemical changes occuring upon electrification. Their investigations seem to show that the immunity of a plant to disease depends mainly upon the nature of the chemical substances in the cell sap in the tissues exposed to infection. This view of immunity is also supported by recent work upon the biologic forms of parasitic fungi found in the Uredineæ[1] and Erysiphaceæ.[2]

In the bleaching of flour by means of the brush discharge, a toxic action of the discharge upon the micro-organisms present has been noted, but if this were operative in the case of the cucumbers one would have expected the disease to have appeared later, or not at all, in the electrified houses, whereas it appeared simultaneously in all the cucumber houses. I find it difficult to believe that when once present the bacteria within the leaf suffer more from the direct action of the current than the leaf itself.

During the whole period of the Bitton experiments Mr. Newman states that, apart from the difficulties with the influence machine and oil engine, the electrical installation gave very little trouble, and only required attention in keeping the wires clear of cobwebs, stray shoots, &c.

GLOUCESTER. A somewhat similar installation was working during the same year over a vegetable garden in Gloucester. Here a somewhat higher voltage was given by the influence machine, and the discharging points were kept five feet above the ground instead of sixteen inches above the tops of the plants as at Bitton. With the crops under electrification,—

Beet showed 33 per cent. increase;
Carrots showed 50 per cent. increase; and
Turnips showed an increase—not determined quantitatively, because of the destructive ravages of slugs on both crops.

The amount of sugar in the beets was determined at the College.

The unelectrified yielded 7·7 per cent. total sugar.
The electrified ,, 8·8 per cent. ,, ,,

Considering the total increase in the root crop this suggests that this method of electrification may find a valuable field of application in the cultivation of the sugar beet.[3]

The results of some small trials with wheat that were made at Gloucester were very favourable, and arrangements were made by Mr. Newman to try the effect of the overhead discharge system upon wheat and barley on a larger scale.

EVESHAM. Thanks to the interest taken in the work by Mr. R. Bomford, of Bevington Hall, near Evesham, Mr. Newman was enabled to use some forty acres of this estate for experimental work in 1906, and experiments commenced on this ground in the Spring of that year, and are still being continued.

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[1] Marshall Ward. Effect of Mineral Starvation on Parasitism of a Uredine Fungus. Procs. Royal Society. Vol. 71. 1902.

[2] Salmon. Cultural Experiments with Biologic Forms of the Erysiphaceæ. Phil. Trans. of Royal Society. 197 B.

[3] Lemstrom. Loc. cit., p. 47 and p. 55.

Some twenty acres of this ground were beneath the discharge field, and as it was necessary for practical purposes to have the discharge wires at a considerable height, the very high tension current required was obtained by means of an induction coil and valve rectifiers upon the system devised and patented by Sir Oliver Lodge, who very kindly lent the necessary apparatus.

It was very largely owing to the generosity of Sir Oliver Lodge, and the advice and help of Mr Lionel Lodge, that Mr. Newman was able to successfully complete the necessary installation and to carry out the experiments.

As it was, owing to the late delivery of some of the apparatus, the work had to be carried on with a somewhat improvised generating station at the commencement on March 16th; by the end of May, however, the installation was completed, and worked fairly continuously during the rest of the season, the current being applied intermittently until July 10th, by which date the wheat had been in ear about a fortnight.

The complete arrangements for generation of the high tension currents, are as follows :—

Direct current, about 3 amperes at 220 volts is generated by a dynamo, driven by an oil engine of about 2 h.-p. The current passes from the dynamo through the primary of a large induction coil with a make and a break contact interposed in the circuit. From the secondary of the coil the high tension current was passed through the rectifiers, and then the one pole connected to the system of overhead wires, the other pole being earthed.

The overhead system of wires covered about 19½ acres of ground. The wires were mounted on insulators placed upon larch poles some 15 feet high, which were placed in rows, the rows being separated by a distance of 102 yards, and the poles in a row being 71 yards apart. Stout telegraph wire carried the current down each row; while thin galvanized iron wires, placed some 12 yards apart, were stretched between the rows and acted as the discharge wires. In this way 22 poles were sufficient to support the wire over the 19 acres.

This acreage was spread over two different fields; in one field of which some 12 acres of wheat were under treatment, in the other 6½ acres of barley and a ½-acre plot planted with potatoes, mangolds, &c.

The wheat field was of 19 acres extent, the remaining 7 acres were sown with English (White Queen) wheat, 1½ acres, and Canadian (Red Fife) on 5½. In the electrified part Canadian wheat occupied 3 acres, English wheat 9 acres.

The results on the barley field, including the small plot, had to be neglected owing to the great local variations produced by the very irregular manuring the field had previously undergone; the wheat field, however, as far as one could judge, had been very uniformly treated previously.

In the wheat, difference was noticeable at an early stage,—the young blades on the electrified part being, in the opinion of many observers of a darker green.

The crop was judged as considerably heavier by several practised observers, and the straw was on an average from 4 in. to 8 in. higher. Both experimental and control plots came into ear at about the same time, but the Canadian wheat under treatment was ready for cutting some three or four days before the control area.

The crops were gathered separately from the electrified and unelectrified plots, and the resultant yields were as under :—

BUSHELS PER ACRE.

	Electrified.	Non-Electrified.	Increase.
Canadian (Red Fife) ...	35½ ...	25½ ...	39 per cent.
English (White Queen)...	40 ...	31 ...	29 per cent.

Moreover the electrified wheat sold at prices some 7½ per cent. higher, several millers in baking tests finding that it produced a better baking flour.[1]

No theoretical conclusions can be drawn from this fact, owing to the uncertainty existing as to what factors determine the strength of wheat, but it is interesting to note that greater strength is usually accompanied by increase in percentage of total nitrogen.

Mr. J. Kirkland of the National School of Bakery, Borough Polytechnic, found the evidence from baking tests supported by the average of dry glutens from all his tests thus :—

In the electrified	11·15 per cent.
In the unelectrified	10·35 per cent.

The somewhat poor yield of wheat obtained from the unelectrified portion of the field is probably explained by a deficiency in lime, which has now been rectified. Further, the wheat was spring sown, and Red Fife, under this condition, does not usually yield good crops. The experiments are being repeated upon wheat during the present season, and strawberries are also under treatment once more.

EARTH CURRENTS. At College further trial has been made of the method of Barrat and Speschnew, in which plates of different metals are sunk in the ground and connected by a wire.

Plates of copper and zinc were used with a copper wire soldered to them.

The first trial was made with Vicia Faba, the beans being planted on February 21st, 1906 ; the control plants were grown between copper and zinc plates not connected with a wire.

The plants where the earth current was passing appeared two days earlier ; in June they still showed markedly greater vegetative development, and though the total yield in the two plots could not well be compared, the average size and weight of beans differed in favour of the electrified plot, thus :—

	Electrified.	Unelectrified.
Average volume of bean ...	2 c.c. ...	1·5 c.c.
Average weight	2·26 grs. ...	1·71 grs.

[1] Tests made by Watkin's Bros., Hereford: and by D. W. Goodwin & Co., Kidderminster.

Another series of experiments with beans was started upon May 25th, but in this case no difference in rate of germination was noted, while later the whole crop was so badly attacked by Aphis that further comparisons could not be made.

The following table shows the results obtained with other plants by this method :—

Wheat, no difference.		
Barley,	Electrical,	matured earlier.
Maize,	,,	the weaker plants.
Cabbage,	,,	markedly better plants.
Radish,	,,	ready for pulling earlier.
Carrot,	,,	larger, and with much more leaf development.
Lettuce,	,,	better developed plants.

The results are then inconclusive, though in most cases the plants where the current is passing have fared better. As an example of the strength of the currents used, with plates of area about 200 square inches, 4 feet apart, a current of 12 milli-ampères was passing, the soil being very damp.

PHYSIOLOGICAL ACTION OF CURRENT.

The chief aim in this paper has been to give an account of these large scale experiments with different methods, but it may be as well to give an account of some of the theories advanced to explain the physiological action of the current, and to describe the results of some further experimental work, though the results of the latter are negative in character.

It is obvious that the practical application of any method of electrification can only be empirical until the physiological effect of the current upon the plant is understood.

One suggestion, frequently made, is that the passage of water up the plant is aided by the electric current. Lemstrom advances this suggestion, and referred to experiments in which he had found that if a negatively charged wire is placed over a capillary tube which dips into water, the water climbs up the sides of the tube and collects in drops at a higher level.

But if a positively charged pole is placed above the tube this did not happen, and with a positively charged overhead wire system he obtained the best results.

J. Chundar Bose [1] explains the rise of sap on the assumption of a pumping action of the living cells throughout the course of the xylem ; the pumping action being a form of response to stimulus.

If this theory is correct the current might be conceived as a stimulus giving rise to increased response, and therefore accelerating the flow of sap.

[1] J. C. Bose. Plant Response. Longmans, Green, & Co. 1906.

The excitatory effects of kathode and anode are antagonistic, but with a current flowing through the soil, there would always be a resultant excitation of the root, because the kathode effect is always greater than the effect due to the anode.[1]

But in the case of overhead discharge with the wires overhead negative, the leaves and stem would on this view be more stimulated than the root, and the result should be a tendency to pump water downwards. On the whole then it is difficult to make out a case for the rise of sap being aided by electric stimulation, and there is no experimental demonstration of its occurrence in the plant. Bose would more probably attribute the effect of overhead discharge to direct stimulus of the growth responses in the plant.

The acceleration of germination noted by so many observers, obviously involves some different factor, the only possible explanation seems to be that the current is used by the seed as a source of energy;[2] this energy being directly used in anabolic process or in accelerating the katabolic processes of respiration.

Pollacci[3] in a recent paper has suggested that the effect of a current passing through a green leaf may be to render carbohydrate synthesis possible from carbon dioxide and water, even when the plant is in the dark.

Bach[4] has suggested that the electrolysis of carbonic acid might result in the formation of formaldehyde in the neighbourhood of the kathode, but he advanced no experimental results in support of this view.

Euler,[5] as the result of practical investigation, found it impossible to obtain formaldehyde in this way.

Waller[6] has detected the presence of small electromotive forces in a green leaf exposed to the light, but they are only found in a living tissue, and chloroplasts are necessary for their occurrence, no current being detected in a living petal exposed to the light.

The experimental evidence that Pollacci brings forward is based chiefly upon the presence of starch in leaves kept in the dark with a current passing through them. Control leaves, also kept in the dark, contained no starch.

Before we were aware of this work, Miss D. Johnson and I had investigated the same point, at first with results which seemed to confirm those of Pollacci.

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[1] Loc. cit., p. 560.

[2] Reynolds Green. Action of Light on Diastase. Phil. Trans. Vol. 188, p. 188.

[3] Pollacci, G. Influenza dell' electricita sull' assimilatione clorofilliana. Atti. Ist. Bot. Pabia II. 11; 7-10. 1905.

[4] Bach. Sur la correlation entre la reduction par l'hydrogene naissant, l'electrolyse et la photolyse de l'acide carbonique. Comptes Rendus. Vol. 126, p. 479.

[5] Euler. Berichte deut chem. Ges. Vol. 37, p. 3415. 1904. See also Meldola. Living Organism as a Chemical Agency. Trans. of the Chem. Soc. 1906. Vol. 89, p. 758.

[6] Waller. Electrical Effects of Light upon Green Leaves. Procs. of the Royal Soc. Vol. 67, p. 129. 1900.

As the result of further experiment, however, it has never been possible to demonstrate starch in an electrified leaf, if that leaf were quite free from starch at the commencement of the experiment. The presence of the starch in the earlier experiments seems to have been due to the inhibition of the normal transformation of starch into sugar, owing to the excessive strength of current used.

The experiments were made with Elodea, with Geranium and Coleus leaves, and also with green filamentous Algæ, such as Spirogya and Cladophora laid across platinum electrodes; the voltage used varied from 1 to 40 volts, above 40 the effect was usually fatal.

With the object of ascertaining whether starch were produced by the action of the silent discharge in the dark, Mr. Newman kindly kept plants beneath the discharge points at Bitton during a continuous run of 27 hours, the leaves being afterwards picked and examined. No starch was found in them.

I find myself then, at present, unable to accept Pollacci's conclusion that starch can be formed by a green plant in the dark if an electric current of suitable strength be passed through it.

It has also been suggested that the effect produced on the soil by the electric current may be beneficial to the plant. Electrolysis undoubtedly takes place, and Dr. Cook found the soil slightly acid near the anode, and alkaline near the kathode, in some of his experiments.

Ewart[1] suggests that the current increases the rate of solution and absorption of the insoluble food constituents present in the soil, but as the amount of electrolysis proceeding is not likely to make the soil locally very acid I do not see that this is likely to be the case.

Finally, there is the possibility that in the case of the overhead discharge, oxides of nitrogen are formed by oxidation of either the nitrogen or ammonia present in the air.

Samples of the soil from the electrified and unelectrified parts of the wheat field in the Evesham experiments were analysed at College, the samples having been taken in the autumn after both crops had been gathered. They showed,—

Electrified	... ...	0·159 per cent. on dry weight.
Unelectrified	... ...	0·056 per cent. on dry weight.

But it is impossible to draw conclusions from isolated analyses of this kind ; however, following up this suggestion, it is intended to keep a continuous check upon the soils by analysis during the present season.

Berthelot[2] considers that the clue to advantage of the electric discharge is to be found in an entrance of atmospheric nitrogen into the plant metabolism, but suggests that this is due not only to the formation of oxide of nitrogen, but also to the combination of gaseous nitrogen with carbohydrates within the plant.

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[1] Ewart. Protoplasmic Streaming. P. 99.

[2] Berthelot. Sur les conditions de mise en activité chimique de l'életricité silencieuse. Comptes Rendus. Vol. 131, p. 772. 1900.

SUMMARY.

The results of experiments with the overhead discharge system of electrification seems to indicate that this method has a distinct effect, usually favourable in character, upon the growth of plants.

The results of experiments with Earth Currents showed occasionally increase in rate of plant growth, but often this method gave no definite effect.

The physiological action of the current is not at all understood ; I am not able to support Pollacci's view that it enables the green plant to elaborate starch in the dark.

In conclusion, it only remains for me to thank others for the help they have given me in various parts of this work ; in particular, I wish to thank Miss D. Johnson for great help with the experimental work ; Mr. Usher for many suggestions, and Miss A. A. Irving and Miss E. M. Rich for various analyses they have carried out for me.

On the Erosion of the Shores of the Severn Estuary.

By Sidney H. Reynolds, M.A., F.G.S.

WHILE the wearing away of the shores of the broader part of the Severn estuary is due mainly to ordinary marine erosion, that of the narrower part is more dependent on the scour of the tides.

For purposes of description the coast line may be divided into six sections.

1.—*From Burnham to Clevedon.*

The coast from the mouth of the Bure at Burnham to the neighbourhood of Clevedon is, in the main, a flat alluvial tract of very recent origin geologically speaking, and is generally bordered by a considerable stretch of blown sand. The four prominent limestone ridges of Brean Down, Worle Hill, Middle Hope, and Clevedon, break its monotony and divide it into a corresponding number of sections, which closely resemble one another.

These sections are—
(*a*) From the mouth of the Bure to Brean Down.
(*b*) From the mouth of the Axe to Worle Hill.
(*c*) From Kewstoke to Middle Hope.
(*d*) From the mouth of the Yeo to Clevedon.

Sections (*a*), (*b*), and (*d*) resemble one another almost precisely. Each commences with the mouth of a river, and consists of a nearly straight strip of flat coast bordered by a shallow sea and terminated by a prominent limestone ridge. Section (*c*) differs in being without any considerable stream at its commencement. In sections (*a*) (*b*) and (*c*), blown sand plays a prominent part in the formation of the coastline, while in section (*d*) the coast is formed by alluvium. The biggest sand-hills occur in the neighbourhood of Berrow, where the church is surrounded by lofty examples, and would long ere this have been buried were not further encroachments artificially prevented. Blown sand is strongly banked up against the southern margin of Brean Down, and is thickly spread over the lower slopes of the Down.

No marine erosion takes place on the flats between the limestone ridges, and very little on the ridges themselves, such erosion as there is being mainly subaerial. Each ridge consists of massive limestone striking east and west; but while in the case of Middle Hope and Worle Hill the dip is in a southerly direction at an angle of about 35^0, in the case of Brean Down the dip is northerly. In each case the scarp side is steeper than the dip slope side, but this is specially noteworthy in the case of Brean Down, where the southern margin is formed by a lofty precipitous cliff. The point of Brean Down beyond the Fort has the highly-dipping limestone beds planed off so as to afford a small but excellent example of a shore platform or plain-of-marine-erosion.

In the Worle and Middle Hope ridges erosion is most marked where the interbedded volcanic series crops out upon the shore as at Spring Cove near Weston-super-Mare, and several spots along the northern shore of Middle Hope. The big thrust plane traversing Worle Hill from east to west strikes the coast to the north of Spring Cove, but contrary to what might have been expected, has not formed a plane of weakness along which any marked erosion has taken place. Part of the northern coast of Middle Hope is bordered by a raised-beach platform, and small masses of raised-beach occur adhering to the cliff face at a height of about 25 feet above high water mark at both Spring Cove and Middle Hope.

2.—*From Clevedon to Portishead.*

At Clevedon itself the coast chiefly consists of highly resistent Carboniferous limestone. At a point on the coast not far to the south of Walton, the Dolomitic conglomerate appears, and with a few insignificant breaks forms the whole coast line till Woodhill Bay, Portishead, is approached. It varies considerably in thickness, not as a rule, however, exceeding 25 feet, and while sometimes lying horizontally more often dips seaward at a low angle. It rests at first on the Carboniferous limestone, and afterwards from Walton northwards and eastwards on the Old Red Sandstone, the palaeozoic rocks in each case having an easterly or south-easterly, *i.e.*, landward dip. It consists of blocks chiefly derived from the underlying palaeozoic rocks, and often large and irregular, embedded in a cement which is mainly calcareous in character. For much of the distance it forms a low platform not covered by the ordinary tides, and terminated at its seaward margin by a talus of big blocks. It is very resistent and shows little erosion. At a few spots, however, the Dolomitic conglomerate screen has been breached, and erosion in the underlying Old Red Sandstone is then rather more rapid. Sometimes the Dolomitic conglomerate is undercut and small caves are formed.

To the east of the lighthouse at Black Nore, the trend of the coast line alters, and then signs of erosion become considerably more marked. This is specially the case at Nore Park cottage, where the path along the coast has been swept away. The damage was, however, entirely due to the great storm of September 10th, 1903, when the pier at Weston-super-Mare was swept away. Under ordinary conditions there is little erosion. As Woodhill Bay, Portishead, is approached the Dolomitic conglomerate disappears, the cliff being formed only of Old Red Sandstone, and here erosion is more rapid.

To the north of the alluvial area of Woodhill Bay the Carboniferous limestone ridge of Portishead Point stands out prominently, and the coast onwards to the landing place is little eroded, being formed of hard Carboniferous limestone or Coal Measures overlain by Dolomitic conglomerate.

3.—*From Portishead to Aust Cliff.*

This whole stretch of coast as far as the southern end of Aust Cliff is formed of alluvium, and shows no erosion, except that there is some on the tidal banks of the Avon near the mouth of the Trym, but this is largely due to the wash of the steamers ascending the river to Bristol.

Aust Cliff consists of the Red and Grey marls of the Keuper, overlain by the shales and limestone bands of the Rhaetic and Lower Lias. Throughout the greater part of its length the base of the cliff is only reached by the water at highest spring-tides, and the main erosion is subaerial, the base of the cliff being occupied by an angular talus and never overhanging. Aust Cliff, however, differs from the opposite Sedbury Cliff in being in the main free from vegetation. Its recession is principally due to the separation of masses of the marl along vertical joints, or sometimes along planes of weakness due to the numerous gypsum veins. A portion of the northern part of the cliff differs from the remainder in being reached by the Severn at high tide, and undercut chiefly owing to the detachment of masses of gypsum. In the neighbourhood of each of the three faults which occur near the southern end of the cliff the strata have been remarkably indurated, and give rise to small promontories which stand out as much as 30 feet from the main face of the cliff. The greatest amount of erosion has taken place near the southern end in spite of the protection afforded by a landing stage (disused since the opening of the Severn Tunnel). The last thirty feet of this landing stage have been broken up by the Severn, and about half the garden of a neighbouring cottage has disappeared.

4.—*From Aust Cliff to the Arlingham Peninsula.*

From Aust Cliff to near the mouth of the Little Avon the coast is formed of alluvium. Near Sharpness Point the Old Red Sandstone comes down to the coast and stretches as far as Tite's Point, where, however, the river is actually bounded by low cliffs of alluvium and re-arranged material, the Old Red and associated rocks being worn down to a mud-covered platform quite inaccessible under ordinary conditions. Alluvium again forms the coast from Tite's Point as far as Frampton-on-Severn. Hitherto the course of the Severn has been practically in a due south-westerly direction, but at this point it commences to wind very much, and at each bend there is deposition at the salient and erosion at the re-entrant angle. At Fretherne, on the southern shore of the Arlingham peninsula, the Lower Lias consisting of shale with subordinate limestone bands crops out upon the coast for a distance of about a mile. Here erosion has been very rapid of recent years. According to a man who gets his living by fishing and fowling on the river the coast in the neighbourhood of Hock Crib, but especially to the south of that point, has lost upwards of fifty yards in the last 30 years. This is probably an exaggeration, but there can be no doubt that the loss has been very considerable. A little further to the south at Frampton the alluvial area has been much added to. At Smith's Wood (Butcher's Cliff of the old geological survey map) the Lias is succeeded by an area of alluvium which extends all round the end of the peninsula.

The southern part of this alluvial area is protected by a wall, at the southern end of which the river impinges, causing great erosion of the adjacent Lias cliffs and necessitating further a recent renewal of part of the wall.

5.—*From Garden Cliff, near Newnham, to the Mouth of the Wye.*

We now pass to the western side of the Severn estuary. Much of the base of Garden cliff is directly washed by the Severn, and is being considerably eroded; the general freedom of the western part of the cliff from vegetation is further evidence of the wear to which it is subjected. When the lower part of the cliff is formed of the Red Keuper marls the erosion is uniform; when the Rhaetic comes down to near the water level the hard bands, and especially the Pullastra sandstone, are strongly undercut. There is some erosion of the Red Keuper marls to the north and south of Newnham, but with the bend of the river at Aure an area of alluvium comes on which continues to be added to.

For a distance of about two miles to the north and a similar distance to the south of Severn Bridge Station the Severn is bounded by a cliff of Old Red Sandstone which is a good deal overgrown, and is separated from the river by the Severn and Wye Railway; there is clearly no fluvio-marine erosion in progress here. From Nass Cliff, near Lydney, as far as the neighbourhood of Tidenham, the coast is formed of alluvium. From near Tidenham to the northern end of Sedbury cliff the coast is bounded by a low cliff of Red Marl, and here the erosion is certainly very considerable. The cliff is vertical, has no protecting talus at the base, and the projecting roots of trees or sometimes whole trees detached from the cliff show how rapid the erosion is. For a short distance near the northern end a soft band of the Keuper comes down to high water mark and is very much undercut, narrow openings penetrating the cliff for as far back as twelve feet at least. At Sedbury Cliff the Red marl is overlain by the Grey marl, Rhaetic and Lower Lias, and here as at the opposite Aust Cliff the retirement of the cliff is more due to the ordinary subaerial agents than to the river. Numerous small slips obscure the base of the cliff, and it is further protected by a talus of blocks from the hard bands of the Rhaetic and Lower Lias. For about half-a-mile to the south of Sedbury Cliff the shore is bounded by a strip of alluvium, and then from the "Three Salmon" to the landing stage it consists of Red marl showing the same rapid erosion as in the area to the north of Sedbury Cliff.

Beachley Point owes its existence to the occurrence of a mass of Carboniferous limestone, which is seen not only at the Point, but practically all along the Eastern coast up to the landing stage. It is overlain unconformably by the Red marl which, as a rule, does not come down to the shore line. In the Geological Survey map no Carboniferous limestone is shown on the east coast of the promontory, and the relation of the Carboniferous limestone to the Trias is represented as a faulted junction.

At one point the Trias comes down to the shore line, and here a small bay has been eroded.

6.—*From the mouth of the Wye to the mouth of the Usk.*

By far the major portion of this stretch of coast is formed of alluvium very slightly raised above high water mark. It has, however, for more than a century been protected from the water by a continuous embankment which stretches from Caldicot pill to the mouth of the Usk. Between the mouth of the Wye and Caldicot pill two masses of Keuper are exposed on the shore, and at each locality the erosion has been considerable. The more northerly of these masses of Keuper occurs at Red Cliff, about a mile to the north of New Passage. The larger and more southerly extends from New Passage to the Roman camp at Sudbrook. The northern part of the exposure is partially protected from erosion by the landing stage and by the breakwater in connection with the Sudbrook ship building works, but where not so protected the erosion is considerable. The strata forming the southern part of the exposure are more massive than those forming the northern, and are finely exposed near the western vallum of the Roman camp. More than half the camp has been denuded away, and further evidence of the activity of marine erosion is afforded by the undercutting of the harder bands in the Keuper, the production of a system of large pot-holes, and the widening of the major joints till some are converted into deep little ravines which run twelve or fifteen yards inland. It is equally clear, however, that little or no change is now in progress, and it hardly seems possible that such marked results could be produced under present conditions of erosion.

The only other spot to the east of the mouth of the Usk, where the monotony of the alluvium is broken is at Gold Cliff, which is formed by a patch of Keuper capped by Rhaetic and Lower Lias. In former times the erosion here has clearly been very great, and a Keuper plain-of-marine-erosion stretches from 100 to 150 yards seaward from the base of the cliff. The cliff has, however, for many years (a local farmer said since 1815) been cased in masonry.

Records of Well Sections at Bristol.

Bristol, *Messrs. J. S. Fry & Son, Union Street.*

		Thickness. Ft.	Ins.	Depth. Ft.	Ins.
Keuper. Ft. Ins. 79 6	Made Ground	11	0...	11	0
	Fine blue and grey clay, probably river silt	19	6...	30	6
	Red marl	3	0...	33	6
	Red sandstone	0	6...	34	0
	"Gravel," water worn specimens of greenish grit	3	0...	37	0
	Hard reddish and pale grit or sandstone	30	0...	67	0
	Reddish and green marl and shale, with two thin bands of red sandstone ...	43	0...	110	0
Coal Measures. Ft. 161	Grey grit	1	0...	111	0
	Coal and shale	2	0...	113	0
	Dark shale	12	0...	125	0
	Coal	1	0...	126	0
	Dark shale	4	0...	130	0
	Hard grey sandstone	4	0...	134	0
	Reddish grey grit	22	0...	156	0
	Dark shale	3	0...	159	0
	Reddish grey grit	5	0...	164	0
	Dark shale	7	0...	171	0
	Hard grey sandstone	9	0...	180	0
	Dark shales, with thin layers of coal...	21	0...	201	0
	Reddish shale	2	0...	203	0
	Reddish grey grit	35	0...	238	0
	Grey shale	3	0...	241	0
	Grey sandstone	8	0...	249	0
	Dark shale	8	6...	257	6
	Red and grey sandstone	12	0...	269	6

BRISTOL. REDFIELD. *Patriotic Corset Works (Messrs. Chappell, Allen, & Co.), Avon Vale Road, St. George.*

Made and communicated by Messrs. ISLER & Co.

Water-level 18 ft. down.

		Thickness. Ft.	Ins.	Depth. Ft.	Ins.
Keuper.	Sandstone	8	0	8	0
	Grey rock	9	0	17	0
	Mottled marl	1	0	18	0
	Grey rock	7	0	25	0
	Mottled clay	5	0	30	0
	Blue clay	18	0	48	0
	Blue stone	5	0	53	0
	Blue clay	18	0	71	0
	Pebbles	10	0	81	0
	Blue rock	25	0	106	0
	Red marl	13	0	119	0
Coal Measures.	Hard blue marl	49	0	168	0
	Marl and shale	5	0	173	0
	Coal	1	0	174	0
	Sand and marl	14	0	188	0
	Sandstone rock	9	0	197	0
	Coal and marl	1	0	198	0
	Stiff marl	4	0	202	0
	Coal	1	0	203	0
	Shale and marl	3	6	206	6

BRISTOL, *Avonside Paper Mills, Avon Street, St. Philip's, Messrs. Mardon, Son, & Hall.*

Made and communicated by Messrs. ISLER & Co.

Water level 10 feet down. Supply 6000 gallons an hour.

		Thickness. Ft.	Ins.	Depth. Ft.	Ins.
Keuper.	Made ground	4	0	4	0
	Marl and ballast	6	6	10	6
	Red marl	5	6	16	0
	Grey sandstone	8	6	24	6
	Red marl	12	0	36	6
	Red sandstone	26	0	62	6
	Red marl	39	6	102	0
	Grey stone	9	6	111	6
	Red marl	10	0	121	6
	Red sandstone	3	6	125	0

BRISTOL, *Caxton Works, Temple Gate, Messrs. Mardon, Son, & Hall.*

Made and communicated by Messrs. ISLER & Co.

		Thickness. Ft.	Ins.	Depth. Ft.	Ins.
Keuper.	Red sandstone	18	0...	18	0
	Red marl	14	0...	32	0
	Red sandstone	1	6...	33	6
	Red marl	19	6...	53	0
	Mottled marl	12	6...	65	6
	Red sandstone	10	0...	75	6
	Red marl	29	0...	104	6
	Red sandstone	5	0...	109	6
	Red marl	15	0...	124	6
	Dark marl	13	6...	138	0

BRISTOL, *Messrs. J. & T. Usher's New City Brewery, River Street, St. Judes.*

Communicated by Messrs. ISLER & Co.

Water level 8 feet down.

		Thickness. Ft.	Ins.	Depth. Ft.	Ins.
	Made ground	3	0...	3	0
Keuper.	Red marl	3	0...	6	0
	Red sandstone	4	6...	10	6
	Gypsum	7	0...	17	6
	Marl	2	9...	20	3
	Red sandstone	8	0...	28	3
	Marl	3	0...	31	3
	Sandstone	6	0...	37	3
	Hard red marl	5	0...	42	3
	Sandstone	3	0...	45	3
	Red marl	3	6...	48	9
	Sandstone	10	0...	58	5
	Marl, variously coloured	3	0...	61	9
	Sandstone	9	0...	70	9
	Marl	2	6...	73	3
	Sandstone	7	0...	80	3
	Marl	2	0...	82	3
	Sandstone	10	0...	92	3
	Mottled clay	3	0...	95	3
	Sandstone	8	0...	103	3
	Marl	2	6...	105	9
	Sandstone	10	0...	115	9
	Marl	3	6...	119	3
Coal Measures	Sandstone	3	3...	122	6
	Shale	7	0...	129	6
	Hard sandstone	7	0...	136	6

Report of Meetings.

For the Year ending December 31st, 1906.

MR. C. K. RUDGE chose "The Harvest of the Sea" as the subject of his Presidential Address on January 25th.

Since then the following meetings have been held :—

Feb. 8th.—Dr. Fryer on the "Aurora Borealis," and Prof. S. H Reynolds, M.A., on the "Teeth of Animals."

Mar. 1st.—Prof. C. Lloyd Morgan, LL.D., F.R.S., on "Instinct."

Apr. 5th.—Mr. G. Munro Smith, M.R.C.S., L.R.C.P., on "Some Observations in a Clifton Garden."

May 3rd.—Prof. S. H. Reynolds, M.A., on "The Limbs of Vertebrate Animals."

Oct. 4th.—Mr. H. J. Charbonnier, on "Local Hymenoptera."

Nov. 1st.—Mr. A. M. Tyndall, B.Sc., on "Clouds."

,, 15th.—Exhibition of Specimens by the Geological Society.

,, 19th.—Visit to the Bristol Museum.

Dec. 6th.—Mr. Herbert E. Balch, on "Caves of the Mendips."

Nearly all the papers were illustrated either by lantern slides, specimens, or experiments.

BOTANICAL SECTION.

IT has chanced of late that attention has been specially directed to some of our bulbous plants—the Liliaceæ and their allies, considered by many people to be the most attractive group in our flora.

Within a few years two or three Alliums have appeared on the Observatory Hill, introduced most probably by some misguided planter who has wished to add something to the botanical attractions of the place. It is a pity that St. Vincent's Rocks have been chosen for the purpose; there can be no doubt that such experiments in cultivation should be confined to gardens. We remember that many years ago there was a mild outbreak of this particular indiscretion, when seeds of the Cheddar Pink were scattered on the cliffs, and one or two patches of that dainty plant were thus intentionally established. But we have now fallen on more mal-odorous times. No less than three new garlics are endeavouring to get a hold. *Allium roseum* is doing fairly well. This is rather a showy plant from Southern Europe; common enough along the Mediterranean. It has broad leaves, large rosy flowers, and head-bulbs also. At the spot where the stems now stand they are gathered as soon as they bloom; but should any bulb off-sets make their way over the edge of the precipice they may form a lasting colony. The second species, *A. carinatum*, is not an entire stranger to this country, but is a doubtful native of Britain. Hitherto it has been found only in Scotland, and near Newark, Notts. At present a very small quantity exists upon the Rocks. The third species has just lately been noticed by Mr. C. Wall, who reports that its stems have been so damaged that a perfect umbel cannot be had. But a specimen he has furnished leaves little doubt that the plant is *A. siculum*; or, more correctly, *Nectaroscordum siculum* Lindl., a rare and beautiful native of Sicily and Sardinia, which does well in English gardens.

The tulip ground near Combe Hay has been visited this spring. Instead of the plants being confined to one field as had been reported, the writer found an abundance distributed in three adjoining large pastures, and so spread over a considerable area. The ground slopes gently towards the south, and is fairly moist. A little more than twenty years ago it was arable land, and the tulips are said to have flowered more freely under the plough than they do at the present time. Now-a-days flowers are very rarely produced, not more than two or three being met with yearly among many hundreds of bulbs.

Another member of the lily tribe, as rare as it is handsome, is the Snake's Head or Fritillary. The chequered petals of this choice flower are so seldom seen in North Somerset that the news of its existence near Barrow Gurney was very welcome. Fortunately the plant seems not to suffer injury from gathering, as at this spot children and others pick practically the whole crop year after year.

A certain Clifton wild-garden possesses a very peculiar sport of that common but yet most charming of our spring flowers, the Blue-bell. Normally each flower upon a scape springs from the axil of two tiny coloured bracts; but the plant in question has developed these bracts to the length of two inches and of the same tint as the foliage. Thus the inflorescence has a most peculiar appearance. Off-sets from the bulb originally discovered and brought in from the woods have since given rise to about twenty individuals, all possessing the same peculiarity. The white blue-bell is fairly frequent, and is a beautiful variety. But a pale pink form is still more attractive. The latter occurs in a wood not far from South Stoke, where it is scattered singly amid a host of the ordinary kind. It is no uncommon thing, however, for blue-flowered plants to vary with other tints.

A delightful spring ramble can be made to the meadows at Churchill where the Narcissi grow. Some open fields on one side of the parish are well filled with patches of the Common Daffodil, and make a brave show about Easter-tide. Not far away, but entirely separate from its sister species, and flowering a month later, the handsome *N. biflorus* covers a space so large that one feels satisfied its first arrival—supposing it really is not indigenous with us—must have been at a very ancient date. It is, in fact, believed that this Narcissus and one or two others were found in England before the snowdrop was introduced. The specific name *biflorus* is not the most apt that could have been chosen, for we see at Churchill many stems bearing but one flower, while others may have three. The curious movements of the flower-stalk in Daffodils must be of importance to fertilization. At first a bud stands nearly erect, then the peduncle bends over until its flower is almost inverted, and finally it rises again to the first position.

How few there are among us who know the flower of Gagea—the Yellow Star of Bethlehem. It appears somewhat more frequently than that of the wild tulip, but is almost as shy. And fewer still there are, perhaps, who can recognise the foliage when flowering is long past. Obviously this plant and the tulip increase and multiply without seeding, or independently of seed, In the case of Gagea the parent bulb produces from ten to twenty tiny bulbules, at first no bigger than sago grains, within its yellowish coat. These are soon cast off to lead a separate life, and then each puts up one tiny radical leaf. Year by year the annual leaf becomes wider and taller until, perhaps at the age of seven, if circumstances be favourable, a flower-stalk is developed. Meanwhile the children bulbs in turn have been setting out a progeny in circles round about. And so, perchance, when one is getting up the root of a brook-side plant in some deep dell where sunlight and shadow mingle between stems of alder and hazel bushes, one may find the earth full of these small granules with their tiny streamers, and perceive that it is a red-letter day, a day of good fortune, that comes not to the botanist oftener than he deserves.

JAS. W. WHITE.

GEOLOGICAL SECTION.

THERE are 53 members at the end of this year, shewing a decrease of 8 from the previous year's membership.

At the first meeting of the year Prof. S. H. Reynolds, M.A., F.G.S., was re-elected President, and B. A. Baker, F.G.S., Hon. Sec.

There have been 8 meetings during the year, papers being read at seven, while one meeting was devoted to an exhibition, when the members of the Naturalists' Society as a whole were invited to be present.

This proved a very great success, as a great many availed themselves of the invitation, and the exhibits were of a varied character, including fine specimens of minerals and crystals, characteristic zonal fossils of the Carboniferous limestone exhibited by Dr. A. Vaughan, and many excellent photographs and lantern slides of geological subjects.

The following were the titles of papers read :—

Jan. 18th.—"The Carboniferous Limestone of the Mendips," by T. F. Sibly, B.Sc.

Feb. 15th.—"The Igneous Rocks of the Eastern Mendips," by Prof. S. H. Reynolds, M.A., F.G.S.

Mar. 15th.—"Visit to South Africa with the British Association in 1905," by J. T. Kemp, M.A.

April 26th.—"Minerals and Shapes," by Dr. A. Vaughan, B.A., D.Sc., F.G.S.

May 17th.—"The Geology of the country around Weymouth," by Prof. S. H. Reynolds, M.A., F.G.S.

Oct. 18th.—"Notes on the Geology of the Isle of Arran," by Prof. S. H. Reynolds, M.A., F.G.S.

Nov. 15th.—Exhibition Meeting.

Dec. 20th.—"On the Inferior Oolite and contiguous deposits of Bath-Doulting District," by L. Richardson, F.G.S.

There was an average attendance (excluding the Exhibition Meeting) of 16 members.

The Financial Report shows a total receipt of £8 5s., including a balance brought forward of £2 15s. from last year. The expenditure has been £5 17s. 4d., leaving a balance of £2 7s. 8d to be carried forward. The receipts this year have exceeded those of last year by 7s. 6d., as some members whose subscriptions were in arrears have paid. Had all members paid their subscriptions to date, the section would be in a much better position. The expenses include an item of £2 which was voted towards defraying the expense of printing the photographs of the Avon Section to illustrate Dr. Vaughan's paper. Besides this, a private subscription was made for the same object, to which the members of the Section liberally contributed.

B. A. BAKER, F.G.S.,
Hon. Secretary.

ENTOMOLOGICAL SECTION.

JANUARY 9th.—Mr. R. M. Prideaux sent for exhibition a box of butterflies, taken by him in Switzerland in 1905, principally from the Rhone Valley between Montreux and Brigue.

Feb. 20th.—Mr. G. C. Griffiths exhibited the two interleaved volumes of Stainton's Manual of British Butterflies and Moths belonging to the late Rev. Joseph Green, containing beautiful water colour drawings executed by him from life.

Mr. Griffiths also exhibited varieties of *Abraxas grossulariata*, including var. *lacticolor*, and an abnormal specimen of *Anosia plexippus* from Fiji, each pair of wings being of different sizes.

The capture of two *Acronycta strigosa* by sugar at Sandhurst, Glos., by the Rev. G. M. Smith, was reported.

April 3rd.—Mr. Edgar A. Prichard exhibited two rare works on Entomology, viz. :—"Natural History of English Insects" by Eleazar Albin, 1767, containing 100 coloured plates, and "The Theatre of Insects" by Thomas Mouffet, Doctor in Physick, 1658.

Mr. G. C. Griffiths exhibited some *Geometræ* from Queensland, Japan, &c. Mr. H. J. Charbonnier gave an account of the life history of the larva of the May fly, *Ephemera vulgata.*

Dr. C. King Rudge exhibited a case of Indian lepidoptera.

The Hon. Secretary exhibited a box of lepidoptera and coleoptera from Orokolo, British New Guinea.

May 2nd.—Mr. G. C. Griffiths exhibited a framed water colour painting, by the late Rev. Joseph Green, of some magnificent varieties in his collection of 10 *Chelonia caja* and 12 *C. Villica.*

Mr. Griffiths also showed a box of moths of the genus *Arctia* for comparison, and many other specimens of lepidoptera.

November 6th.—Mr. G. C. Griffiths exhibited six specimens of *Laphygma exigua* from Penarth and Sussex, and a discussion took place upon the remarkable immigration of this species this year, *Heliothis peltigera*, *Dianthœcia*, *conspersa* (black var.), *Hadena glauca* (black var.), and *Cucullia gnaphalii.*

The Hon. Secretary showed a series of *Agrotis ripae*, bred from larvæ found on *Salsola kali* on Braunton Burrows.

Mr. H. J. Charbonnier exhibited specimens of *Mecinus collaris* found on *Plantago maritima* on the banks of the Avon, and remarked upon the gall produced in the stem by the larva; also specimens of *Cionus scrophulariœ*, together with a flower head of *Scrophularia aquatica* having thereon the *puparium* made by the larva.

Dec. 11th.—Mr. H. J. Charbonnier exhibited specimens of the following "frog-hoppers," *Tettigonia viridis*, *T. vulnerata*, and *T. flavostriatus*, etc.

Mr. G. C. Griffiths exhibited some "*Papilios*," including *Papilio Homerus*, *P. caiguanabus*, *P. cacicus*, *P. Godeffroi*, *P. alopius*, *P. Electryon*, etc.

The Hon. Secretary showed a box of insects taken at Downderry, Cornwall, including 3 specimens of *Satyrus janira*, having cream coloured patches on the wings, a pupa case and bred fly of *Gasterophilus equii*, *Tabanus bovinus*, etc.

CHARLES BARTLETT,

June 12, 1907. *Hon. Secretary.*

FOURTH SERIES, Vol. II. 1907,—8,—9.

PROCEEDINGS

OF THE

BRISTOL NATURALISTS' SOCIETY.

EDITED BY THE HONORARY SECRETARY.

"*Rerum cognoscere causas.*"—VIRGIL.

BRISTOL:
PRINTED FOR THE SOCIETY
MCMXI.

INDEX TO VOL. II. (FOURTH SERIES).

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FOURTH SERIES. VOL. II. PART I.

The Strata exposed in constructing the Filton to Avonmouth Railway.

By J. W. Tutcher.

CONTENTS.

I. INTRODUCTION.

In the *Quarterly Journal* of the Geological Society for 1902 and 1904 Professor S. H. Reynolds and Dr. A. Vaughan described the strata exposed in making the South Wales to London direct line between Filton and Wootton Bassett. Dr. A. Rendle Short also described in detail a Rhætic section on the same line at Stoke Gifford.[1]

The present paper may be regarded as supplemental to those communications: its purpose being to record the strata cut through in making a westward extension of this line from Filton to Avonmouth.

II. DESCRIPTION OF THE EXPOSURES.

(A) The Filton Section.

The first cutting West of Filton Station is crossed by the main road from Bristol to Gloucester at a point half-a-mile North of Filton Church. In this cutting the basal beds of the Lower Lias, and their junction with the Rhætic can be seen.

The strata in this section take the form of a low anticline, the Upper Rhætic being exposed only in the middle portion of the cutting.

So far as it can be seen, the Rhætic here agrees precisely with the records of the Stoke Gifford section, one mile East.[2] The only fossils found are Ostracods; these are well preserved and fairly common at certain levels in the limestone band.

The junction of the Upper Rhætic with the Lias is well marked by the presence of the Cotham marble (Landscape stone).

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[1] Quart. Journ. Geol. Soc. Vol. lx (1904) p. 175.

[2] Quart. Jour. Geol. Soc., Vol. lx. (1904), p. 175 and p. 195.

Filton Railway Cutting.

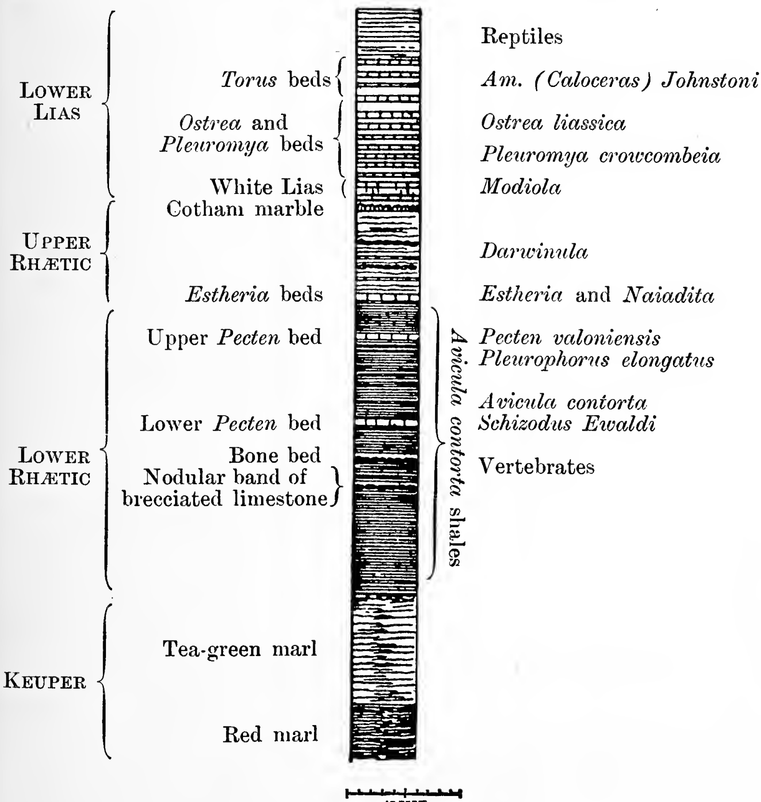
			Ft.	In.	
Lower Lias.	Torus Beds. *Hemera; megastomatos.*	Soil and clayey shale	5	0	Reptilian Vertebræ.
		Limestone, hard, grey, evenly bedded	0	5	*Am. (Caloceras) Johnstoni*, Sow. (*Am. torus*, d'Orb.) *Lima gigantea*, Sow.
		Shale, with thin nodules of limestone	0	5	
		Limestone, with nodular top ...	0	5	*Pholadomya glabra*, Ag. *Astarte consobrina*, Chap. & Dew
		Shale	0	10	*Ostrea ungula*, Münst
		Limestone	0	5	*Caloceras Johnstoni*, Sow.
		Shale, with thin limestone... ...	0	10	*Cidaris arietis*, Quenst.
		Limestone, dark grey, with rusty joint planes, very evenly bedded ... ... Thin shale parting	0	7	*Caloceras Johnstoni*, Sow. *Lima gigantea*, Sow. *Pholadomya glabra*, Ag.
		Limestone, blue	0	4	*Pecten dispar*, Terq.
	Pleuromya and *Ostrea* Beds.	Shale	0	5	*Cidaris arietis*, Quenst.
		Limestone	0	2	
		Shale	0	7	
		Limestones, blue, five 2 in. beds with rather thicker shale partings	1	11	*Ostrea liassica*, Strickl. (very common). *Pleuromya liasina*, Schubl. *Hemipedina Bowerbanki*, Wright
		Limestone, blue	0	5	
		Shale	0	3	*Hemipedina Bowerbanki*, Wright
		Limestone, grey, evenly bedded ...	0	4	*Pecten dispar*, Terq. *Pinna Hartmanni*, Ziet.
		Limestones, three thin beds with shale partings	1	0	*Ostrea liassica*, Strickl. *Pleuromya liasina*, Schubl. *Lima* cf *punctata*, Sow. *Astarte obsoleta*, Dunk. *Hemipedina Bowerbanki*, Wright
		Limestone	0	5	*Ostrea liassica*, Strickl. *Pholadomya Fraasi*, Oppel. *Pleuromya crowcombeia*, Moore, Tate. *Protocardium Phillipianum*, Dunk.
		Shale, with thin limestone ...	0	3	
		Limestone, blue	0	6	*Pleuromya crowcombeia*, Moore, Tate. *Modiola liasina*, Terq. *Modiola minima*, Sow. *Protocardium Phillipianum*, Dunk. *Unicardium arenacea*, Terq. *Macrodon hettangiensis*, Terq.
	White Lias.	Limestone, light grey, compact, conchoidal fracture (Sun bed)	0	10	*Pleuromya crowcombeia*, Moore, Tate. *Modiola minima*, Sow., Moore. *Pseudomonotis decussata*, Münst.
		Shale	0	2	
		Cotham marble, 3—5 ins.	0	4	
Rhætic.	Upper Rhætic.	Shale, grey, marly	2	0	
		Limestone, light grey, fissile, nodular and septarian in places	0	3	*Darwinula.*
		Shale, grey, marly (seen)	1	0	

The White Lias is represented by a single bed with sun bed characters; further West it becomes thicker. The *Pleuromya* and *Ostrea* series follow—*Pleuromya crowcombeia* is abundant in the lower portion, becoming rare about two feet above the White Lias where *Ostrea liassica* is the commonest fossil.

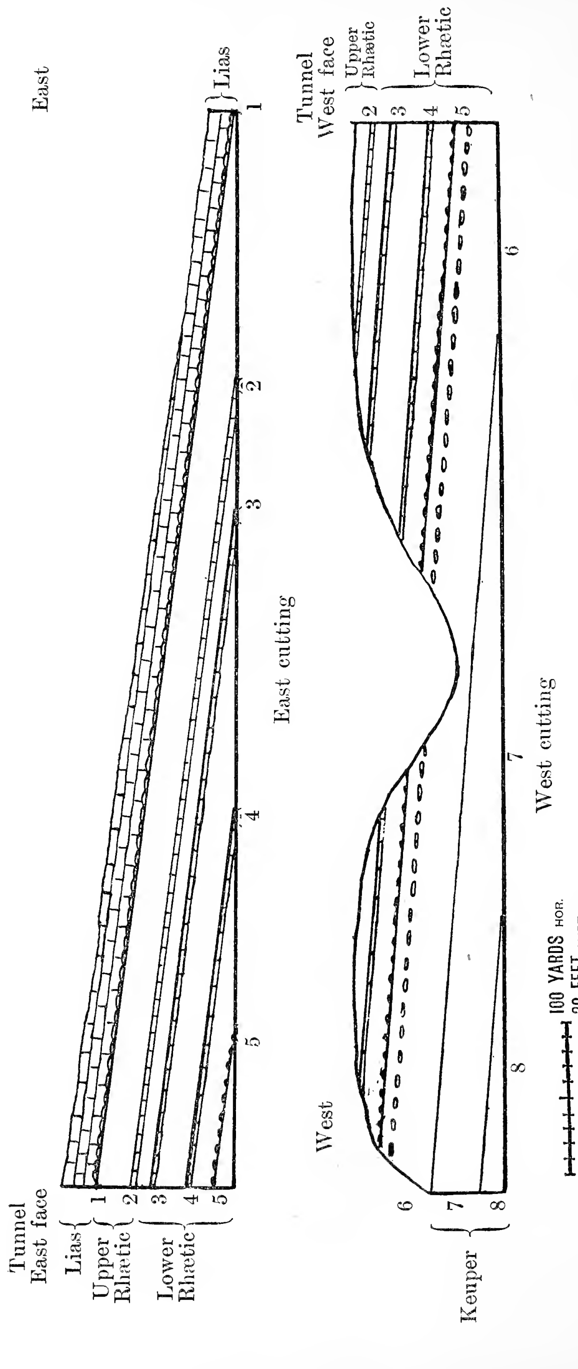
The most notable circumstance of the Filton cutting is the apparent absence of the Ammonite, *Psilonotoceras planorbis*, which in this district is usually in evidence just above the *Ostrea* beds. The only Ammonite found at Filton belongs to the *Am. torus* group, viz., *Caloceras Johnstoni.* This species enters abruptly and is abundant; it indicates a later date than *Am. planorbis.*

The clays in the upper part of the section have yielded no fossils that would identify them. It may be remarked, however, that in most of the local sections, the *angulatus* zone is ushered in by similar thick clays or shales.

The upper portion of the vertical section (down to the White Lias) was constructed from data supplied by the Filton cutting.



Vertical section of the strata exposed in the Filton and Charlton Railway Cuttings.



Charlton Railway Cuttings, East and West of Tunnel.

1. Cotham Marble. 2. *Estheria* and *Naiadita* beds. 3. Upper *Pecten* bed. 4. Lower *Pecten* bed. 5. Bone bed. 6. Infra bone bed shales, with nodular limestone band. 7. Tea-green Marl. 8. Red Marl.

(B) The Charlton Section.

The next cutting to be described is at Charlton, one mile West of Filton. Considerable interest in this section arises from the fact that a complete series of the Rhætic beds is here exposed. The cutting is nearly one mile long, interrupted for 300 yards in the middle portion by a tunnel.

The beds at this place are arranged in feeble anticlinal and synclinal flexures, especially noticeable in the cutting West of the tunnel. The dip averages about 3 degrees to the E.N.E.; this is sufficient to bring within observation all the strata from the Lower Lias to the Keuper Marls, although, at the time of writing (July, 1908), the excavations have not been carried to the level of the permanent way.

The horizontal section *(vide page 8)* indicates the general arrangement of the strata, and the position of the more important beds; it takes no account, however, of the slight flexures above noted.

The following details of the strata down to the level of the bone bed were compiled chiefly from observations made near the East face of the tunnel, and those below the bone bed from the Western cutting.

Charlton Railway Cutting.

			Ft.	In.	
LOWER LIAS.	*Pleuromya* and *Ostrea* Beds.	Limestones, grey, weathering yellow, thinly bedded, disturbed and rubbly	2	0	*Lima* cf. *punctata*, Sow. *L. tuberculata*, Terq. *L. hettangiensis*, Terq. (small specimens). *Pholadomya Fraasi*, Oppel. *Pleuromya crowcombeia*, Moore, Tate. *Astarte obsoleta*, Dunk. *Pinna Hartmanni*, Ziet. *Myoconcha psilonoti*, Quenst.
		Limestone, grey, shelly, in two layers	0	5	*Ostrea liassica*, Strickl. *Pleuromya crowcombeia*, Moore, Tate. *Protocardium Phillipianum*, Dunk. *Unicardium (Lucina) arenacea*, Terq. *Arcomya (Thracia)* cf. *subrugalosa*, Dunk. *Modiola minima*, Sow. *M. liasina*, Terq. *Pinna Hartmanni*, Ziet. Turbinate *Gasteropods*.
		Shale	0	1	
		Limestone, blue	0	4	
		Shale	0	2	
		Limestones, three thin beds, with clay partings	0	3	
		Limestone, hard, blue	0	5	
		Limestones, four thin beds, with shale partings	1	1	
	White Lias.	Limestone, light grey, argillaceous	0	8	*Modiola minima*, Sow. *M. minima*, Sow, Moore. *Gervillia præcursor*, Quen. *Plicatula intusstriata*, Emm. *Lima valoniensis*, de France. *Protocardium Phillipianum*, Dunk.
		Limestone, rubbly, pale yellow ...	0	10	*Pleuromya crowcombeia*, Moore, Tate. *Plicatula intusstriata*, Emm. *Macrodon hettangiensis*, Terq.
		Limestone, grey, surface covered with shells	0	3	*Pleuromya crowcombeia*, Moore, Tate. *Modiola minima*, Sow., Moore. *Pseudomonotis decussata*, Münst.
		Shale, blue	0	4	*Pseudomonotis decussata*, Münst.

	Bed	Ft.	Ins.	Fossils
UPPER RHÆTIC.	1 COTHAM MARBLE— Limestone, compact, arborescent markings & coarsely corrugated top; passing laterally into thinner bands of blue and brown stone without the ridged top, and often without the landscape markings, 3—6 ins. ...	0	4	*Pseudomonotis decussata*, Münst
	2 Sandy bed, iron stained ...	0	1	
	3 Shale, grey, marly	2	0	
	4 Limestone, grey, very irregular, nodular and concretionary, septarian, cavities lined with calcite, 2—8 ins.	0	5	*Darwinula.*
	5 Shale, similar to 3	1	0	
	6 Limestone, hard, gritty, ripple marked	0	1	
	7 Shale, as 3 and 5...	0	5	
	8 Limestone, large septarian nodules, similar to 4, 3—6 ins.	0	4	
	9 Shale, grey, marly, with thin limestone	1	0	
	10 Limestone, grey, gritty, micaceous, ripple marked	0	2	
	11 Shale, grey, marly, with thin seams of limestone ...	0	10	
	12 ESTHERIA BED— Limestone, grey, fissile, with thin bands of darker colour giving the freshly fractured surface a streaked appearance	1	6	*Naiadita lanceolata*, Brodie. *Darwinula.* *Estheria minuta* var *Brodieana*, Jones. *Pecten valoniensis*, de France. Insect fragments, Fish scales and teeth.

	Bed	Ft.	Ins.	Fossils
LOWER RHÆTIC.	13 Shale, greenish black, with band of marl containing many fragmentary shells and Insects	1	9	*Pecten valoniensis*, de France. *Avicula contorta*, Portlock. *Myophoria postera*, Bronn. *Protocardium Phillipianum*, Dunk. *Cardium cloacinum*, Quenst. *Schizodus Ewaldi*, Bornemann. *Pleurophorus elongatus*, Moore. *Plicatula intusstriata*, Emm. *Cardinia* cf. *regularis*, Terq. *Gyrolepis Alberti*, Ag.
	14 Limestone, grey, gritty, pyritic, with fibrous calcite above; passing laterally into a more sandy and fissile bed. Absent in places	0	3	*Pecten valoniensis*, de France. *Schizodus Ewaldi*, Born. *Pleurophorus elongatus*, Moore. *Gyrolepis Alberti*, Ag. *Acrodus minimus*, Ag. *Hybodus minor*, Ag.
	15 Shale, black, laminated (very fossiliferous)	0	5	*Avicula contorta*, Portlock. *Myophoria postera*, Bronn. *Schizodus Ewaldi*, Born. *S. concentricus*, Moore. *Cardium cloacinum*, Quenst. *Anomia* sp. *Pleurophorus elongatus*, Moore.

LOWER RHÆTIC—*Continued.*

	Ft.	Ins.	
16 UPPER PECTEN BED— Limestone, dark grey, fibrous calcite top. Usually splits along the middle line, upper part marly, sometimes sandy; lower part, hard, pyritic, & very shelly	0	6	*Pecten valoniensis*, de France. *Pleurophorus elongatus*, Moore. *Schizodus Ewaldi*, Born. *S. concentricus*, Moore. *Myophoria postera*, Bronn.
17 Shales, black, clayey in upper part, more perfectly laminated below. Some pyritic layers and sandy courses. Very fossiliferous at several levels	7	0	*Avicula contorta*, Portlock. (very common). *Myophoria postera*, Bronn. *Schizodus Ewaldi*, Born. *Protocardium Phillipianum*, Dunk. *Pleurophorus elongatus*, Moore. *P. angulatus*, Moore.
18 LOWER PECTEN BED— Limestone, blue, hard, pyritous, fibrous calcite top, generally splits into two bands, the upper band very shelly, the lower one septarian, and often of a bone bed character ...	0	7	*Avicula contorta*, Portlock. *Pecten valoniensis*, de France. *Schizodus Ewaldi*, Born. *S. concentricus*, Moore. *Pleurophorus angulatus*, Moore. *Modiola minima*, Sow. In places, bones, scales, teeth, and coprolites.
19 *(a)* Shale, black, firm, thickly laminated, 9 ins. *(b)* Shale, hard, imperfectly laminated, not crumbly, rusty joint planes, 1 ft. 6 ins *(c)* Shale, similar to *a*, 6 ins.	2	9	Fossils scarce, a few specimens of *Schizodus Ewaldi*, Born., and *Protocardium Phillipianum*, Dunk.
20 Marl, dark grey, micaceous ...	0	5	*Gervillia præcursor*, Quenst. *Gyrolepis Alberti*, Ag. *Acrodus minimus*, Ag.
21 BONE BED— Shales, black, interstratified with thin calcareous bands, gritty, pyritic, micaceous, containing scales, teeth, bones, coprolites, and pebbles. *Schizodus* and other Lamellibranchs abound in the upper part of the series. In the lower part the hard beds are thicker and more distinctly bone beds in character. Occasionally the intervening shales are missing, the hard beds merging into one thick band which, at the western end of the section is a conglomeratic bone bed similar to that at Aust ...	0	7	*Schizodus elongatus*, Moore. *Schizodus*, Sp. *Gervillia præcursor*, Quenst. *Mytilus cloacinus*, sp. nov. *Acrodus minimus*, Ag. *Gyrolepis Alberti*, Ag. *G. tenuistriatus*, Ag. *Saurichthys acuminatus*, Ag. *Colobodus.* *Sphærodus minimus*, Ag. *Hybodus raricostatus*, Ag. *H. minor*, Ag. *H. cuspidatus*, Ag. *Nemacanthus monilifer*, Ag. *Rysosteus Oweni.* Reptilian teeth, Labyrinthodont bones, Coprolites, quartz pebbles.
22 Shale, black, crumbly, earthy in places	2	0	
23 Large and very irregular nodules of brecciated limestone, no fossils, 3—9 ins.	0	6	
24 Shale, black, containing selenite. Fossils scarce ...	9	0	*Schizodus Ewaldi*, Born. *Avicula contorta*, Portlock. *Protocardium*, sp. (small specimens). *Orbiculoidea ?* *Gyrolepis.*

		Ft.	Ins.
KEUPER	Marl, in nodules, brown with greenish grey centre	0	8
	Marls, greenish grey	9	6
	Marls, red, to base of section as now seen	8	0

The Lias is seen only in the cutting East of the tunnel. One specimen of *Am. (Caloceras) Johnstoni* was observed among the debris, but the Ammonite could not be found *in situ*, in fact the beds scarcely reach the level at which Ammonites would be expected.

The White Lias is here rather thicker, but, in other respects the Lias agrees practically with the *Ostrea* and *Pleuromya* beds of the Filton cutting.

The Cotham marble and upper portion of the Rhætic are also seen only in the East cutting.

At the West face of the tunnel the highest beds consist of the basal part of the Upper Rhætic, and at this place the *Naiadita* bed (12) differs somewhat from its equivalent East of the tunnel. The sequence is as follows :—

UPPER RHÆTIC AT THE WEST FACE OF CHARLTON TUNNEL.

			Feet.	Ins.
8	Limestone, yellowish grey		0	2
9	Marl, with thin limestone		1	0
10	Marl, hard, grey ; one specimen of *Pecten valoniensis*		0	3
11	Shale, marly, yellowish grey, with thin limestone bands		1	0
12	*(a)* Limestone, bluish grey, gritty ...	1 in.	1	1
	(b) Limestone, yellowish grey, fissile, with some gritty courses (*Naiadita* bed) cemented to	7 ins.		
	(c) Limestone, bluish grey	2 ins.		
	(d) Marl, brownish grey	3 ins.		

The fossils of bed 12 are—*Pecten valoniensis*, *Protocardium Phillipianum*, *Cardium cloacinum*, *Estheria minuta* var. *Brodieana* *Darwinula* sp., *Naiadita lanceolata,* fish scales, teeth, coprolites, and occasionally bones.

Naiadita and *Darwinula* are common in 12 (*b*); *Estheria* on the other hand is rare here, but common in 12 East of the tunnel.

The fossils of the upper part of the Lower Rhætic are much better preserved in the eastern than in the western cutting, due probably to their greater protection from surface conditions; below bed 16 there are no differences in this respect.

There are three *Pecten* beds at Charlton, numbered 14, 16, and 18 respectively. Bed 14 is irregular in occurrence and in character, but 16 and 18 are continuous and conspicuous beds, and these are referred to in this paper as the upper and lower *Pecten* beds. The commonest fossils in these beds are members of the genus *Schizodus* (= *Pullastra* Auctt.), but since this genus ranges throughout the Lower Rhætic, and specific determination of its members is not easy, it has little value as an index form. On the other hand *Pecten valoniensis* is easily recognised even when fragmentary, and its range is sufficiently restricted and well defined to render it useful for index purposes, *vide* diagram page 17. The *Pecten* beds 14 and 16 are above the shales in which *Avicula contorta* is usually most abundant; bed 18 is below these shales, and the *Pectens* in it, although common enough, are generally of small size.

The hard shale (19) is discussed in Section V.

The bone bed group (21) exhibits considerable lateral variability. Speaking generally it passes from a series of thin stratified beds in the eastern cutting, to a definite breccia at the end of the western cutting. At an intermediate point, viz., just West of the tunnel, the sequence is as follows:—

Bed 20, 5 inches.

21	Shale	1 inch.
	Bone bed, $\frac{1}{2}$—2 inches	$1\frac{1}{4}$,,
	Shale	$1\frac{1}{2}$,,
	Bone bed, 1—3 inches	2 inches.

500 yards further West the character of the bone bed series is markedly different.

Bed 20, 5 inches.

21	Sandy bed, very irony	3 inches.
	2 or 3 pyritic grits with fibrous calcite partings and containing *Schizodus*	2 ,,
	Calcareous breccia, resembling the bone bed at Aust. Some of the included fragments full of *Schizodus*, 3—8 inches	5 inches.
	Irony sand	2 ,,

A little further West a band of dark blue limestone, consisting almost entirely of shells of *Schizodus* was found above the bone bed; but usually this bed is broken up and its fragments intermixed with the bone bed breccia.

At the present time the infra bone bed series can be seen only in the western cutting. The nodular band of brecciated limestone (23) is the only hard bed in this series. It makes a prominent and regular feature, maintaining its position in relation to the bone bed above and the tea-green marls beneath, to the end of the section. This rock is quite unfossiliferous; its appearance suggests the contemporaneous breaking up of a hardened mud.

The shales (24) are poor in fossils; scales and teeth occur occasionally, and on certain levels, chiefly about four feet from the base, isolated specimens of *Avicula contorta*, *Schizodus Ewaldi,* and *Protocardium* sp., were collected. Generally these shales rest directly on a nodular band of hard grey marl, the line of junction being quite sharp; occasionally, however, a thin sandy seam intervenes between the black shales of the Rhætic and the tea-green marl of the Keuper series.

In a subordinate cutting a little West of this section only the red marls of the Keuper series are seen. In them is a small fault with a downthrow to the West of about six feet. This is the only fault observed throughout the sections.

The lower part of the vertical section (from the White Lias to the Keuper) was constructed from data supplied by the Charlton cuttings, *vide* page 7.

(C) The Hallen Cutting.

The only other cutting of importance on this railway is at Hallen, about one mile West of the Charlton cutting. Here the Keuper marls are well displayed; they consist of thick beds of red marl with bands of a bluish grey colour at more or less regular intervals. The beds exhibit the same undulatory character that has been observed in the Charlton cutting.

An extraordinary deposit of Gypsum occurs near the western end of this cutting. It appears in nodular masses many feet in thickness. Some thousands of tons of this rock, for which a ready market was found, have already been extracted. At present the cutting is about 20 feet deep; it will ultimately reach twice this depth in places, but, judging by the excavations made for piers of bridges &c., no lower formation will be disclosed.

III. CORRELATION OF THE RHÆTIC AT CHARLTON WITH PYLLE HILL.

The correlation of a series of deposits bed by bed, even in contiguous areas, must always be attended with doubt and difficulty. But since, in most of the recent local work on the Rhætic, some attempt has been made to bring the sections into line with the one at Pylle Hill described by the late E. Wilson, it is perhaps desirable to give the following table of suggested equivalents at Charlton—

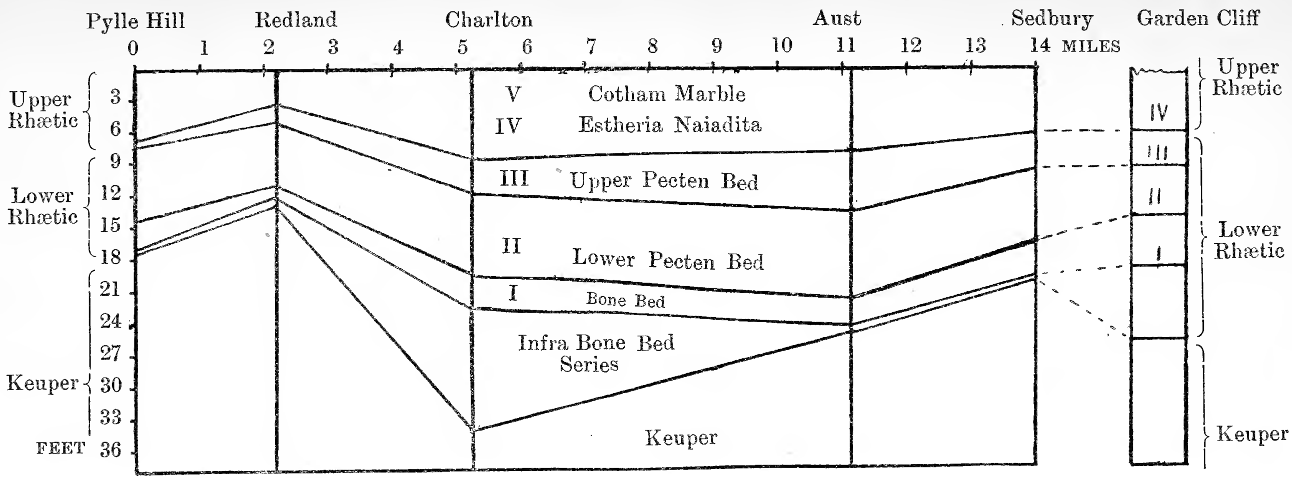
Pylle Hill,		Charlton.	Pylle Hill,		Charlton.
Upper Rhætic.			Lower Rhætic.		
n	=	1	h	=	13—15
m	=	2—9	g	=	16
l	=	10	d, e, f	=	17
k	=	11	c	=	18
i	=	12	a′, b	=	19
			a	=	20—21

IV. VARIATION IN THICKNESS OF THE RHÆTIC.

Reference to the diagram on page 15 will make clear the variation in thickness of the Rhætic deposits, so far as they are known, on a line drawn from Pylle Hill, just South of Bristol, to Sedbury, in Monmouthshire. A section of the Lower Rhætic at Garden Cliff, 14 miles N.N.E. of Sedbury, is given for comparison. The diagram also indicates the position of the more constant and easily recognised beds.

The Cotham marble is recognised at all the sections excepting Garden Cliff. The upper *Pecten* bed occurs in all the sections; apparently it is the most constant hard bed in the Lower Rhætic of this district. The lower *Pecten* bed is not recognised as such at Pylle Hill, Redland, or Sedbury; but, at Pylle Hill, a "thin pyritic sandstone," and at Redland a "ferruginous band" separates the crumbly shale above from the harder unfossiliferous shale below.

DIAGRAM I.



Relative thickness of Rhætic deposits below the Cotham marble, from Pylle Hill, Bristol, to Sedbury Cliff, Monmouthshire.

With correlated section of the Lower Rhætic at Garden Cliff for comparison.

DIVISIONS OF THE RHÆTIC (*System of Reynolds and Vaughan*)	V.	Maximum of *Ostracoda*
	IV.	,, of *Phyllopoda*
	III.	,, of *Pecten valoniensis*
	II.	,, of *Avicula contorta*
	I.	,, of *Vertebrates*

V. POSITION OF THE BONE BED.

There are, in many Rhætic sections, deposits at different levels which are more or less bone beds in character. At Charlton, for example, the basal part of the Upper Rhætic—West of the tunnel—and the lower *Pecten* bed, contain in places all the constituents of a bone bed as defined by Mr. W. H. Wickes.[1] Such deposits may be found both above and below the bone bed now under discussion. This bed is distinguished by having its vertebrate contents more evenly distributed, in greater abundance, and by its position in the general sequence. For, the evidence now available tends to the conclusion that such beds were in process of formation, at approximately the same date, over a large area.

It is true this bed is found in different localities at varying distances above the base of the Rhætic series, but the explanation of this fact, suggested by Mr. L. Richardson, appears to meet the case satisfactorily. He remarks that, "There is evidence to suggest that there were earth-pressures at work at the close of the Keuper Epoch, which caused the deposits to be thrown into slight synclinal and anticlinal flexures. In the depressed areas the earlier deposits of the Rhætic were laid down, and successive overlap on to the marls seems to have taken place." [2]

In this view it would of course be futile to attempt any correlation of the bone beds at different localities, by comparing their position in relation to the amount of Rhætic deposit below. The only method of correlation applicable to this case is to note their relation to succeeding deposits of more constant character, and therefore of less doubtful identity.

Some assistance to this end may be obtained by the application of a table compiled by Prof. Reynolds and Dr. Vaughan, giving a general sequence of Rhætic deposits as exhibited by all the local sections.

General sequence of the Rhætic.[3]

Cotham marble.

Upper Rhætic	V. Shales, *Ostracods* and *Estheria* ...	Description abridged.
	IV. Shales maximum of *Estheria* ...	
Lower Rhætic	III. Dark shales (usually with one or more beds of dark limestone), the maximum of *Pecten valoniensis*.	
	II. Black shale, with occasional thin sandy bands, containing the maximum of *Avicula contorta*, and probably also of *Schizodus Ewaldi* and *Myophoria postera*	
	I. Non fissile black shale with few fossils. Beds poor in *mollusca*, but frequently teeming with *vertebrate* remains.	

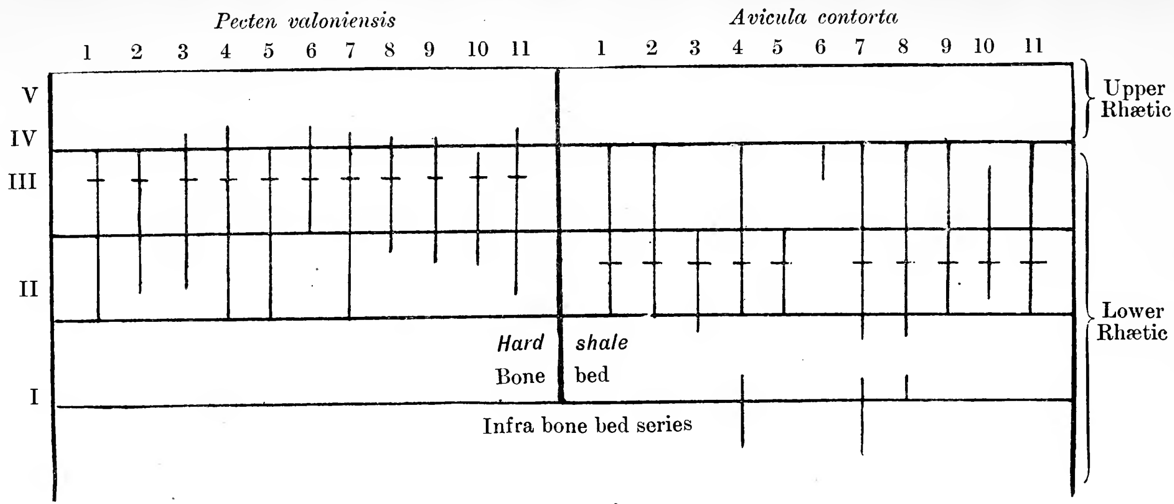
This Table has been applied in Diagrams I. and II.

[1] Bristol Naturalists Society's Proceedings. New series, Vol. X (1904), p. 219.

[2] Quart. Journ. Geol. Soc., Vol. lx. (1904), p. 356.

[3] Quart. Journ. Geol. Soc., Vol. lx. (1904), p. 199.

DIAGRAM II.



Vertical range of *Pecten valoniensis* and *Avicula contorta* as indicated by the most recent records.

1. Pylle Hill. 2. Redland. 3. Cotham. 4. Charlton. 5. Aust. 6. Sedbury. 7. Garden Cliff. 8. Sodbury. 9. Stoke Gifford. 10. Goldcliff. 11. Lavernock.

The record of *Avicula contorta* at Sedbury is probably incomplete.

The short transverse lines indicate the positions of maxima.

It may be now observed that most writers who have described in any detail sections of the Lower Rhætic, note the presence of a hard shale with a paucity of fossils between the softer shale in which *Avicula contorta* is most abundant and the horizon at which vertebrate remains are common ; or, applying another index fossil, below the range of *Pecten valoniensis*, *vide* diagram II., page 17.

The following is a summary of these observations extracted from the descriptions of L. Richardson, Prof. Reynolds and Dr. Vaughan, Dr. Rendle Short, and E. Wilson.

		Ft.	Ins.
1	PYLLE HILL—		
	Black shales, firm, generally unfossiliferous ...	1	6
	Black shale, with pockets of grit, containing bone-bed fossils, including *Ceratodus* ...	0	5
	Keuper		
2	REDLAND—		
	Black shale, hard, not crumbly, very barren ...	1	9
	Bone-bed	0	2
	Green and black marl	0	6
	Ferruginous band	0	1
	Keuper		
3	COTHAM—		
	Black shale, hard, a few specimens of *Avicula contorta* and *Axinus* (no measurement) ...		
	Keuper		
4	CHARLTON—		
	Black shale, hard, very few fossils ...	2	6
	Bone-bed series	0	7
	Black shale, with band of calcareous breccia...	11	6
	Keuper		
5	AUST—		
	Black shale, with arenaceous bands containing *Pullastra*, the upper part hard, very barren	4	0
	Bone bed, 1—6 ins. ... ... averaging	0	4
	Black shale	0	10
	Keuper		
6	SEDBURY—		
	Black shales, firm (no fossils recorded) ...	1	2
	Black shale, earthy	0	6
	Sandstones and shales, alternating ...	0	8
	Bone-bed	0	4
	Keuper		

		Ft.	Ins.
7	Garden Cliff—		
	Black shale, firm, not very fossiliferous ...	1	0
	Black shale with sandstone layers ...	0	7
	Bone-bed	0	1
	Black shales with sandstones	6	5
	Keuper		
8	Sodbury—		
	Black shale, non-fissile, with a rare tooth or vertebra (no measurement)		
	Bone-bed	0	3
	Palæozoic rocks		
9	Stoke Gifford—		
	Black shale, hard, very barren	2	0
	Keuper		
10	Goldcliff—		
	Black shale, firm (no fossils recorded) ...	2	0
	Grit, shale, and sandstones, with bones, teeth, and scales	1	0
	Keuper		
11	Lavernock—		
	Black shale, tough (no fossils recorded) ...	1	1
	Various thin sandstones, limestones, and shales, with fish remains	2	9
	Bone-bed	0	1
	Shales, marls, and limestones, including the "Sully Beds"	16	0

It will be noted in looking through the preceding list that at Cotham and at Stoke Gifford no bone bed was found ; the hard shale at those places resting directly upon the Keuper marl. Probably the explanation of these exceptions is, that the Keuper marls at those places were not submerged when the bone bed deposits were laid down, but that they were submerged sufficiently soon afterwards to receive the sediment which formed the hard shale.

It would appear that wherever in these areas the Lower Rhætic is sufficiently complete, a deposit of bone bed, or some deposit of equivalent character, is found. This deposit is succeeded by a series containing a distinctive barren shale, which occupies a definite position in relation to *Pecten valoniensis* and *Avicula contorta*, viz., below the first appearance of the one and the maximum development of the other.

This similarity of general sequence, lithological and palæontological, over so large an area seems to support the view that the deposits in question are stratigraphical equivalents one of another, notwithstanding their varying position in relation to the apparent base of the Rhætic series.

VI. PALÆONTOLOGICAL NOTES.

Mytilus cloacinus, sp. nov.

Anterior outline slightly arcuate, ventral margin rounded, posterior margin gently convex as far as the hinge line, which is straight and equals one-third the length of the shell. Beak angle 40 degrees. Valves obtusely carinated from the beaks to the antero-ventral border, sloping evenly from the carina to the posterior margin, and sharply on the anterior side. Growth halts well marked.

The specimens are generally casts: some fragments of the shell which have been observed do not exhibit any ornament.

Dimensions, length 42 mm., width 21 mm., thickness 12 mm.

Geological position; Lower Rhætic.

Remarks—The specimen figured is a nearly complete cast from the bone bed at Aust Cliff. Examples have also been collected from the bone beds at Sedbury and at Charlton. This fossil appears to be not uncommon on the bone bed horizon, but, so far as I can discover, it has been found at no other level.

Cardinia concinna, Sow; *C. aff. regularis*, Terquem, Vaughan.

A. Vaughan, Quart. Journ. Geol. Soc., Vol. lx. (1904), Pl. xviii., fig. 4, p. 204.

This shell is rather common in the upper part of the *Avicula contorta* shale at Charlton.

Protocardium (Cardium) Phillipianum, Dunker.

W. Dunker, "Palæontographica I." (1847), t. xvii., f. 6, p. 116.

Cardium rhæticum, Merian.

P. Merian, Geol. Bermerk. u.d. Nordl. Vorarlberg (1853), t. iv., fs. 40 and 41, p. 19.

It may be that Merian's shell is specifically distinct, but, in practice, it has been found impossible to separate the Rhætic specimens of this genus from those found in the White Lias and *Pleuromya* beds.

Pleuromya (Pteromya) crowcombeia, Moore, Tate.

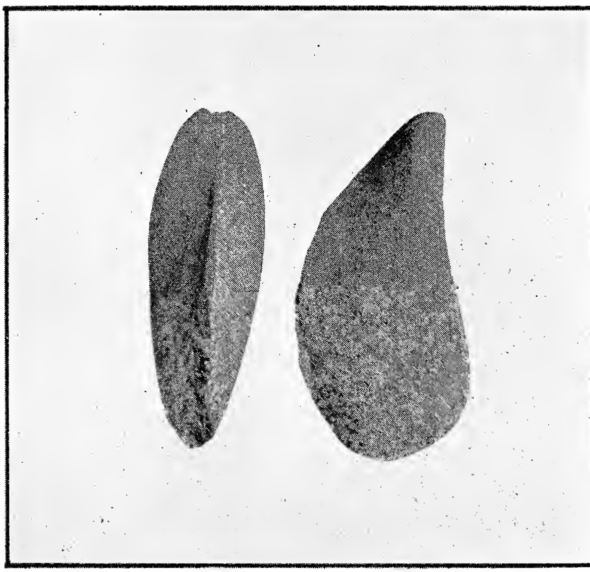
R. Tate "Yorkshire Lias" (1876), Pl. xiii, fig. 10, p. 406.

The identity of Moore's small shell from the Rhætic, with the much larger examples from the White Lias and *Pleuromya* beds, is doubtful.

Modiola minima, Sow, Moore.

C. Moore, Quart. Journ. Geol. Soc., Vol. xvii. (1861), Pl. xv., fig. 26, p. 505.

The *Modiola* thus indicated in this paper has not been found outside the White Lias, in which, after *Pleuromya crowcombeia*, it is perhaps the commonest fossil. It is specifically distinct from the small *Modiola minima*, Sow, and should receive another name.



Mytilus cloacinus, sp. nov., Rhætic bone bed.—Aust Cliff.

Arcomya cf. *(Thracia?) subrugulosa*, Dunker.

W. Dunker, "Palæontographica I." (1847), t. xvii., f. 3.

Specimens which are in general agreement with Dunker's figure occur rarely in the *Pleuromya* beds. They differ in having the umbones rather more elevated, and the posterior margin more obliquely truncate. Our shell is allied to the genus *Arcomya*, Ag.

Unicardium (Lucina) arenacea, Terquem.

M. O. Terquem, "Palæont.' de Hettange" (1855), t. xx., f. 8.

This species is distinguished from *Unicardium cardioides*, Phillips, by its more equilateral and less quadrate form. The beaks are not directed forward to the same extent as in the last named shell.

Myoconcha psilonoti, Quenstedt.

F. A. Quenstedt, "Der Jura" (1858), Tab. iv., fig. 15.

Casts of a large *Myoconcha* from the *Pleuromya* beds are somewhat doubtfully referred to this species.

Astarte obsoleta, Dunker.

W. Dunker, "Palæontographica I." (1848), t. xxv., fs. 8, 9, p. 178.

Astartes of rather small size with concentric ridges only in the young stage, are referred to this species. They are rare in the White Lias but common in the *Pleuromya* beds.

Astarte consobrina, Chapuis and Dewalque.

M. F. Chapuis and M. G. Dewalque, "Foss. du Luxembourg" (1855), Pl. xxii., fig. 3, p. 149.

This *Astarte*, often confused with *A. obsoleta*, is quite distinct in form, and the concentric ridges are present at all stages of growth. It appears in the upper part of the *Am. torus* beds, and becomes common in the *angulatus* zone.

My best thanks are due to Messrs. H. Lovatt & Co., the contractors for the Railway, for facilities afforded in the examination of the sections, to Dr. A. Vaughan for assistance in various ways, and to Mr. W. H. Wickes for many valuable suggestions and help in the field work.

On an Ancient Skull from the Cave of Lombrive in the Pyrenees, and a comparatively Modern one from Wiltshire.

By John Beddoe, M.D., LL.D., F.R.S., &c.

THIS skull was discovered between forty and fifty years ago, in the celebrated cave of Lombrive in the Pyrenees. It came into the hands of Mr. Philip John Worsley, who brought it to England and presented it to me; and he and I have now the pleasure of handing it over, as our joint gift, to the Bristol Museum, whose collection of crania has now attained considerable proportions and value.

The skull in question was embedded in stalagmite, and though it is not possible to give it anything at all approaching to a date, we cannot, I believe, be wrong in putting it at least far back in the neolithic period, if not even earlier. Like Mr. Burnard's Cattedown fragments, for which he plausibly enough claims palæolithic antiquity, and on which I have myself reported in that belief, it is an instance of a very early human relic displaying rather high characteristics.

It is true that for a male, as I take it to be, it is small in capacity and in most of its measurements; but it is not coarse in lineaments or over thick or heavy: the bounding curves are soft, and the skull, though rather narrow, is "well filled." It is not prognathous nor platyrrhine. The vertical aspect is elliptic rather than anything else: the lower occipital, from the inion to the opisthion, is shorter than usual. The sutures generally are open, and the teeth are sound, and though somewhat worn, do not indicate advanced age. The orbital index is somewhat low, about 77. The well-balanced form of the skull seems to lead to a degree of agreement in the various estimates of capacity which is unfortunately not very common. The average resultant of ten methods is 1320 cubic centimetres, of six diametral ones 1324, of four peripheral ones 1316 (which is also exactly my own estimate). The extremes are Welcker's C (Diametral), which is 1294, and Pearson's basio-bregmatic (also Diametral) which rises to 1360. The peripheral and diametral methods here agree wonderfully well when averaged; but the former agree better among themselves and are most satisfactory. In the British skull which I am presently to describe, you will find a different state of matters.

Broadly speaking, I should ascribe this skull to the Mediterranean race, that is, to one of its remote ancestors; but I do not recognise any special likeness to the old Cromagnon men, nor yet to the modern Basques.

As to the provenance of the second cranium, there is little to be said. It came from a long-disused Quakers' burying-ground in Bradford-on-Avon, and may with great probability be described as having belonged to a Wiltshire Quaker of the eighteenth century or thereabouts. It found its way into the possession of Mr. H. W. Pearce, of Bradford-on-Avon, who at my instigation has presented it to the Bristol Museum.

It is probably, but not certainly, masculine, and is not far off the average in size, its length being above, and its maximum or parietal breadth equal to, the standard, while its altitude is distinctly below it, the skull being platykephalic. It is not characteristically English; I should put it between the sphenoid and parallelopipedal types of Sergi. This type does however occur among Dr. McDonell's seventeenth century London skulls, and there is an instance of it among Mr. John Pritchard's Carmelites, which are now in our Museum. The forehead is vertical, but narrow and low, and the parietal breadth, though comparatively large, yields an index of only 76·3, which is mesatikephalic, and close to the ordinary English mean.

I have said that I think this cranium masculine, but the conjecture is grounded almost entirely on its size. On the other hand the absence of strong muscular impressions, the verticality of the forehead, and the large size of the lower occipital, may point in the other direction. It is, however, as I think, probable that the Quakers of the eighteenth century, drawn as they were from the middle rather than from the labouring class, would not exhibit, as a body, any great evidence of muscular development.

The estimation of the capacity is rather more interesting than usual. I have tested it by ten different methods, six of which are based on diameters, and four on peripheral arcs. The former yield an average of 1423 cubic centimetres, the latter of 1542, and the largest of the former (Pelletier's) is less by 78 than the smallest of the latter (Beddoe's). The discrepancy depends on the platykephalic form, or in other words on the relative smallness of the vertical diameter. The contrast with the higher and more regularly formed Lombrive skull is striking.

The nearest approach to accuracy is likely to be gotten by averaging the results of at least one peripheral and one diametral process.

TABLE OF MEASUREMENTS.

		Lombrive.	Bradford-on-Avon.
Length.	Glabello-max.	179 M.M.	186 M.M.
	Fronto-inial	165	189
	Glabello-inial	169·5	183
	Ophryo-max.	174	185
	Facial	59·98 ?	59. 98 ?
Breadth.	Frontal min.	93·5	90
	Stephanic	110·5	111
	Zygomatic	129 ?	121
	Auricular	113·5 ?	111
	Maximum	131	142 pl.
	Mastoid	Large	128
	Asterial	108 ?	113

TABLE OF MEASUREMENTS.—*Continued.*

		Lombrive.	Bradford on-Avon.
Nasal		45 ? 22 M.M.	— M.M.
Orbital		37. 29	37. 32
Arcs.	Circumf.	498	534
	Sagitcal Frontal	120	145
	to Lambda	247	279
	to Inion	318	335
	to Opisthion	360	396
	Transverse (Q) to Mid-ear	310	313
	Vert. to upper border	304	310
Length.	Foramen	34. br. 31	33
	Basio-nasial	105	92·5
	Basio-alveolar	100	—
Height.	Basio-bregmatic	134	128
Indices.	Latitudinal	73·2	76·34
	Altitudinal	74·8	68·8
	Nasal	49·3	—
Capacity.	Diametral Processes—		
	Welcker C.	1294 C.C.	1406 C.C.
	Pearson 12	1360	1418
	P. and Lee	1330	1420
	Manouvrier	1309	1420
	P. and Lee, 10 bis.	1336	1436
	Pelletier	1313	1440
	Peripheral Processes—		
	Beddoe	1316	1518
	Pearson	1325	1531
	Pearson G. F.	1322	1541
	Welcker D	1300	1578
Average of ten		1320·5	1471

Pebble-swallowing Animals (a sequel to "The Rhætic Bone-Beds.")

By W. H. Wickes.

PARTICULAR attention was called in the previous paper to the Quartz pebbles so frequently found in the Bone-Beds, associated with the animal remains, and evidence was brought forward to show the probability that the pebbles had been swallowed by the various creatures during life. Since the publication of that paper so much additional evidence on the subject (both old and new) has been collected that it may be of interest to place before you these further facts, and also to state the varied and peculiar theories advanced in explanation of this curious phase of animal life.

The earliest definite report the writer has seen is in 1858,[1] where a note appended to a paper by Godwin Austen states: "M. Deslongchamps, of Caen, pointed out many years since that modern Crocodiles are in the habit of swallowing pebbles, and he suggested that certain smoothly rounded stones, which are occasionally found in the fine-grained oölitic strata of Normandy may have been voided by the Crocodiles of the period.

I am indebted to Mr. Bowerbank for the information that Sharks also swallowed small stones, hence another agency by which the shingle of the White Chalk may have been transferred to areas of deep sea."

The next notice is nearer our own district.[2] In 1866 Mr. T. Codrington, F.G.S., writing on the geology of the Berks and Hants Railway, reports, "Near the east end of Savernake tunnel the scapulæ, with some ribs and vertebræ of a Plesiosaurus were found. It is remarkable that among the ribs were some six or seven grey quartzose pebbles, varying from half-an-inch to an inch in diameter. I never saw another pebble in the sand, and these occurred at some depth below the Chloritic Marl, in which there are sometimes small pebbles, although none occur in it here." (This specimen is now in the Natural History Museum, South Kensington, in the same cabinet with another, labelled "Gizzard-stones in Peloneustes, from Oxford Clay, Peterborough.")

In 1867[3] Mr. W. S. Burton, F.G.S., writing on "Rhætic Beds near Gainsborough," notes "the occurrence here and there in the bed of small smooth pebbles, principally quartz, which in all probability the fishes of those days, like the Cod and other fishes of our own that take their food off the ground, had swallowed, either by chance or purposely, for the sake of the zoophytes and other substances encrusting them."

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[1] Q.J.G.S., Vol. xiv., p. 258. [2] Wiltshire Arch. Mag., Vol. ix., p. 170.
[3] Q.J.G.S., Vol. xxiii., p. 318.

Ten years afterwards[1] the matter was brought before the Geological Society by Professor Seeley, the report of which is as follows :

ON MAUISAURUS IN GAULT, AT FOLKESTONE.

"In the lower dorsal region of the animal about a peck of ovate and rounded pebbles occurred, of a diameter from quarter of an inch to nearly two inches. They are chiefly of opaque milky quartz, several are of black metamorphosed slate, and a few of fine-grained sandstone and hornstone, some of the pebbles showing a veined character, such as might be derived from the neighbouring Palœozoic rocks of the North of France. Pebbles being of such rare occurrence in the Gault, it would seem natural to account for these associated stones on the hypothesis that they were swallowed by the animal with food, as is the case with certain living reptiles and birds.

If this view should be held admissible, it would suggest that as the teeth were too small for anything but prehension, a structure analagous to a gizzard, or the stomach of an Edentate, may have used these pebbles to assist in breaking up or crushing the food on which the Saurians lived."

In the subsequent discussion, Mr. J. W. Hulke suggested "that the animal may not have swallowed the pebbles as an aid to the comminution of food in its stomach, but that they were introduced in the stomachs of fish which it had swallowed. The flesh and subsequently the bones of these would be digested and absorbed, whilst the indigestible stones, if the stomach of the Plesiosaurus was like that of Crocodiles, would be unable to pass through the small pyloric opening into the intestine, and must permanently remain in the stomach."

Ten years later (1887)[2] we find a paper on this subject in our own Society's Proceedings entitled, "Remarks about Seals and their so called 'Ballast Bag,'" by A. J. Harrison, M.B., Lon. This extremely interesting paper is too long to quote in full, and as it has been already printed in the Proceedings we must be contented with a summary of the main features. The writer (who has had a large and varied experience of the diseases and peculiarities of animals) first had his attention drawn to the subject by the discovery that a Seal, which had died in the Clifton Zoological Gardens, had a number of pebbles and other indigestible matter in the stomach. Further, on visiting a relative (the Rev. F. W. Bindley), he was shown what was called the "Ballast Bag" of a Seal (or Sea-lion), from the Cape of Good Hope, containing a large number of pebbles, and was informed that at the Cape fisheries the finding of such bags of pebbles was not at all unusual. Also, that about 1873 a small local commission was formed to investigate the matter, and several of these pebble bags were obtained and brought home. Further, that conferring with Mr. Bland Sutton (pathologist to the London Zoological Society), it was stated that all Sea-lions examined there after death contained a varying amount of stones in their stomachs, and (an important feature) in all cases the

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[1] 1877, Q.J.G.S., Vol. xxxiii., p. 546.

[2] Bris. Nat. Proc., Vol. v., Part iii., 1887—8, p. 290.

stones found were foreign to the locality and not such as would be picked up in the Gardens. They must have been in the stomach for years. All were beautifully rounded and polished. (At the reading of this paper one of these stomachs from the Cape filled with pebbles was exhibited, being kindly lent by Dr. Harrison, and formed a most interesting and convincing piece of evidence. The whole length is 14 inches, and largest circumference $9\frac{1}{2}$ inches; in its dried state it weighs 2 lbs. 2 ozs., and as the viscus is probably only 2 ozs. or less, there must be quite 2 lbs. of stones—all of these, which can be seen through the small incisions made, are of white or pale quartz, well rounded, and of a silky smoothness, very different in the latter respect from the ordinary beach pebble. Judging from the average weight of those which can be removed, it is estimated the number of the pebbles in this stomach would be from 90 to 100).

Some years afterwards, in 1894, the same writer, in his Presidential Address to the "Bristol Medico-Chirugical Society," again refers to the subject as follows: "It is not at all an uncommon thing to find in the stomachs of Seals quantities, even large quantities, of stones, gravel, and pieces of rocks, rounded off, which have evidently been in the stomach a very long time. This condition is found in the Sea-lions, or Cape Seals, to a more marked extent than in ordinary Seals. I have the notes of a case where ten pints of stones, weighing twenty-two pounds, were found. The explanation of the reason does not seem very clear. The stones are doubtless swallowed, but for what purpose? The tradition amongst the Seal hunters is this, that when the Seals get very fat they cannot sink themselves in the deeper water with the same facility as when they were thinner, and so they take in the stones as ballast, and the stomachs, with their strange contents, are locally known as 'Ballast Bags.'

The theory is a pretty one, almost romantic, but I don't think we can accept it. I collected a good deal of information about this subject some years ago, and embodied the results in a paper I had the honour of reading before the 'Bristol Naturalists' Society.' I think that probably there is a physiological reason." (These notes by Dr. Harrison will be further referred to later on).

Some observations by two French geologists appear in the "Bulletin Soc. Geologique de France," C. Janet (1891), and Vaillant (1892), both of whom give numerous instances of pebbles found in fishes, proving the possibility of their being transported from their original to other localities by such means.

Frank T. Bullen (the well-known author of many excellent works on Marine Life) writes (1904), "All Seals and Penguins (which are a sort of connecting link between seal and bird) have a habit of swallowing large quantities of stones, most probably for digestive purposes, since they do not masticate their food. These stones, after some time, naturally have their angles rubbed off and become pebbles, like the smaller fragments in a bird's gizzard."

In his entertaining work, "Creatures of the Sea" (1905), he refers to the Penguin in the following quaint passage, "A ballasted bird . . . Like most of the Seals, and for probably the same hidden digestive reasons, the Penguin thinks well to burden his belly with boulders. Sir James Ross notes that in the stomach of one of them he found ten pounds weight of quartz, granite, and trap. Well, the poor thing needs, no doubt at too frequently recurring times, something to impart a sense of fulness and stability to the stomach; for that organ is not only of huge size in proportion to the build of the bird, but has in common with the Seals and Sharks, and the majority of Deep Sea People, a flood of digestive juices capable of dealing almost (as a sailor would say) with scupper nails!"

It is a curious fact (which has occurred many times in scientific and other matters) that two or more observers, working at the same time on a certain subject, at a distance from, and entirely unknown to each other, should have been investigating similar phenomena, and arrived at similar conclusions in explanation of the facts. This is commonly termed "the long arm of coincidence," and in this instance it certainly is a long arm, extending many thousands of miles! While the writer was working out the problem of the pebbles in the Rhætic Bone-Beds, certain North American geologists were engaged on the pebbles found with remains of Saurians in Kansas and South Dakota. The following extracts from their reports furnish important evidence on the subject:—

Kansas State Board of Agriculture (1st biennial report, p. 62). Professor Mudge, writing on the fossil Plesiosaurs found, notes "another interesting feature, showing an aid to digestion similar to that of many living reptiles and birds. This consists of well-worn siliceous pebbles, from a quarter to half-an-inch in diameter . . . They were the more curious as we never found such pebbles in the Chalk or Shales of the Niobrara." (These pebbles are now in the Yale collection).

Dr. Williston (Palæontologist to the University of Chicago)[1] writes: "At Ellsworth, Kanas (Benton Limestone), were found Plesiosaur bones with a lot of siliceous stones, 125 pebbles, with several vertebræ and ribs. Some pebbles were still attached to the ribs by the original matrix, showing deposition was contemporaneous with that of the skeleton. The pebbles vary in weight from 1 gramme to 170 grammes. The smaller ones were worn into more or less perfect ellipsoids, but the larger ones are more irregular in shape, having suffered less abrasion.

It seems probable that most of the pebbles had been obtained by the animal from the sea beaches bordering the Black Hills, but not a few of them, consisting of red quartzite, are quite identical with the quartzite boulders so often found in the drift of Eastern Kansas, which have come from the vicinity of Sioux City, Iowa.

The specimens show conclusively that the pyloric orifice must have been well provided with a sphincter, and that no solid substances passed into the intestinal canal; one need never expect to find plesiosaur coprolites containing undigested remains of bones or other solid material.

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[1]Field Columbian Museum, No. 73 Geological Series, Vol. ii., No. 1, Plate, xxix.

The nearest place where the animal could have found such pebbles on the sea beaches must have been several hundred miles away from Ellsworth. We may conclude therefore that the Plesiosaurs were roving animals."

In a further letter, 1905 (accompanied by a capital photograph of Plesiosaur stones) Dr. Williston writes: "Whether all pebbles in such bone-beds can be ascribed to marine organisms, I have considerable doubt, but that in many instances that is the real case I have little doubt.

In the Cretaceous of Western Kansas there are, in isolated localities, thin bone-beds with numerous small rounded siliceous pebbles, intermingled with the remains of fishes and reptiles. To have ascribed their occurrence in such places to the carrying action of water seemed to me very improbable, since the nearest land regions of those times were several hundreds of miles away, and a continuous land connection is entirely out of the question. Nor could sea currents have carried them through such great distances.

I had for that reason, long before, reached practically the same conclusion that you have, that they were the residue of the stomach contents of fishes and reptiles."

In 1904[1] Mr. Barnum Brown (American Museum of Natural History, New York) writes: "During the summer of 1903 the writer collected fossils in the Niobrara Shales of South Dakota. In nearly every instance of Plesiosaurs a large number of siliceous stones were found associated with the bones, often embedded in the matrix en masse. In one specimen, in which the largest dorsal vertebræ were four inches in diameter, there were at least half a bushel of these stomach stones, ranging from the size of a walnut to four inches across . . . The conclusion seems evident that invertebrate animals (Baculites, Scaphites, &c.) formed a large part of the food of Plesiosaurs, and that in default of crushing teeth the breaking up of the food was effected by the aid of these stomach stones, the presence of which further implies a thick-walled gizzard-like arrangement in the alimentary canal."

THEORIES.

The preceding evidence being ample for the subject, we can now consider the various theories which have been envolved to account for the presence of these pebbles.

The first one is that of the fishermen, that the stones are swallowed as "ballast" to enable the animal to swim lower in the water. This theory has a wide range, being held not only by the Sealers of Cape Colony, but also by the Cod-fishers of Newfoundland and other parts. However, as Dr. Harrison has demonstrated in his paper, this has no foundation, the so-called "ballast bag" being really the stomach, and further, the creature does not appear to be able to eject the stones when they are no longer required for "ballast." These two objections are sufficient to dispose of this idea, which is simply an ingenious but fallacious attempt to account for the stones in the animal's interior.

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[1] "Science," Vol xx., p. 184.

The second theory is that the pebbles are swallowed by accident, that is, the animal in feeding on succulent material, such as sea-anemones, spawn, or other adhesive delicacy, might swallow any stones adhering thereto. This theory may account for a small portion, but stones taken in this manner would be of all sorts and varieties, both as regards composition and color, but this does not accord with the facts, for (as will be shown later on) the pebbles found are nearly all of a certain class, and singularly uniform in their nature, so that, while not denying that a small percentage may be attributed to accident, this cause is quite insufficient to account for the majority of those found.

The third theory is that they are taken inadvertently, *i.e.*, by mistake. It is quite possible this may sometimes occur. We all know that wet pebbles frequently "look nice," and a young and silly fish or seal might be taken in by appearances and bolt a pebble or two, just as the human baby will swallow marbles and other indigestible trifles! This would accord with the fact recorded by more than one observer, that seal pups have been seen playing on the ice with pebbles, and they may occasionally swallow a few. But the same objection applies to this theory as to the previous one, that it only covers a small portion of the ground, and leaves the main question untouched.

The fourth theory, which meets the facts better than any of the others, is that these stones were swallowed intentionally for the purpose of assisting digestion. In reviewing the evidence several important points stand out prominently. The first is that all the animals noted as addicted to this habit (both recent and fossil) were fish-eaters, that is, creatures which lived mainly or entirely on fish. The second point is that all of them were either entirely or practically deficient in molars or crushing teeth. It is true the Seal family have molars, but (as pointed out by Dr. Harrison) they are mostly of a trenchant or chisel-like character, and more useful for cutting or separating than for grinding or masticating purposes. The third point is equally important. A comparison of the pebbles found, whether in the rocks or recent animals, shows a remarkable similarity in general character. They are nearly all siliceous (quartz, quartzite, or kindred rock), a very small percentage being non-siliceous, and another peculiar feature is, they are nearly all white, or very light tints approaching white. Further, they agree in shape, size, and general characteristics. Dr. Williston kindly sent an excellent photograph of Plesiosaur stones from Kansas, and when this is compared with the pebbles in the Rhætic Bone-Beds, or in the recent Sea-lion's stomach, the "family likeness" is undeniable.

As regards the whiteness of the greater part of the pebbles, this is a remarkable feature, as in most pebble-beds or beaches white quartz pebbles are scarce, the great majority being dark or full-colored, exactly the reverse of the "stomach stones." This certainly indicates that these stones were purposely selected by the animals as being the most suitable for the purpose required, and that can only be as an aid to digestion. (As regards selection of material by animals, numerous cases are known, one which comes pretty close to this subject being the domestic fowl, which selects flint for its gizzard if it can get it. This is so well known to poultry farmers that "Flint-grit for fowls" is kept in stock at many seed-shops).

As most of the fish-eating creatures either swallow their prey whole or in chunks, and are also terrible gluttons, a great strain must be thrown on their digestive organs, and there is little or no doubt that these pebbles are useful in breaking up the food by acting as a crushing mill, and thereby greatly facilitating the process of digestion. This appears to be the most reasonable solution of this interesting question, and in accordance with the observed facts.

As regards its application to Geology, it explains the presence of small quantities of pebbles in deposits to which they are foreign (especially when associated with animal remains). These have frequently been hitherto accounted for by various theories (such as drift, &c.) of an inconclusive and unsatisfactory character.

SUMMARY.

A Summary of the principal points in this paper may be of service :—

1.—That there is abundant evidence from various sources that sundry animals, both fossil and recent, have acquired a habit of swallowing stones, sometimes in considerable quantities.

2.—That the animals addicted to this practice were fish-eaters, and were also partially or entirely deficient in true molars, or crushing teeth.

3.—That the stones found in or with these animals are nearly all of the same character as regards their composition and color, an enormous majority being either white or pale-colored Silica.

4.—That this clearly indicates they were not taken indiscriminately, but purposely selected.

5.—That the only purpose for which they could have been useful was as an aid to digestion, somewhat analagous to the well known action of the gizzard-stones in graminivorous birds.

The following is a list of animals reported as "stone swallowers":— Reptiles—Plesiosaurus, Mauisaurus, Peloneustes, Elasmosaurus, Teleosaurus, Crocodile. Cetacea and Fishes—Seal, Sea-lion, Walrus, Dolphin, Porpoise, Shark, Dog-fish, Cod, Hake, Sting-ray. Birds—Penguin.

(It has been further reported that pebbles resembling "stomach-stones" have been found with remains of Brontosaurus and Diplodocus, but as no definite details have as yet come to hand, these giants can only be mentioned provisionally).

This list, as well as the evidence in connexion therewith, might be extended, but as it is possible that the matter before you is quite as much as you are likely to swallow at one sitting, it may be the best policy to conclude, thanking you for your kind attention.

Silurian Fossils from certain localities in the Tortworth inlier.

By F. R. Cowper Reed, M.A., F.G.S., & S. H. Reynolds, M.A., F.G.S.

In a forthcoming part of the *Quarterly Journal* of the Geological Society (that for November, 1908) is a paper by us dealing with the fossiliferous rocks of the Southern half of the Tortworth inlier. To this paper tables are appended giving general fossil lists from various parts of the area, but not giving as a rule the detailed lists from each individual locality. We have thought that these detailed lists are of sufficient importance to local geologists to merit publication in the proceedings of the Bristol Naturalists' Society. Hence the following paper, which is to be regarded as supplementary to that referred to above. As there described the fossils come partly from rocks of Llandovery, and partly from rocks of Wenlock age.

(1) THE LLANDOVERY ROCKS.

(a) *The Avening Green, Damery, Ironmill Wood, and Tortworth areas.*

The above localities lie on the outcrop of the most fossiliferous Llandovery rocks of the district, a series of grits, shales, and sandy limestones having a thickness of some 500 ft. and lying between the two bands of trap which, as is well known, occur associated with the Llandovery in this region.

The following fossils are from Avening Green, mainly from the river side exposure, but in part from a trench dug in one of the cottage gardens, and from blocks scattered over the surface of the fields to the north and west of the hamlet :—

Vioa prisca
Lindstrœmia bina
,, *subduplicata*
Streptelasma elongatum
Palæocyclus preacutus
Favosites forbesi ?
Cornulites sp.
Tentaculites anglicus
Dinobolus davidsoni
Cœlospira hemispherica
Strophomena ? arenacea
,, *compressa*
Strophonella euglypha
Orthis elegantula
,, *polygramma*
Meristella sp.
Rhynchonella nucula
,, *serrata*
Stricklandinia lens
,, *lirata*
Atrypa reticularis
Leptæna rhomboidalis
Spirifer sp.
Chonetes striatella var.
Holopella sp.
Pleurotomaria sp.
Horiostoma globosum
Cyclonema corallii
Tentaculites anglicus
Orthoceras sp.
Encrinurus punctatus
Phacops weaveri
Calymene sp.

Lord Ducie's collection contains two well-preserved tails of *Encrinurus punctatus* in a fresh grey limestone from Avening, also a tail of *Phacops caudatus.* The calcareous Llandovery sandstone occurring by the stream at Avening Green is again seen in the neighbourhood of Damery Bridge where the rocks are better exposed and more fossiliferous than anywhere else in the district.

The following fossils have been obtained from the small quarry and the road section to the south of Damery Bridge—both of these exposing the same rocks :—

Favosites forbesi
Lindstrœmia bina
" *subduplicata*
" *subduplicata* var *crenulata*
" *uniserialis*
Streptelasma elongatum
Cœnites juniperinus
Chonetes striatella var.
Stropheodonta compressa
Strophomena ? arenacea
Orthis elegantula
" *hybrida*
" *calligramma*
Spirifer crispus
" *elevatus*
Cœlospira hemispherica
Rhynchospira baylei
Atrypa reticularis
Meristella sp.
Rhynchonella serrata
" *nucula*
Pentamerus undatus ?
Leptœna rhomboidalis
Stricklandinia lens
" *lirata*
Plectambonites sp.
Loxonema sp.
Bellerophon sp.
Murchisonia sp.
Holopella sp.
Tentaculites anglicus
Cornulites serpularius
Primitia sp.
Calymene blumenbachi
Phacops elegans
" *weaveri*
" *downingiæ*
Encrinurus punctatus
Cheirurus sp.

The commonest fossils are *Atrypa reticularis*, *Cœlospira hemispherica*, *Rhynchonella nucula*, and *Strophomena compressa ; Spirifer crispus* and *Phacops weaveri* are also common.

The Jermyn Street Museum contains the following fossils from Damery Bridge not represented in our collection :—

Monograptus priodon
Cyrtia exporrecta
Spirifer plicatellas
Eichwaldia capewelli
Ptilodictya lanceolata
Holopella obsoleta
" *tenuicincta*
Pterotheca acirostris
Actinoceras subconicum
Prœtus sp.

The Bristol Museum contains the following fossils from Damery Bridge not represented in our own or in the Jermyn Street collections :—

Orthis reversa var. *mullockensis*
Orthonota sp.
Pterinea retroflexa
Goniophora cymbæformis
Bellerophon trilobatus
Pleurotomaria (large species)

Exposures of sandstone and sandy limestone along the hedge bank to the north of the road leading from Damery quarry to Charfield Mills were found to contain the following fossils :—

Ptilodictya sp.	*Rhynchonella nucula*
Atrypa reticularis	,, *serrata*
Cœlospira hemispherica	*Modiolopsis* sp.
Chonetes striatella var.	*Horiostoma globosum*
Spirifer elevatus var.	*Loxonema sinuosa*
Orthis elegantula	*Tentaculites anglicus*
Strophomena compressa	*Encrinurus punctatus*

Many of these species were also found in a roadside exposure to the west of Damery Bridge.

The following Llandovery fossils, practically in situ, were also found on the slope of the hill just south of the old trap quarry at Whitehall Villa :—*Encrinurus punctatus, Spirifer elevatus, S. crispus, Cœlospira hemispherica, Atrypa reticularis.*

Further to the west at Ironmill Wood the same rock-series occurs, and the following fossils were found, mainly in loose blocks in the wood :—

Lindstrœmia bina	*Stricklandinia lirata*
,, *subduplicata*	*Rhynchonella nucula*
Favosites forbesi	,, *serrata*
Strophomena arenacea	*Platyceras* sp.
Strophonella sp.	*Holopea* sp.
Orthis elegantula	*Tentaculites* sp.
Scenidium lewisi ?	*Phacops (Phacopidella)* sp.
Atrypa reticularis	,, *(Dalmanites)* sp.
Spirifer crispus ?	*Encrinurus punctatus*
Plectambonites transversalis	*Beyrichia* sp.
Leptæna rhomboidalis	

We further found the following fossils in a little copse by the stream about 250 yards north of Crockley's Farm :—

Lindstrœmia subduplicata	*Chonetes striatella* var.
Streptelasma elongatum	*Spirifer* sp.
Atrypa reticularis	*Stricklandinia lens*
Leptæna rhomboidalis	*Phacops weaveri ?*
Rhynchonella sp.	Crinoid stems

(b) The Charfield Green Area.

This patch of Silurian rocks, which has a maximum length of about a mile, and a width of about half-a-mile, is surrounded on all sides by Keuper. The most important fossil locality is Cullimore's quarry, where a highly fossiliferous calcareous ash is seen overlying the upper trap band. Fossil lists from this locality are given in the *Quarterly Journal of the Geological Society.*[1] At many points, however, the main

[1] Vol. 57 (1901) p. 271, and Vol. 64 (1908), p. .

Llandovery horizon between the two trap bands has yielded fossils. The first exposure to which we wish to refer is one by a little pond a short distance N.W. of Pool Farm, where from calcareous Llandovery sandstone the following species of fossils were obtained :—*Palæocyclus* sp., *Atrypa reticularis*, *Rhynchonella serrata*, *Strophomena* sp., a gastropod and crinoid stems.

The main part of this exposure dips at 15° S.S.W., but part dips W. 20° S. at a high angle.

Abundant Llandovery débris was found at several points in the fields between Pool Farm and Charfield Mills.

Débris from the field immediately to the north of Pool Farm contained the following fossils :—

Lindstrœmia subduplicata	*Atrypa reticularis*
Rhynchonella serrata	*Tentaculites anglicus*
Cœlospira hemispherica	*Encrinurus punctatus*

The following fossils were obtained in calcareous sandstone of the usual type in an old greatly overgrown quarry about 150 yards E.N.E. of Charfield Station :—

Cœlospira hemispherica	*Spirifer elevatus*
Rhynchonella nucula	,, *crispus*
Atrypa reticularis	*Holopella* sp.
Strophomena ? arenacea	*Tentaculites* sp.
Chonetes striatella var.	*Phacops weaveri*
Strophonella euglypha ?	*Lindstrœmia ?* sp.

Inspection of the map of Buckland and Conybeare shows this to be probably Long's quarry, from which *Phacops weaveri* and *Cœlospira hemispherica* in the Jermyn Street collection were obtained. Weaver[1] mentions the occurrence of strontian sulphate in Long's quarry.

Abundant débris in the cultivated field in front of the cottages to the south contained :—

Strophomena compressa	*Pleurotomaria* sp.
Cœlospira hemispherica	*Tentaculites anglicus*
Chonetes striatella ?	*Phacops weaveri*
Orthis elegantula ?	*Encrinurus punctatus*
Atrypa reticularis	Crinoid stems
Rhynchonella nucula	*Lindstrœmia* sp.
Goniophora cymbæformis	

The following fossils in Lord Ducie's collection from Charfield railway cutting probably came from a point not very far removed from this spot :—

Strophomena ? arenacea	*? Murchisonia* sp.
Encrinurus punctatus	*Gomphoceras* sp.
Phacops weaveri	*Trochoceras* sp.

[1] Trans. Geol. Soc. 2nd Series. Vol. 1, p. 334.

NOTE.—Long's, Cullimore's, Ponting's, Barber's, and Horsley quarries are referred to under these names in Buckland's and Conybeare's paper. These quarries have all been abandoned for many years, and are not now known by these names.

Many exposures occur in the bed of the little stream, which, flowing in a north-easterly direction, joins the Little Avon near Ebury Hill. The lower trap band is well exposed in the stream and field to the south, and to the east of the trap band and dipping under it at a low angle is calcareous sandstone with *Cœlospira hemispherica*. To the west, and therefore overlying the trap band, is red micaceous sandstone, in which occurred :—

Cœlospira hemispherica
Strophomena compressa
Chonetes striatella var.
Horiostoma globosum
Phacops weaveri
Tentaculites sp.
Crinoid stems

To the west of the railway line Llandovery sandstone, dipping at 30° to 35° W.S.W., occurs in the bed of a little stream about midway between Vine Cottage and Hillhouse Farm, and yielded *Atrypa reticularis*. A short distance further north at Fowler's Court Farm, there is a considerable exposure of Llandovery dipping 10° W. 15° S. Here we obtained the following fossils :—

Encrinurus sp.
Cornulites scalariformis ?
Spirifer sp.
Stricklandinia sp.
Leptæna rhomboidalis
Rhynchonella serrata
Lindstrœmia sp.

(2) THE WENLOCK ROCKS.

(a) The Whitfield and Falfield areas.

By far the most important locality for Wenlock fossils in the district is Whitfield, where there are two old quarries, one to the east of Brinkmarsh lane (Rifle Cottage quarry), one to the west (Brinkmarsh quarry). Many fossils from these quarries are in all the principal collections, as is shown by the following list :—

R. = Rifle Cottage quarry. W. = Whitfield or Brinkmarsh quarry.

	Our Collection.	Bristol Museum.	Lord Ducie's Collection.	Jermyn St. Museum.	Sedgwick Museum.
Cyathophyllum trochiforme ...	R. ...	* ...	...	...	...
C. articulatum	...	...	* ...	* ...	*[1]
C. augustum	...	...	...	...	*[1]
C. sp.	W. ...	..	...	...	*
Hallia mitrata	R. W. ...	* ...	* ...	* ...	
Zaphrentis ? sp.	...	...	...	...	*[1]
Propora tabulata	R. ...	...	...	...	
Favosites aspera	...	...	...	...	*
F. forbesi	...	* ...	* ...	...	*
F. hisingeri	R. ...	...	...	* ...	*
Syringopora bifurcata	...	...	...	...	*
S. sp.	...	...	* ...	...	
Thecia swinderenana	R. ...	* ...	* ...	...	
Alveolites sp.	R. ...	...	* ...	...	
Cœnites intertextus	...	* ...	...	...	
C. juniperinus	...	* ...	...	...	

	Our Collection.	Bristol Museum.	Lord Ducie's Collection.	Jermyn St. Museum.	Sedgwick Museum.
Monotrypa crenulata		*	*		*
Fistulipora sp.					*[1]
Stenopora fibrosa	R.				
Monticuliporoid	R.		*		
Crania striata ?			*		
Discina sp.				*	
Orbiculoidea sp.				*	
Leptæna rhomboidalis	R. W.		*		
Orthis basalis	R. W.		*	*	*
O. elegantula	R. W.	*			
Whitfieldella didyma		*			
Strophonella funiculata	R.				
Strophomena ? waltoni	R. W.		*		
Stropheodonta filosa	R. W.				
Orthothetes pecten		*			
Meristella sp.	R.		*		
Pentamerus galeatus	W.				
Spirifer crispus	R.		*		*
S. elevatus		*	*		
Atrypa reticularis	R.				
A. imbricata			*		
Rhynchospira bouchardi		*			
Rhynchonella davidsoni	R.		*	*	*
R. diodonta	R.	*			
R. nucula	R.	*	*		
R. borealis					*
Glassia læviuscula		*			
Trematospira salteri		*			
Fenestella sp.			*		
Ptilodictya scalpellum	R.				
Grammysia cingulata			*		
Pterinea exasperata			*		
P. lineata			*		
Goniophora sp.			*		
Platyceras oppressum					*
P. cornutum			*		
Horiostoma globosum (sculptum auctt.)	W.		*	*	*
H. discors		*	*		
Holopella sp.	R.				
Holopea sp.		*			
Gomphoceras æquale					*
Serpulites perversum				*	
Cornulites serpularius			*		
Lichas sp.	W.				
Calymene blumenbachi		*	*		

[1] These specimens are simply labelled Tortworth, but the character of the matrix is such as to afford a strong presumption that they came from Whitfield.

	Our Collection.	Bristol Museum.	Lord Ducie's Collection.	Jermyn St. Museum.	Sedgwick Museum.
Calymene sp.	R.	...	...	...	...
Homalonotus sp.		...	...	...	... *[1]
Phacops caudatus		... *	...	...	... *
P. downingiæ	R.	...	...	...	...
Illænus sp....	R.	...	...	...	...
Beyrichia sp.	W.	...	...	...	...
Primitia sp.	R.	...	...	...	...

By far the commonest fossil in Brinkmarsh Quarry is *Hallia mitrata*; next in point of abundance come *Orthis basalis* and *O. elegantula Leptæna rhomboidalis.*

The following fossils were found in a hole dug in search of celestine at a point a short distance N.E. of Brinkmarsh Farm :—

Phacops downingiæ	*Atrypa reticularis*
,, *caudatus*	*Rhynchonella borealis*
Encrinurus punctatus	,, *diodonta*
Calymene blumenbachi	,, *nucula*
Platyceras sp.	,, *wilsoni*
Bellerophon ? sp.	*Rhynchotreta cuneata*
Pterinea cf. *planulata*	*Leptæna rhomboidalis*
Spirifer elevatus	*Orthis elegantula*

Proceeding north, the next fossil locality of importance is an old quarry about a quarter-of-a-mile N.W. of the Tortworth Court Gas Works. In the map of Buckland and Conybeare this is marked as Barber's quarry, and in the Sedgwick Museum the following fossils are labelled "Barber's quarry" :—*Thecia swinderenana, Favosites hisingeri, Favosites forbesi,* "*Monticulipora*" sp., *Orthis basalis, Rhynchonella wilsoni* var. *davidsoni.*

Falfield Mill was formerly a rather noted fossil locality, and the older collections contain a considerable number of fossils from it, as is seen from the following list. At the present time, however, it is very difficult to find any fossils :—

	Lord Ducie's Collection.	Jermyn Street Museum.	Sedgwick Museum.
Hallia mitrata		... *	...
Cyathophyllum sp.		... *	...
Cœnites intertextus	*	...	...
,, *juniperinus*		... *	...
Favosites hisingeri	*	...	...
Alveolites repens	*	...	...
Monotrypa crenulata		... *	...
Strophomena ? waltoni	*	...	...
Rhynchotreta cuneata		...	... *
Spirifer plicatellus var. *radiatus*		...	... *
Scenidium lewisi ?	*	...	...
Whitfieldella didyma		... *	...
Grammysia cingulata		... *	...
Platyceras cornutum		...	... *
Prœtus sp.		...	... *

(b) The Daniel's Wood area.

Several exposures of fossiliferous limestone occur in the neighbourhood of Daniel's Wood and Little Daniel's Wood. The most southerly is by the stream a quarter-of-a-mile due north of Brook Farm, where two distinct lithological types occur, a flaggy micaceous sandstone and underlying it a peculiar highly fossiliferous coarsely crystalline, sometimes sandy, limestone with many little mud pans, occasional grit pebbles, abundant fragments of horny brachiopods and a considerable number of other fossils. The most interesting fact about this deposit however is that it undoubtedly contains ashy particles, and therefore implies either that volcanic action extended into Wenlock time, or more probably that we have here a small patch of Llandovery appearing in an area which is predominantly Wenlock. We obtained here the following fossils :—

Monticuliporoid
Favosites gothlandica ?
Orbiculoidea rugata
Lingula sp.
Chonetes striatella
Orthis elegantula
Rhynchonella nucula
Ctenodonta anglica ?
Orthonota sp. ?
Bellerophon sp.
Orthoceras sp.
Beyrichia klœdeni
Primitia sp.

Several small indeterminate gastropods were also found.

At about the middle of the western margin of Little Daniel's Wood there are poor exposures of sandy crinoidal limestone dipping at 25 ° in a south-easterly direction. We obtained at this point :—

Hallia sp.
Cyathophyllum sp.
Monotrypa crenulata
Crinoid stems
Spirifer elevatus
Orthis elegantula ?
,, *rustica ?*
Orthothetes pecten
Atrypa reticularis
Stropheodonta filosa ?
Plectambonites transversalis
Meristina sp.
Orbiculoidea sp.
Beyrichia sp.
Cornulites sp.

And in crinoidal limestone, which is poorly exposed at the southern end of the wood—*Spirifer crispus*, *Whitfieldella didyma*, *Strophomena compressa*, *Alveolites repens ;* also *Platyceras* sp., *Pterinea retroflexa*, *Rhynchonella nucula*, *Rhynchonella* sp., *Orthis elegantula*, *Chonetes striatella* var., *Orbiculoidea* sp., and crinoid stems in calcareous sandstone.

(c) The Charfield Green area.

Wenlock beds are exposed in several small quarries near Oldbrook and Poolfield Farms, but yield few fossils in situ. The following were, however, obtained from blocks used in building an old wall at Pool Farm, these having been probably derived from one of the quarries :—

Strophomena compressa
Rhynchonella nucula ?
Orthis elegantula ?
Atrypa reticularis
Pterinea retroflexa
Cornulites sp.
Phacops sp.
Illœnus sp.
Homalonotus sp.
Beyrichia sp.
Primitia sp.
Crinoid stems

(d) *The Horseshoe Farm area.*

All the Wenlock deposits hitherto described probably occur on very much the same general horizon. But the probability of the occurrence of higher, *i.e.*, Ludlow, beds is suggested at one or more points in the district. At Horseshoe Farm, in the extreme southern part of the inlier, a considerable series of fossils was obtained from beds at a level, in fact, just below the Old Red. The following is the list, which is interesting, as in spite of the proximity to the Old Red Sandstone, the fauna is rather of Wenlock than of Ludlow type :—

Orthothetes pecten
Strophonella funiculata
Strophomena euglypha ?
Orthis elegantula
,, *rustica*
Rhynchotreta cuneata ?
Leptæna rhomboidalis
Anastrophia deflexa ?
Pentamerus galeatus ?
Chonetes striatella
Meristina tumida
Atrypa reticularis
Trematospira salteri
Scenidium lewisi
Spirifer elevatus
,, *crispus*
,, *sulcatus*
Orbiculoidea rugata
Pterinea lineatula ?
,, sp.
Cucullella antiqua ?
Orthonota sp.
Modiolopsis sp.
Tentaculites sp.
Phacops caudatus
Calymene blumenbachi
Beyrichia klædeni
Crinoid stems
Monticuliporoid

Lord Ducie's collection contains a considerable number of fossils from Horseshoe Farm. The following are preserved in yellowish or whitish sandstone :—

Monticuliporoid
Rhynchotreta cuneata
Rhynchospira baylei
Spirifer plicatellus
Aviculopecten danbyi
Pterinea retroflexa
Phacops caudatus
,, *downingiæ*
Encrinurus punctatus
Tentaculites anglicus

Leptæna rhomboidalis and *Rhynchonella stricklandi*, which also have been found here, are preserved in limestone. The collection from this locality also includes *Atrypa reticularis* and *Spirifer crispus*. The occurrence of *Aviculopecten danbyi* is very suggestive of Ludlow.

The discussion of the palæontological features of these faunas as a whole, with their special bearing on the stratigraphical problems of the district, will be found in our paper in the *Quarterly Journal of the Geological Society.*

Fish Teeth and Spines from the Carboniferous Limestone of the Bristol District

By Sidney H. Reynolds, M.A., F.G.S.

THE limestone of the Bristol district, and especially of the Avon section, has long been noted for the number and variety of the fish teeth and spines which it contains. Although, as is well known, the great majority of these are from certain well-marked horizons—the *Palate bed* at the base of K^1, according to Dr. Vaughan's notation, and the *Fish beds* in the upper part of Z^2—still a certain number occur at other horizons, though as a rule such specimens in collections are simply labelled "Carboniferous limestone, Bristol." Owing to the detailed study to which the Carboniferous limestone of the district has been subjected, it is now possible, from the character of the matrix, to tell, in the great majority of cases, the particular horizon from which a specimen has been derived, and with Dr. Vaughan's kind assistance this has been done for the various local collections of Carboniferous fish teeth. It has further been thought worth while to record the number of specimens of each species present in the chief collections, as this gives some idea of the relative abundance of the different species. It will be noted that the great majority of specimens are from the Avon quarries. The nomenclature adopted is that in the British Museum catalogue of fossil fish.

AVON SECTION.

The richest horizon for fish remains is afforded by the well-known Fish beds (Z^2) from which the following fossils in the local collections have been obtained :—

	Number of Specimens.		
	Univ. Coll. Collection.	Stoddart Collection.	Bristol Mus. Collection.
Chalazacanthus verrucosus (spine) ...	...	...	1
Chomatodus cinctus	3 ...	2 ...	numerous
Cladodus milleri	1 ...	...	4
Cochliodus contortus	3 ...	2 ...	numerous
C. sp.	2 ...	1 ...	
Ctenacanthus major (tenuistriatus) (spines)	15 ...	3 ...	14
C. brevis (spines)	...	...	5
C. sp. (spines)...	1 ...	2 ...	
Deltoptychius acutus	...	1 ...	
D. gibberulus	3 ...	...	

Note.—I have to thank Dr. A. Smith Woodward, F.R.S., for help in the identification of some of the specimens.

	Number of Specimens.		
	Univ. Coll. Collection.	Stoddart Collection.	Bristol Mus. Collection.
Deltodus expansus		2	
D. sublævis		2	4
Helodus turgidus	13	6	very num's
H. cf. *expansus*	1		
H. sp.	2	1	
Lophodus mammillaris	2		
L. didymus	1	3	
Oracanthus milleri (spines)	18	2	8
O. pustulosus (spines)			1
Orodus ramosus	3	1	numerous
O. gibbus		1	
Petalodus cf. *linearis*	1		3
P. sp. approaching *Hastingsiæ*		1	
Physonemus hamatus (spines)	1		3
Psammodus rugosus	20	12	numerous
Psephodus magnus	13	7	
Sandalodus morrisi		2	3
Streblodus colei	2		4
S. egertoni	1		
Tomodus convexus	12	8	numerous
Xystrodus egertoni	2		1
X. striatus		1	

Tomodus convexus, *Psammodus rugosus*, *Helodus turgidus*, *Chomatodus cinctus*, *Streblodus colei*, *Deltodus sublævis*, *Psephodus magnus*, and *Cochliodus*, are also represented in Mr. J. W. Tutcher's collection.

Next in importance to the "*Fish bed*," as a horizon for vertebrate fossils, is the well-known "*Palate bed*" at the base of K^1. Though the number of species met with at this horizon is by no means so great as in the "*Fish bed*," one species, *Psephodus lævissimus*, has occurred in greater numbers than any other in the district at any horizon.

	Number of Specimens.		
	Univ. Coll. Collection.	Stoddart Collection.	Bristol Mus. Collection.
Cladodus mirabilis	2	3	
C. ? new sp.	1		
Ctenacanthus brevis		1	1
C. major		2	
C. sulcatus		1	1
C. ? new sp.	3		
Orodus cinctus	3	1	2
O. ramosus	1	3	
Petalodus linearis	1	6	numerous
Psephodus lævissimus	39	23	very num's
Psammodus rugosus		1	

Fish remains are rare in the *Syringothyris* beds (horizon C), but the Bristol Museum contains two specimens of *Psammodus rugosus* and one of *Cochliodus contortus*, which the character of the matrix shows were derived from the *Laminosa*-dolomite. Fish remains are equally uncommon in the *Dibunophyllum* beds (horizon D), but the University College collection contains one specimen of *Copodus*, three of *Psephodus magnus*, and one of ? *Tomodus convexus* from these beds, and the Bristol Museum contains a specimen of *Psephodus magnus* from the same beds, probably the upper part.

The University College collection also contains a tooth of *Psephodus magnus*, and another of *Psephodus lævissimus* from the "*Bryozoa bed*" (horizon A) of the Avon section.

BURRINGTON.

It is remarkable what a small amount of fish teeth have been found in this fine section. The "*Palate bed*" of the Avon section if present at all is not exposed, and though the "*Fish bed*" has been recognised it is far from rich. The University College collection contains a tooth of *Helodus* sp. and one of *Tomodus* sp. from the "*Bryozoa bed*" (horizon A), and Dr. Vaughan has collected *Psammodus rugosus* and a spine of *Ctenacanthus* from the "*Fish bed*" (horizon Z^2). Mr. W. H. Wickes has a tooth of *Helodus turgidus* from the same horizon, and a second *Helodus* tooth from lower beds (Z^1).

SODBURY.

The "*Palate bed*" is well marked, and a fair number of teeth of *Psephodus lævissimus* have been found in it.

WICKWAR.

A spine of *Ctenacanthus* has been recently found in the more southerly of the two quarries, 300 yards W. of the Rectory, the horizon being that of the "*Fish bed*" of the Avon section.

WESTON-SUPER-MARE DISTRICT.

A tooth of *Helodus turgidus* was found in the Milton road quarry (horizon C), and several teeth of *Psephodus magnus* have occurred in the Z^2 beds of Swallow cliff.

PORTISHEAD DISTRICT.

The upper part of Z^2 is exposed in the quarry in Weston big wood, and teeth were formerly to be obtained from the quarrymen there. Unfortunately no record has been kept of the species found except that Prof. Lloyd Morgan records[1] finding a spine of *Oracanthus* here. Mr. W. H. Wickes has a tooth of *Psephodus* from the K^2 beds exposed on the shore S. of Battery Point.

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[1] Proc. Brist. Nat. Soc., new ser., vol. v. (1885-8), p. 29.

Report of Meetings.

For the Year ending 31st December, 1907.

THE Presidential Address by the retiring President, Mr. C. K. Rudge, L.R.C.P., M.R.C.S., entitled, "Notes on the Habit and Structure of the Mollusca," was given upon February 7th. Other meetings were held as follows :—

Jan. 17th.—J. W. White, F.L.S., "The Botany of Montserrat."

Feb. 26th.—Exhibition Meeting, arranged by the Entomological Section.

Mar. 7th.—B. T. P. Barker, M.A., "Yeasts."

,, 19th.—Exhibition Meeting, arranged by the Botanical Section.

April 4th.—H. Bolton, F.R.S.E., "Coal Measures of Ashton Vale."

,, 16th.—Exhibition of Specimens relating to Zoology.

May 2nd.—J. H. Priestley, B.Sc., "The Soil and Plant Formations."

Oct. 10th.—Prof. S. H. Reynolds, M.A., "Lakes and Rivers."

Nov. 7th.—H. J. Charbonnier, "Notes on Local Mammals."

,, 21st.—Exhibition Meeting, arranged by the Geological Section.

Dec. 5th.—G. Munro Smith, M.R.C.S., L.R.C.P., "A morning on the Downs."

The following Exhibits were shown by members at the ordinary meetings of the Society :—

Feb. 7th.—The feet of the female Capercailzie—Mr. H. Matthews.

Mar. 7th.—A specimen of Centriscus Scolopax, the "Trumpet" or "Bellows" Fish, found in the stomach of a Hake—Mr. H. Matthews.

April 4th.—An unusually large specimen of the British Adder—Mr. C. K. Rudge, M.R.C.S., L.R.C.P.

April 4th.—An abnormal flower of Richardia Æthiopica, possessing apparently a double spathe—Miss Dorothy Hudd.

May 2nd.—A fasciated branch of Cratægus Oxyacantha—Mr. G. S. Chapman.

Oct. 10th.—A specimen of Strophanthus hispidus—Miss Holdship.

Nov. 7th.—A specimen of crystalline Gypsum—Mr. J. W. White, F.L.S.

Dec. 5th.—A specimen of Clover brought from the North of Ireland as the typical Irish Shamrock—Mr. J. W. White, F.L.S.

At the December meeting a communication from Dr. J. Beddoe, F.R.S., was read by the Hon. Secretary, and is printed in full in this volume of the Proceedings of the Society.

BOTANICAL SECTION.

IT might well be supposed that all botanical discovery in the country around Bristol had been by this time effected, and that explorations carried on by so many observers during so long a period had completed the list of floral treasures contained in the district. The longer we live, however, the more certain it appears that finality in field-botany is still as far off as it may be in any other investigation of nature's mysteries; and for this there are other reasons than that sight fails or energy weakens. Experience shows that rare species are often confined to extremely small areas dotted about in secluded localities. Not infrequently plants seem to be reduced to the verge of extinction by causes that vary and are difficult to estimate. Their last lingering holds may long escape detection. In many cases they are brought to notice eventually more by accident than by design, for to them there are no guides. A square yard or two of rock on some unfrequented slope, a few feet of river bank where no footpath runs, a tiny bit of bog on a remote hillside, or, it may be, the margin of a little peaty pool among the heather of high moorland—any one of these may shelter all that remains within a whole county of some beautiful wild flower, grass, or sedge. Proportionate to the difficulties encountered—to the barren hours or days spent in hunting up such hiding places—and to the botanical value of the plants which they conceal, is the delight of a fortunate explorer when the unexpected meets his eye, and the satisfaction of a topographer who is enabled to fill some gap in his floral plan.

Since our last Report was written the delight and satisfaction described above have descended upon us lavishly. Hardly anything has happened but the unexpected—the almost unhoped for! Surprise has succeeded surprise in an astonishing sequence. Truly the botanical work done about Bristol during the past twelve-month is of the first order. Classified systematically the results run as follows :—

Ranunculus Lingua, the rare Great Spearwort, distinguished by its tongue-like leaves, fine stature, and great golden flowers as big as crown-pieces, was unknown in the county of Gloucester until last June, when specimens were brought to a meeting of University College Botanical Club by Miss Brooks, the discoverer, who gathered them in the Boyd valley above Bitton. There, in a very wet swamp, concealed among osiers and rank aquatic vegetation, is an abundance of this beautiful buttercup, much more luxuriant than any I have met with elsewhere.

Corydalis claviculata is another plant not previously noticed in Gloucestershire. A frail delicate species that is apparently dying out in the region around Bristol, for it can no longer be found at St. Stephen's Hill. There survives, however, a small patch of it on a sandstone outcrop of the coal-measures, about nine miles north of the Exchange.

Geum rivale. We now have two good stations for this in N. Somerset—between Hallatrow and Hinton Blewett in open pasture, and towards the "Blue Bowl" and Compton Martin in wet hedge-bottoms.

Carum Carvi, the Caraway, is uncommon everywhere, and is usually a waste-ground casual resulting from kitchen refuse. As such it has appeared several years in succession in St. Philip's Marsh.

Galium erectum. There was but one other habitat known in West Gloucester before Mr. Bucknall and I found it to be abundant on a rocky slope not far from the village of Iron Acton. As a help in distinguishing this from *G. Mollugo*, it should be remembered that the latter blooms at least three weeks later. The flowers of *erectum* are larger, and are borne upon ascending or erect pedicels and branches.

The whole plant is stiffer and more slender—in general, less than two feet high.

Polygonum Raii. A specimen gathered near New Passage in 1865 by the late Dr. St. Brody has been found in his herbarium at Gloucester. I fear it is not likely to be again met with in that county, but the Rev. E. S. Marshall has detected a small colony at the other extremity of the Bristol district, among low sandhills near the mouth of the river Brue. Thus we now have records for this Polygonum from both divisions.

Aceras anthropophora. Strong evidence that the Green-man Orchis formerly grew on the high ground—Weston Lodge Farm—between Weston-in-Gordano and the sea has been furnished by Mr. A. E. G. Way, who cultivates in his "wild garden" plants derived from roots obtained from the ridge some fifteen years ago. The ground has been repeatedly searched since without result.

Littorella lacustris. We owe the recognition of this tiny aquatic to a Surrey botanist, Mr. C. E. Salmon, who saw it last year submersed in a Mendip pool. After a month's drought in July last the water had fallen so low that several specimens flowered upon the margin. They were only one inch high. We must go back to the seventeenth century for the last local notice of this plant, then recorded from near Glastonbury by Ray.

Eriophorum latifolium was added to the Somerset Flora by Mr. Salmon on the same occasion. He found only a small quantity of it in a Blackdown bog, and I have not yet been fortunate enough to hit upon the spot. It is very remarkable that last July Miss Roper and her brother discovered this rare cotton-grass—never before suspected to grow in Gloucestershire—in a secluded valley among the southern spurs of the Cotswolds. There is about an acre of it in a lovely locality, but just two miles outside our district I regret to say.

Schœnus nigricans. Mr. Leo H. Grindon's discovery on the coast between Portishead and Clevedon is described with fair detail—if rather ornately—in the pages of the old *Phytologist.* Many of us, from time to time, have vainly endeavoured to identify his pleasant "bubbling spring," but it was not until sixty-four years had gone by that Miss Livett's persistence was rewarded. When she conducted me to the place I saw that we had often passed within a yard or two of the one little clump, so happily hidden, that survives. Still, there it was, seated in a chink of the wet limestone rock, producing about a dozen flowering stems yearly. The spring no longer bubbles, it barely trickles now, for fresh-water is less plentiful than formerly along that line of coast.

Carex divisa, a submaritime species absent hitherto from the Gloucestershire lists. An increasing patch of it has for some years been under observation in St. Philip's Marsh, not far from the tidal Avon. Its foliage and stems are well developed to a height approaching two feet, but the spikes are unusually small, owing possibly to poor nourishment afforded by the dry ashes into which the plant's roots have now spread. It may be that the sedge is of alien introduction, but I am rather inclined to look on it as a survival from the ancient salt-marsh vegetation of the place. In any case it must shortly disappear, unfortunately, from the extension of works and factories over the ground.

Carex stricta. It is gratifying to be able to announce the undoubted presence of this sedge, in considerable quantity within a few miles of the city. Thus far there have been only some unconfirmed reports of its occurrence near Bath, which were not accepted by the author of the *Flora of Somerset.* This is a critical species, sometimes misunderstood, although in reality well defined by its densely tufted habit, the filamentous leaf-sheathing, and a peculiar veining of the fruit. Mr. Bucknall and I found it about some water holes in the marsh land between Tickenham and Wraxall.

Carex vesicaria. Another most valuable find to the credit of Miss Roper, who has published her discovery in the *Journal of Botany.* In this case the plant extends a few feet along the bank of a Frome tributary in the parish of Iron Acton. It is a handsome sedge of quite typical growth, and had never before been gathered, for sure, either in Somerset or West Gloucester.

JAMES W. WHITE, F.L.S.,
Hon. Sec.

GEOLOGICAL SECTION.

I REGRET to have to report a large falling off in membership. At the end of 1906 there were 53 members, but at the end of this year there are only 40. During the last Session the Section has lost three members by death, Mr. T. Foster Brown, Mr. Henry Watson, and Dr. W. B. Gubbin.

There were nine meetings during the year, one of which was an exhibition meeting, to which members of the Bristol Naturalists' Society were invited, and a great many availed themselves of the invitation, showing great interest in the specimens of minerals, fossils, photographs, and Lantern Slides, which were explained by the exhibitors.

The following papers were read during the year:—

Jan. 24th.—Annual Meeting. Lantern Slides of "New Zealand," described by Hy. Watson.

Feb. 21st.—"Erosion of the Shores of the Bristol Channel" and "A small bone cave at Clevedon," by Prof. S. H. Reynolds, M.A., F.G.S.

Mar. 21st.—"Geology of the Transvaal," by A. J. Hall, B.A., B.Sc., F.G.S.

April 25th.—"A Silurian Inlier on the Eastern Mendips," by Prof. S. H. Reynolds, M.A., F.G.S.

May 23rd.—"Lamellibranchs," by Dr. A. Vaughan, B.A., D.Sc., F.G.S.

June 20th.—"Mountain Limestone, some Chemical Problems suggested by it," by C. A. Seyler, D.Sc., of Swansea.

Oct. 17th.—"The Geology of Skye," by Prof. S. H. Reynolds, M.A., F.G.S.

Nov. 21st.—Exhibition Meeting.

Dec. 19th.—"The Faunal successional of the Carboniferous Limestone (upper Avonian) of the Midlands," by T. F. Sibly, B.Sc.

There was an average attendance (excluding the Exhibition Meeting) of 16 members.

The Financial Report shows a total receipt of £8 6s. 8d., including a balance of £2 7s. 8d. brought forward from last year, with an expenditure of £5 0s. 3d., leaving a balance of £3 6s. 5d. to be brought to next year's accounts. The receipts have exceeded those of last year by 11s.

Owing to the large falling off of membership, it is hoped that members will endeavour to induce their friends to join the Society, as in a large city like Bristol there must be many interested in Geology who might support the Society.

B. A. BAKER, F.G.S., *Hon. Sec.*

ENTOMOLOGICAL SECTION.

JANUARY 15th.—Annual Meeting. Mr. G. C. Griffiths exhibited a specimen of *Deilephila euphorbiæ* taken at Braunton, also of *Chœrocampa celerio* taken at Brighton. Mr. H. J. Charbonnier remarked upon phases in the life history of the "Snow Fly," *Aleyrodes prolotella*, illustrated by microscopic slides. A discussion took place upon the Distribution of Species and Change of Type during the period of historical record.

Feb. 19th.—The following specimens, amongst others, were exhibited. By Mr. H. J. Charbonnier, *Trichocera annulata*, *Camptocladius atirrimus*, *Ptinus sexpunctatus* taken from the nest of an *Anthropora*, also pupæ of the leaf cutter bee *Megachile Willughbiella*. By Mr. Griffiths, fine varieties of *Cerastis spadicea*, *Cosmia trapezina*, *Orthosia lota*, and *Arctia lubricipeda*, also an example of *Laphygma exigua*, from Penarth. By Mr. C. Bartlett, microscopic slides of scales from the wings of *lepidoptera*. Dr. Rudge produced the Second Report of the Wellcome Research laboratory, showing fine plates of insects responsible for malaria, sleeping sickness, &c., in man.

Feb. 26.—Exhibition Meeting arranged by the Entomological Section.

April 20th.—Mr. Griffiths exhibited specimens of *Abraxas grossulariata* vars. *fulvapicata* and *fulvapicata-lutea*. Mr. Charbonnier exhibited on behalf of Mr. C. J. Watkins, of Painswick, a large number of microphotographs of Insects. Dr. Rudge exhibited some boxes of brilliant exotic *coleoptera*, and the collection of British *lepidoptera*, formed by the Hon. Sec., was examined.

Nov. 26.—Mr. Charbonnier reported his discovery, in Clifton, of males of the fly *Epidapus scabii*, which were found running about the earth in which were contained narcissus bulbs. Mr. Griffiths showed a collection of Swiss *Lepidoptera* taken at Bérisal and other localities, including *Melitæ Bérisalensis*, *Polyomæmatus dorilis*, *Lycæna sebrus*, *L. cyllarus*, *etc.*

The Hon. Sec. reported taking some larvæ of *Agrotis ripæ* in the sand, under plants of *Salsola kali*, at Kewstoke Bay.

CHARLES BARTLETT,
Hon. Sec.

FOURTH SERIES, VOL. II., Part II. (issued for 1908). Price 2/6.

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FOURTH SERIES. VOL. II. PART II.

Sketch of the Geological History of the Bristol District.[1]

By C. Lloyd Morgan, LL.D., F.R.S., & S. H. Reynolds, M.A., F.G.S.

BRISTOL is situated in a district of most varied geological interest. Within the limits of an afternoon's excursion almost every geological horizon from the Llandovery to the Chalk, with the exception of the Permian, is readily accessible. The picturesque and diversified scenery of the Bristol district not only delights the eye of the lover of natural beauty, but affords admirable examples of sculptured relief, leading on the thoughtful observer to enquire into their mode of origin.

For geological purposes the Bristol area may be taken as bounded on the west by the Severn and Bristol Channel, and on the north by a line drawn from Tite's Point on the Severn to the Stroud Valley. On the south it may be regarded as including the Mendip Hills, and on the south-east as limited by the edge of Salisbury Plain. Further to the north its eastern boundary may be drawn across the hilly country from Bradford-on-Avon, through Box and Badminton, to Nailsworth and Stroud.

THE SILURIAN ROCKS.[2]

These, the oldest rocks of the Bristol district, are exposed in two somewhat widely separated areas, forming the well-known inlier of Tortworth, and that recently discovered in the eastern Mendips. These two areas agree with one another, and differ from all other Silurian regions in Great Britain in the fact that they include a development of contemporaneous igneous rocks with well-marked lavas and tuffs. In the Tortworth area these igneous rocks form two bands associated with the Llandovery strata, which are remarkably fossiliferous. In addition to the lava, which is andestic or basaltic in character, a band of highly fossiliferous tuff occurs overlying the upper lava band. The Llandovery rocks of Tortworth are succeeded by a

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[1] For general accounts of the Geology of the Bristol District see T. Weaver, "Geological Observations on Part of Gloucestershire and Somersetshire", 'Trans. Geol. Soc.', Ser. 2, I., Pt. ii., p. 317 (1824); W. Buckland and W. D. Conybeare, "Observations on the South-Western Coal District of England", *ibid.*, p. 216; H. B. Woodward, "The Geology of East Somerset and the Bristol Coalfields", 'Memoirs of the Geological Survey of England and Wales,' 1876; W. J. Sollas, "On the Geology of the Bristol District", 'Proc. Geol. Assoc.', VI. (1880), p. 378; T. Wright, Presidential Address to Section C of the British Association, Bristol, 1875; H. H. Winwood, "Geology of the Bath District", British Association Handbook, Bath, 1888; W. H. Hudleston, Presidential Address to Section C of the British Association, Bristol, 1898, reprinted in the 'Geol. Mag.', New Ser., Sec. iv., Vol. V. (1898), p. 458.

[2] For the Silurian rocks see the papers by Weaver and by Buckland and Conybeare quoted above; also by R. I. Murchison, "The Silurian System" (1839), p. 454; J. Phillips, 'Memoirs of the Geological Survey of England', II., pt. 1 (1848), pp. 190—198; also papers by C. Lloyd Morgan and S. H. Reynolds in the 'Q. Journ. Geol. Soc.', LVII, 1891, p. 267; by S. H. Reynolds, *ibid.*, LXIII, 1897, p. 217; and by F. R. C. Reed and S. H. Reynolds, *ibid.*, LXIV, 1898, p. 512.

development of Wenlock rocks, including two bands of limestone, which, though they have yielded numerous fossils at certain localities, contain a somewhat meagre fauna as compared with that of the Silurian inliers further to the north. The Ludlow rocks of the southern part of the area in the neighbourhood of Tortworth are thin and poorly exposed, and do not show the normal development met with in Herefordshire and Shropshire. At Tite's Point (Purton Passage) on the Severn, however, there is a more normal development of the Ludlow rocks, with a representative of the Ludlow bone bed.

Fig. 1.

Reproduced by kind permission of the Council of the Geologists' Association of London.

In the eastern Mendip area, in the neighbourhood of Downhead and Stoke Lane, the principal development of Silurian rocks is a thick mass of pyroxene andesite, which has long been quarried at Moon's Hill, and was till lately regarded as an intrusive mass. Interbedded in this lava is a well marked band of tuff, and the base further rests on a varied series of tuffs of which a thickness of nearly 100 feet is seen in the Sunnyhill quarry at Stoke Lane. Certain bands in the tuff at Sunnyhill, and at other points further to the east, have yielded a considerable series of fossils of Llandovery type.

A further series of fossils of the same general character occurs in bands of sandy shale which were exposed in laying a line of rails from the Downhead quarry, and which are apparently the youngest Silurian rocks occurring in the district. It appears, therefore, that the eastern Mendip Silurians do not include any representatives of the Wenlock or Ludlow strata. An explanation of this is suggested later on in the section dealing with the Old Red Sandstone.

One other Silurian stratum occurring in the eastern Mendips requires mention, namely, a remarkable mass of coarse ashy conglomerate, consisting in the main of blocks of andesite embedded in a matrix of tuff. This deposit, which shows little or no sign of stratification, forms two masses, the relation of which to the other rocks of the district is unfortunately nowhere visible. Although the generally well-rounded character of the blocks tells against this view, it is possible that the masses of ashy conglomerate mark the vents or necks from which the lava and tuff were ejected.

THE OLD RED SANDSTONE.

The succeeding beds of Old Red Sandstone indicate a change of physical conditions. For the remains of marine organisms which characterize the Silurian strata do not occur in the Old Red Sandstone. A few fish scales alone break the palæontological barrenness of these deposits, which would seem to have been laid down in a land-locked area, cut off from the Devonian sea by some physical barrier. The nature of this barrier we cannot determine. Barren conglomerates, sandstones, and red shales occur throughout the district as far south as the Mendips, where they form the arched summits of the hills. But in the not distant Quantocks somewhat further south there are found marine beds of the normal Devonian type. Perhaps shoals and sand-banks stretched between the present sites of these two ranges of hills, and separated the southern sea from the fresher waters of the Old Red Sandstone area, shifting at times, no doubt, further south, but never, so far as we know, allowing the marine deposits to advance further north.

The best places for examining the Old Red Sandstone are on the shore to the south of Woodhill Bay, Portishead, and in the railway cuttings on the Portishead and Avonmouth lines. In each of these localities the rocks have yielded fish scales, and in each they contain, in addition to the usual beds of sandstone, shale, and conglomerate, certain calcareous deposits, sometimes forming large irregular masses of limestone, sometimes acting as a calcareous cement for the conglomerate. No trace of fossils has been found in these limestones, and their origin was probably chemical. The pebbles of the conglomerate are of distant origin, and consist of quartzite, jasper, and rarely igneous rocks, such as quartz-felsite.

One of the most interesting points about the Old Red Sandstone of the Bristol district is its remarkable variation in thickness. While in several places, as in the Avonmouth and Portishead Railway cuttings, and formerly in those of Sodbury and Tytherington, the upper beds passing into the Carboniferous rocks are well seen, at one locality only, Tite's Point on the Severn, does there seem to be the possibility of a conformable passage down into the Silurian, and nowhere in the district is there a complete section of the Old Red Sandstone available. The thickness of the rocks as exposed also shows a surprising amount of variation. While in the cuttings on the Avonmouth and Portishead lines a thickness of over 1500 feet is seen, in the Tortworth district the thickness is reduced to some 200 to 300 feet at most. This attenuation of the Old Red Sandstone, and the probable absence of the greater part of the Ludlow series in the Tortworth district, is probably to be attributed to upheaval and erosion of the area in late Silurian and early Devonian times. The apparent absence of Wenlock and Ludlow strata in the eastern Mendips admits of a similar explanation.

CARBONIFEROUS ROCKS.

From whatever point of view they are considered, whether the economic, scenic, or stratigraphical, the Carboniferous strata yield to no others in the district in point of importance. They may be readily divided into an upper series, in the main non-marine in character, the Coal Measures and Millstone Grit, and a lower completely marine assemblage of strata, the Carboniferous Limestone series. It will be convenient to treat these separately.

Carboniferous Limestone Series.[1]

The Bristol district is fortunate in possessing what are probably the two finest and most continuous sections of the Carboniferous Limestone series in the British Isles, viz., those of the Avon and of Burrington; while at a number of other points, the Sodbury and Tytherington railway cuttings, the Cheddar Gorge, the Wickwar quarries, the coast sections of Clevedon and of the Weston-super-Mare district, a large part of the succession is finely exposed.

The detailed palæontological work of Dr. Arthur Vaughan has led to the successful zoning of the Carboniferous Limestone, and his methods have been most ably applied by Dr. T. F. Sibly[2] in the Mendips and Weston-super-Mare districts.

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[1] See A. Vaughan, "Palæontological Sequence in the Carboniferous Limestone of the Bristol Area", 'Q. Journ. Geol. Soc.', LXI., 1905, p. 181, and "The Carboniferous Limestone Series (Avonian) of the Avon Gorge", 'Proc. Bristol Nat. Soc.', 4th Series, I., part ii., 1906 (issued for 1905) p. 74.

[2] 'Q. Journ. Geol. Soc.', LXI. (1905), p. 548, and LXII. (1906), p. 324; also 'Proc. Bristol Nat. Soc.', 4th Series, I., pt. i. (1905, issued for 1904), p. 14.

Dr. Vaughan's primary divisions of the Carboniferous Limestone series are as follows:—

Upper Carboniferous Limestone, or Viséan	Dibunophyllum Zone. Seminula Zone.
Lower Carboniferous Limestone, or Tournaisian	Syringothyris Zone. Zaphrentis Zone. Cleistopora Zone.

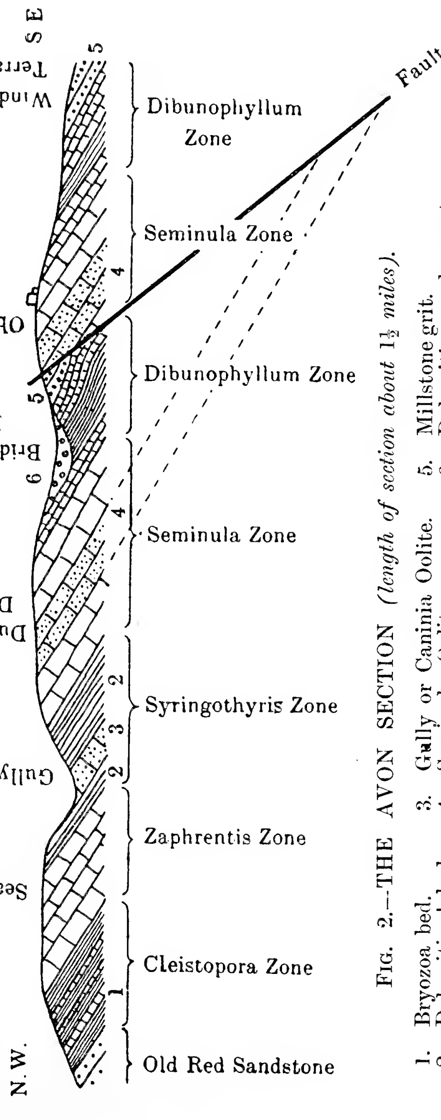

FIG. 2.—THE AVON SECTION (*length of section about* 1½ *miles*).

1. Bryozoa bed.
2. Dolomitized beds.
3. Gully or Caninia Oolite.
4. Seminula Oolite.
5. Millstone grit.
6. Dolomitic conglomerate.

The *Cleistopora Zone*, so called after a small compound coral, corresponds to the Lower Limestone Shales of previous writers. The lower beds consist of shales with thin limestones well exposed in the Avon section, and forming passage beds into the Old Red Sandstone. They contain bands with lamellibranchs and ostracods, and are succeeded by a massive red limestone, known as the "Bryozoa Bed." In this the organic remains have been converted into oxide of iron, and though crinoidal ossicles greatly preponderate, polyzoa are also fairly numerous. The occurrence of bands of limestone in which the fossils are similarly converted into oxide of iron, at about this horizon, throughout the district, from Tytherington on the north to Burrington Combe in the Mendips on the south, seems to indicate the prevalence of some general conditions in the shallow sea—conditions which are not easy of explanation. Just above the "Bryozoa Bed" in the Avon section is the well-known "Palate Bed," from which great numbers of teeth and coprolites of elasmobranch fish have been obtained. The "Palate Bed" has also been detected in the Sodbury cutting. Succeeding the "Palate Bed" are other shales and thin-bedded limestones forming the upper beds of the *Cleistopora Zone*. The succeeding *Zaphrentis Zone* consists of massive limestone characterised by the great abundance of Spirifers and, especially in the upper part, of Zaphrentid corals. It is well exposed in the Black Rock quarry and the two northern quarries on the left bank of the Avon, and also at Wickwar, Clevedon, Woodspring (near Weston-super-Mare), and elsewhere. The upper part of the *Zaphrentis Zone* contains the well-known "Fish Beds" from which the vast numbers of teeth of elasmobranch fish to be met with in most collections have been obtained.

Following the *Zaphrentis Zone* is the *Syringothyris Zone*, which in the Avon section shows a strong lithological contrast to the beds both above and below, being relatively unfossiliferous, and consisting of a mass of very pure white oolitic limestone—the "Gully or Caninia Oolite"—both overlain and underlain by beds consisting largely of dolomite. These beds are clearly of relatively shallow-water origin, and point to some physical disturbance which caused a check to the regular deposition of deep-water limestones. In this connection it is interesting to note that there is further evidence of disturbed conditions afforded by the occurrence of a volcanic episode [1] in the *Syringothyris Beds* of Weston-super-Mare. The rocks which are exposed at Spring Cove include a mass of basaltic lava about 40 feet thick, while the overlying limestone contains disseminated ashy particles up to a height of at least 8 feet from the base. The basalt is associated with a peculiar mass of agglomeratic material which Prof. W. S. Boulton, who has paid much attention to the section,[2] regards as a fluxion tuff. This deposit is further noteworthy for containing numerous masses of limestone which

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[1] See Sir A. Geikie and A. Strahan 'Summary of Progress of Geol. Survey of the United Kingdom for 1898', p. 104 (1899), C. Lloyd Morgan and S. H. Reynolds 'Q. Journ. Geol. Soc.', LX. (1904), p. 137, see also 'Proc. Bristol Nat. Soc.', New Series, X., pt. iii. (1904 issued for 1903), p. 188.

[2] 'Q. Journ. Geol. Soc.', LX. (1904), p. 158.

in many cases are considered by Prof. Boulton to have been picked up in the form of calcareous mud, and squeezed into the spaces between spheroidal masses of basalt. Other sections of volcanic rocks occur at Woodspring, three miles to the north of Spring Cove, and at Goblin Combe, near Wrington; but at each of these sections the lava plays a subordinate part, the principal igneous rocks being calcareous tuffs, which at Woodspring have a thickness of upwards of 100 feet. It is noteworthy that at Woodspring and Goblin Combe the igneous rocks are not quite contemporaneous with those at Spring Cove, occurring as they do in the uppermost part of the Zaphrentis beds, *i.e.*, some 350 feet below those at Spring Cove.

At the top of the *Syringothyris Zone* the *Tournaisian* or Lower Carboniferous Limestone ends, the succeeding *Seminula Beds* belonging to the Upper Carboniferous Limestone or Viséan. These rocks, consisting as they do in the main of massive limestone, are frequently quarried, and hence are excellently exposed in many parts of the Bristol district, as in the Avon and Wickwar quarries and the Cheddar Gorge. While certain fossils, especially *Lithostrotion* among the corals and *Seminula* among the brachiopods, occur in great abundance, the *Seminula Beds* are characterised by a relatively impoverished fauna, showing little variety as compared with that in the overlying and underlying strata. The beds are however decidedly variable lithologically, and include a thick mass of white oolitic limestone, the Seminula oolite, and in the upper part a series of peculiar concretionary beds well seen in the cutting and quarry at Chipping Sodbury.

The uppermost division of the Carboniferous Limestone, the *Dibunophyllum Zone*, is again highly fossiliferous, being specially characterised by the multitude of corals of the genera *Lithostrotion*, *Lonsdaleia*, *Dibunophyllum*, and *Alveolites*. The great majority of the Bristol corals shown in museums are derived from these beds. Though well exposed in the Avon section, the *Dibunophyllum Beds* are not so often seen as are the *Seminula* and *Zaphrentis Beds*. They are however well exposed, and very fossiliferous in the quarries at Flax Bourton and Wrington. They show much lithological variation, and include beds of grit, shale, and conglomerate. They were formerly known as the "Upper Limestone Shale," a term which, like the corresponding "Lower Limestone Shale," should now be regarded as of merely lithological significance, and of value only when the denudation features of the district are under consideration.

Upper Carboniferous Series.[1]

The limestones of the Lower Carboniferous rocks are succeeded by a mass of very hard red grit, with layers of shale and conglomerate,

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[1] For the Coal Measures see H. B. Woodward "Geology of East Somerset and the Bristol Coalfields", 'Mem. Geol. Surv. of England and Wales', 1876; J. McMurtrie "The Coal-fields of Somersetshire", 'Proc. Somerset Arch. and Nat. Hist. Soc.', XIII., pt. 2, p. 119; other papers in the 'Proc. Bath Nat. Hist. and Antiq. field club', vol. 1 (3), p. 127, *ibid.*, vol 2, page 454, etc.; also J. Anstie, 'The Coalfields of Gloucestershire and Somersetshire', 1873.

the whole being known as the Millstone grit. These rocks are seen at the great fault below Observatory Hill, Clifton, at Brandon Hill, at Long Ashton, at the Wick rocks, and at various other localities in the Bristol district. An interesting fact which has been brought into prominence by Dr. Vaughan's researches is that the grit beds do not everywhere come on at the same horizon. Thus in the immediate neighbourhood of Bristol the lower part of the Millstone grit contains a marine assemblage of fossils—*Productus*, *Lithostrotion*, etc., and is clearly more closely related to the underlying limestone than to the overlying Coal Measures, while in the North of England the Millstone grit is clearly more related to the Coal Measures. Hence it seems desirable to use the term with a mainly lithological significance and not as denoting an exact horizon in the Carboniferous series. The Coal Measures of the Bristol district are sub-divided as follows:—

Upper	Radstock series Farringdon series	2,000
Middle	Pennant series	2,000
Lower	Kingswood series Bristol series	2,500

The productive coal seams occur principally in the upper and lower beds, the middle or Pennant series consisting chiefly of hard grey and red sandstones, which form one of the most important building stones of the district.

The Coal Measures of the Radstock district have long been famous for the number and excellent preservation of the plant remains, and for the extraordinary amount of faulting and disturbances to which the rocks have been subjected. Until lately no evidence was available to show that the sea ever gained access to the swamps and lagoons in which the Bristol coal beds were being laid down, as it did in some parts of northern England; Mr. H. Bolton has, however, recently described [1] an interesting marine fauna including brachiopods, lamellibranchs, gasteropods, cephalopods, and fish from the lowest Coal Measures of Ashton, proving that marine episodes occurred in the Bristol Coal Measures just as they did further to the North.

A well-known point of interest in connection with the Bristol Coal Measures is the extent to which they are covered by overlying secondary strata. Hence, in mining the Coal Measures of the Ashton district, the Keuper is penetrated; to reach the productive strata in the Radstock district, the Lias, and even the Inferior Oolite.

With the close of the Coal Measure period the first and longest chapter in the geological history of the Bristol district comes to an end. Throughout the vast period from the commencement of Silurian to the end of Carboniferous times the district was one in which prolonged and gradual depression was accompanied by the formation

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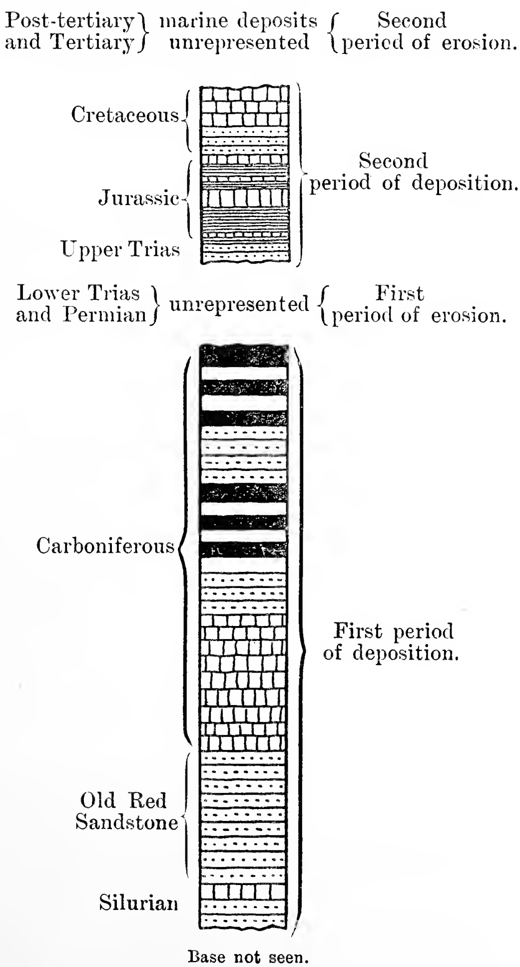
[1] 'Q. Journ. Geol. Soc.', LXIII. (1907), p. 445.

of layers of deposit, sometimes insufficient in amount to keep pace with the subsidence, sometimes in excess of it and causing shallowing of the water. Although it is true that in the Llandovery period there was a volcanic episode, and that there is evidence of upheaval and erosion during the latter part of the Silurian and beginning of the Old Red Sandstone periods, while further the Carboniferous dolomites and volcanic rocks point to the Bristol district being affected by the widespread Mid-Avonian disturbances, yet, on the whole, throughout this enormous lapse of time, during which strata to the thickness of probably 12,000 feet were accumulated, the

Fig. 3.—PERIODS OF EROSION AND DEPOSITION IN THE BRISTOL DISTRICT.



district was one of regular and gentle sedimentation. None of the present physical features had then any existence.

But this was not to continue indefinitely. At the close of the Carboniferous period the Bristol district was involved in the great system of earth movements, variously known as the Armorican or Hercynian, which can be traced so widely over western and central Europe. The effect of these movements was to throw the strata into two sets of ridges and accompanying troughs, one set exemplified in our district by the northern extension of the Bristol Coal field with its bounding limestone ridges passing through Tytherington to the west, and Chipping Sodbury to the east, having their axes running north and south, and a second set exemplified by the Mendips and Broadfield down having their axes running east and west. These two sets of uplifts intersect in the Radstock district and are no doubt responsible for the remarkably disturbed character of the Carboniferous strata there.

In this way the Bristol district was upheaved above sea level, and became subjected to a prolonged period of sub-aerial denudation in all probability under desert conditions, lasting throughout the Permian and earlier part of the Triassic period, and constituting the second chapter in its geological history. During Keuper or late Triassic times the salt lakes which, during the Permian and Bunter periods, lay to the north and south of the Bristol area, gradually extended and crept over the low lying part of the district, and in their more open waters the red and grey marls with masses of gypsum seen at so many points near Bristol were laid down. The higher hills, however, which even the prolonged denudation had been unable to wear away, stood out of the salt and barren waters of the Keuper sea as an archipelago of islands of which Mendip was the largest.[1] And as the waters crept up their sides and occupied their valleys as salt creeks, the stones and boulders which lay upon their flanks formed, with cementing materials deposited by the lake, the massive deposit known as Dolomitic Conglomerate. An excellent example of such a boulder-filled creek, remarkable for the extreme size of the blocks, is seen in Bridge Valley Road, Clifton. When it was occupied by the Keuper waters the Avon Gorge had no existence. The hollowed sides of the creek are still traceable, rising on the one hand towards Durdham Down and on the other towards Observatory Hill. Eastwards, towards Cotham, lay the spreading salt lake; westwards lay the head of the creek; and on the opposite or Somersetshire side of the present Avon Gorge may be seen the flat lying deposits resting unconformably upon the older rock surface, and formed when the waters had crept yet further up the valley. Some observers impressed by the size of the blocks, have called in the aid of glacial action to explain their presence, but there is no evidence of glacial striation to be seen here or elsewhere in the Bristol district. It may, parenthetically, be remarked that the term Dolomitic Conglomerate

[1] See "The Mendips; a geological reverie", 'Proc. Bristol Nat. Soc.', new series, V. (1885-8), p. 236.

is one by no means free from objection, as frequently the rock is not dolomitic, and it is more often a breccia than a conglomerate. Round the flanks of the Mendip hills the Dolomitic Conglomerate is often much in evidence extending, near Priddy, up to or above the 800 feet contour line, and the finer grained varieties which, in spite of their heterogeneous character, can be readily dressed, are quarried for building stone. One of the best localities for the study of this curious deposit is along the shore between Portishead and Clevedon, where it is seen resting with marked unconformity on the Old Red Sandstone. It may be noted that, as a rule, the blocks in the Dolomitic Conglomerate are in the main of purely local origin, consisting of Carboniferous Limestone when it rests on Carboniferous Limestone, Old Red Sandstone when it rests on Old Red Sandstone. Very few fossils have been found in the Dolomitic Conglomerate, but the bones of the reptiles *Proterosaurus* and *Thecodontosaurus* were many years ago obtained during quarrying operations at Clifton.

A glance at a geological map of the district will show what a large part is covered by the Keuper marls. They are to be seen in various railway cuttings and quarries near Bristol, as at Pylle hill, and the Malago brick and tile works, but are best exposed at Aust, where the fine coast section shows the usual division into an upper thinner series of Grey or Tea-Green marls, and a lower thicker series of Red marls. Here, too, the gypsum occurring in irregular bands, veins, and lumps, is very well seen, though never occurring in masses approaching in size those exposed in the cutting at Hallen on the new Filton and Avonmouth railway. The Keuper beds of the Bristol district are further of interest from the fact that they contain two deposits of considerable economic importance, viz.:—celestine, and ochre or raddle,—red and yellow oxide of iron, in an earthy state. The former mineral, which is or has been, worked at Yate, Bitton, Winford, Abbot's Leigh, and many other places in the Bristol area, is exported to Germany and used in sugar refining. The ochre or raddle is mined at Winford and at Wick rocks near Warmley. Red oxide of iron was also formerly extensively worked in the Dolomitic Conglomerate to the S.E. of Priddy in the Mendips.

During the deposition of the Triassic beds in England, important physiographic changes were taking place in Europe, and these were soon to make themselves felt in the neighbourhood of Bristol. While the waters of the Keuper lake were creeping up the slopes of the Mendip Isle and Durdham Downs, an extensive mediterranean sea was giving rise to contemporaneous marine strata in the region which now forms the Eastern Alps. There, some 2,000 feet of Rhætic strata[1] follow the marine equivalents of the Keuper of Northern

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[1] Among earlier papers describing the Rhætic strata of the district are those of T. Wright, 'Q. Journ. Geol. Soc.', XVI. (1860), p. 374; C. Moore, *ibid.* XVII., p. 483, and H. W. Bristow, 'Report Brit. Ass. (Bath) Trans. Sect.', p. 50. A. R. Short's paper, 'Q. Journ. Geol. Soc.', LX. (1904), p. 170, contains a full bibliography with references to the numerous papers on the Rhætic strata of the district that have appeared in recent years.

Europe. Slowly the waters of this southern sea stole northwards, until at last they invaded the English Keuper lake. And with them came marine reptiles, *Ichthyosaurus* and *Plesiosaurus*, and fishes such as *Hybodus*, *Saurichthys*, and *Ceratodus*. The remains of these reptiles and fish occur in the greatest abundance in the Rhætic Bone Beds, so well known at Aust and elsewhere in the Bristol district. These interesting deposits, though showing much variability, are, as a rule, breccias or conglomerates consisting of fragments of the neighbouring Palæozoic rocks mingled with bones, teeth, scales, and coprolites, the whole being embedded in a matrix which is generally calcareous, or pyritous, sometimes sandy. The character of both fragments and matrix varies with that of the underlying Palæozoic rock.

As regards the origin of these curious deposits, the explanation most generally given is that the vertebrate immigrants from the open Rhætic sea to the south, entered the area of the old Keuper lake before the saltness of the water was sufficiently reduced to form a suitable medium in which they could live, with the result that they died in thousands and their remains formed the bone beds.

This theory affords no explanation of the facts that more than one bone bed may occur at different levels in the series, and that the bone beds are not invariably at the base of the series. Mr. W. H. Wickes[1] has brought forward an ingenious explanation regarding the bone beds as due to shifting shoals of fish and of the reptiles which preyed on them. His theory not only offers an explanation of the variability in number and position of the bone beds, but also of their irregular distribution and of the fragmentary character of the vertebrate remains, nothing approaching a complete skeleton being ever found.

We have divided the geological history of the district into chapters, in each of which is recorded a definite and continuous episode in evolutionary development. The first chapter is occupied with the formation of the Palæozoic strata, the Silurian, Old Red Sandstone, and Carboniferous. The second is concerned with the uplift, under severe earth pressures, of these rocks, with their ridging into arches and troughs and with their early fashioning under the tools of denudation. The third deals with the burial of the carved surface under the newer Mesozoic sediments. First, the denuded lowlands were occupied by the waters of the Keuper lake; these then crept up the sides of the hills, and formed creeks in their valleys, until only an archipelago of islands broke the surface of the lake. Then the sea gained access, and the Rhætic beds were formed in the waters around the sinking archipelago. As Lias times followed, the islands disappeared, and were covered by deposits[2] of this age, the lithological character of which—often a white or light-grey limestone of slightly crystalline texture—may well puzzle the geologist accustomed

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[1] 'Proc. Bristol Nat. Soc.', New Series X., pt. 3 (1904 issued for 1903), p. 213.

[2] See C. Moore, 'Q. Journ. Geol. Soc.', XXIII. (1867), p. 449.

to the Lias of Lyme Regis or Whitby, till a *Pecten pollux* or other characteristic fossil reveals their true age. To the north-east of Durdham Downs, to the north of Chipping Sodbury, on Broadfield Down to the west of Dundry, near Shepton Mallet, and above the Harptree ridge on Mendip, to mention but a few localities, Liassic strata rests unconformably upon Mountain Limestone without any intervening Trias or Rhætic. Thus the archipelago sank, and only the upper part of the Mendip Isle remained above the water, not to be completely submerged till the Inferior Oolite times, even if then it had wholly disappeared beneath the Jurassic waters.

Owing to the diversities of the physical features of the sea in which they were deposited, the Liassic[1] strata vary much in volume and distribution. The finest sections of Liassic strata in the Bristol district are those of the Sodbury railway cutting, now unfortunately earthed in and invisible, of the Keynsham quarries and others near Stinchcombe, around Bath, and in the Radstock district. Throughout the central and southern parts of the area the Lower Lias beds are both thicker and better developed than the Middle or Upper Lias; and owing to the fact that they contain hard bands they are far more frequently quarried than are the higher beds. But towards the northern part of our area in the Wootton-under-Edge and Dursley districts the Middle Lias includes the hard beds of earthy limestone or calcareous sandstone known as the Marlstone, and this is frequently quarried.

Below the normal Lias strata come the beds known as the White Lias series, consisting of an upper relatively persistent band of cream coloured limestone, the "Sun Bed," and a lower equally persistent band, the well known Cotham or Landscape marble. Between these two is a series of thin-bedded limestones, which while having a thickness of 5 feet in the Radstock district dies out as one passes northward from Bristol.

The most noteworthy point about the Lower Lias of our area is the decrease in thickness and increase in calcareous character as one passes southwards. At Leckhampton hill, Cheltenham, the Lower Lias is from 600 to 700 feet thick; in the Sodbury section it is about 200 feet thick to the top of the *Capricornus* zone, and at both localities it is predominately shaly. Near Keynsham only part of the Lower Lias can be seen, but such zones as are exposed have only half the thickness of the corresponding strata at Sodbury, while Tawney's well-known descriptions show that the thickness at Radstock is about half that at Sodbury, the whole series up to the *Jamesoni* beds being only about 10 feet thick. The Keynsham development is far more calcareous than that at Sodbury, while that at Radstock

[1] For the Lias see H. B. Woodward, "Mem. of Geol. Survey", 'The Jurassic Rocks of Britain, vol. 3, the Lias of England and Wales (Yorkshire excepted)'; C. Moore, 'Q. Journ. Geol. Soc.', XXIII. (1867), p. 450; E. B. Tawney, 'Proc. Bristol Nat. Soc.', Series 2, i. (1874-6), p. 167; and more recently papers by A. Vaughan, J. W. Tutcher, and others in the 'Q. Journ. Geol. Soc.', LVIII. (1902), p. 719; 'Proc. Bristol Nat. Soc.', New Series X., pt. 1 (1903 issued for 1901), p. 3.

consists practically entirely of limestone. Succeeding the Lias come the deposits known as the Cephalopod bed and the associated Midford sands. The latter show much variation in thickness. At Stinchcombe the sands are 230 feet thick, and at Sodbury 185 feet; here they underlie the Cephalopod bed resting directly on the Upper Lias. Further south at Midford they are about 100 feet thick, while still further to the south they become rapidly thinner, being reduced to 5½ feet at Timsbury and disappearing to the south of Wellow. In the southern part of the area too, while there is a well-marked bed rich in Cephalopods, it is not the equivalent of that further to the north, as it underlies the sands instead of overlying them.

The succeeding Inferior Oolite[1] beds yield some of the finest of the Jurassic freestones, and have been quarried since Roman times at Dundry. They are finely exposed at Doulting, Vallis vale, and at Stroud, Stinchcombe, Wootton-under-Edge, and other places along the edge of the Cotteswolds. Much attention has been paid to them in recent years by Messrs. Buckman and Richardson, showing the presence of local non-sequences or the absence of certain of the life-zones. Of the 27 sub-divisions which these authors recognise in the Inferior Oolite series not one is traceable over the whole area, this being in most cases clearly not due to lithological changes, but to local erosion and non-sequence.

The most complete development of the Inferior Oolite is at Leckhampton hill outside our area; here it is about 200 feet thick, consisting of the Ragstone series above, the Freestone series in the middle, and Pea Grit series below, but as the Inferior Oolite is traced southwards along the Cotteswold escarpment, all the middle and lower beds gradually die out, till at Bath the Upper Trigonia Grit, the lowest bed of the Ragstone series, rests directly on the Midford sands. At Dundry an important bed of freestone comes on above the Upper Trigonia grit, and in the Eastern Mendips a second bed of freestone, the Doulting stone occurs at what according to Mr. L. Richardson is a still higher level. Neither of these freestones is represented as such in the Cotteswolds. In the eastern Mendips, at the well-known Vallis quarries, the Upper Trigonia Grit and the Dundry freestone have disappeared, like the Freestone and Pea Grit series further to the north, so that the Doulting beds rest directly on the Carboniferous Limestone.

Resting on the Inferior Oolite is the Fuller's Earth, a marly clay with hard bands. Though seen in small exposures at many points in the district, and reaching a thickness of 130 feet at Wootton-

[1] For general accounts of the Lower Oolitic rocks see H. B. Woodward, 'Mem. of Geol. Survey', "The Jurassic rocks of Britain, vol. iv., the Lower Oolitic Rocks of England"; J. W. Tutcher, "The Lower Oolites near Bristol", 'Proc. Bristol Nat. Soc.', New Series IX. (1898-1900), p. 150; for the Dundry exposures, S. S. Buckman and E. Wilson, 'Q. Journ. Geol. Soc.', LII. (1896), p. 669, and 'Proc. Bristol Nat. Soc.', New Series, VIII. (1896-98), p. 188; for the Bath-Doulting district, L. Richardson, 'Q. Journ. Geol. Soc.', LXIII. (1907), p. 383.

under-Edge, it is far thinner than in Dorset. It was formerly much used in fulling at the cloth mills of Bradford-on-Avon and elsewhere. Owing to its impervious character it throws out many springs and has caused numerous slips on the slopes of the Cotteswolds.

The succeeding Great or Bath Oolite which caps the hills about Bath is well known for the excellent freestone long quarried at Minchinhampton, Bath, Box, Bradford-on-Avon, etc. In the Sodbury tunnel it has a thickness of about 100 feet and may reach a greater thickness near Bath, but to the south of Bradford-on-Avon it rapidly thins out and disappears, so that the succeeding Forest Marble rests directly on the Fuller's Earth.

The Forest Marble, which is finely exposed in the cutting eastward from Badminton on the South Wales direct line, consists of marly clays associated with irregular bands of shelly oolitic limestone having a thickness of about 100 feet. When followed to the north the Forest Marble becomes reduced in thickness, while in Dorset on the other hand it swells out to a thickness of 400 feet. Near Bradford and Bath the well-known Bradford Clay having a thickness of 10 feet or less underlies the Forest Marble.

The Cornbrash, the highest member of the lower Oolites, consists of pale earthy and rubbly limestones. It is highly fossiliferous, and near Hullavington Station has a thickness of 11 feet.

The Upper Oolitic and Cretaceous strata can scarcely be considered to enter the Bristol district as defined at the outset, but reference must be made to the oolitic ironstone which till recently was worked in the Corallian at Westbury.

With the close of Cretaceous times the second prolonged period of depression and sedimentation forming the third chapter in the geological history of the Bristol district comes to an end.

With the beginning of Cainozoic or Tertiary times the whole district has been elevated to form dry land, and the second period of prolonged denudation is initiated. This final re-emergence must probably itself have been accompanied by marine denudation. It must be remembered that the uplift of the area from beneath the waters of the Chalk sea was not sudden but gradual. As the oozy bottom was slowly raised to the surface it was played upon by the waves, which would readily erode the soft layers of recently deposited and little consolidated material. We may picture the battle of contending forces. Those of upheaval were striving by steady uplift to raise the sea-bottom into dry land. Those of marine denudation eroded the oozy deposits as they came to the surface. Layer after layer was lifted to the sea level. Layer after layer was swept away by the breakers. What eventually decided the struggle and gave to upheaval the final victory, it is impossible to say. It is not improbable that over the Mendips marine denudation, during the process of upheaval, held its own until the hard core of the old range was laid bare. But these conclusions are largely conjectural. We know that the upheaval, then or somewhat later, took place in such a way as to give to the

Mesozoic strata, and the old land surface on which they rested, a prevalent gentle easterly dip. And we have good reasons for concluding that the limestone ridges round Bristol were still covered by Secondary deposits when the district once more formed dry land. The beginnings of our present system of river drainage were then outlined, and the fourth chapter in the Geological history of the district exhibits the action of these denuding forces, first on the Secondary rocks, and secondly on the old pre-Mesozoic land surface, gradually laid bare.

The Severn and its tributaries, especially the Bristol Avon, play the leading parts. The depression through which the Severn now passes is a very old physical feature. Great faults such as that which, near Cattybrook, has brought the Coal Measures against the more resisting Lower Carboniferous rocks, and those which disturb the strata near Portishead, may have helped to outline its southern shore. Prolonged denudation scoured it out; and in Triassic times it seems to have formed an arm of a lake, narrowing westwards. On the re-elevation of the land in Tertiary times it began to be what it now is, a dominant line of drainage, and poured its waters, as now, westwards into the Atlantic. Tributary streams bore down to this ancient Severn the dèbris removed from the Secondary rocks, wearing them back to the escarpment which continues the line of the Cotteswolds southwards towards Bath, and leaving outliers (of which Dundry is a conspicuous example) standing out as hills of circum-denudation, surrounded by the shrunken streams which have carried off the detritus from their weathered flanks.

If we endeavour to picture the scene when, in early Tertiary times, the tributaries of the Severn began their work of denudation, and when heavy rains swept the gentle slopes of their valleys, we see as yet no sign of the ridges of Carboniferous Limestone or Old Red Sandstone which now form such marked features of the landscape. The pre-Mesozoic land-surface, in the immediate neighbourhood of Bristol, was still buried beneath a gently undulating sheet of Secondary strata, in the hollows of which the streams had already established their course—a course thus necessarily wholly independent of the ancient physical features still enveloped in the sediments of the Secondary age. Unless we realise that the Avon and its tributary the Trym, had their course determined long before the Downs emerged into view through subsequent denudation, it is quite impossible to understand how the gorges of Clifton and Combe Dingle came into existence. One may liken the effects of sub-aerial denudation to the concurrent action of two processes; first, the file-like fretting of the streams in their beds; and secondly, the wasting of the whole surface by means of the sand-paper action of rain and the crumbling disintegration of the weather. But the stream has a double office; not only does it deepen its channel, but it bears seawards all that rain and the weather wear off the valley slopes. Where the rocks are soft and yielding the sand-paper and the file act at nearly equal rates: the valley is wide with gentle slopes. Such were probably the conditions when the Avon and the Trym at length reached the level at which the backs of the Bristol Downs were just laid bare. As the concurrent action of the two denudation processes continued through long ages, the effects where the ancient ridges of old rocks slowly emerged were different from those where pre-Mesozoic sculpturing had already formed broad and open valleys in which the more yielding Triassic and Liassic strata still awaited removal, as for example in the valley between Durdham Down and Kings Weston Down (see fig. 4).

The action of the river-files was restricted to the rate at which they could cut through the harder rocks in the lower part of their course, for the erosion of the softer beds above was limited to the depth to which the notches in the harder strata were cut. And since the superficial waste, due to rain and weather, continued with unbating vigour over the more yielding area, the valleys here remained broad and open. But over the old ridges, whose existence was primarily due to their powers of resistance to an earlier superficial erosion, rain and weather had little power. The action of the file outran that of the sand-paper, and the gorges of the Avon [1] and the Trym resulted. They impress the eye from their narrow cleft-like form and their steep sides. But, gauged by the amount of material removed, they are characterised rather by defect than by excess of denudation. The quantity of sedimentary deposits swept away by the Avon during the formation of its striking gorge at Clifton is far inferior to that removed in an equal length af the river's course above Keynsham, where the valley widens out and has a much less impressive appearance.

Another example of the way in which the newer rivers cut defiles through the older ridges is seen near the northern boundary of the Gloucestershire coal field. A range of Carboniferous Limestone upland here forms the containing rim of the basin in which the lower-lying Coal Measures lie. From Almondsbury through Tytherington, Cromhall, Wickwar, and so round to Chipping Sodbury, runs a tract of Carboniferous Limestone forming a horse-shoe ridge. Most of the drainage of the Coal Measure area is into the Frome which joins the Avon at Bristol. And one might naturally expect that the horse-shoe ridge would form the watershed of the whole of this drainage area. But this is not so; for within the limestone rim, south of Cromhall, there rises a small stream which, instead of joining the Frome drainage, makes northward for the ridge, breaches it in the well-wooded and

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[1] The recognition of the existence of the old glacier lakes in the Vale of Pickering by Mr. C. Fox Strangways ('Mem. Geol. Survey, the Jurassic Rocks of Britain', I, 1892, p. 423), and in the Cleveland Hills by Prof. P. F. Kendall ('Q. Journ. Geol. Soc.', LVIII, 1902, p. 471, and 'Proc. Yorks. Geol. and Pol. Soc.', XV., pt. i., 1903, p. 1) has suggested a new explanation of the origin of certain gorge-like valleys, viz., that they are the overflow channels cut by the escaping water from such ice-dammed lakes. Mr. F. W. Harmer has recently ('Q. Journ. Geol. Soc.', LXIII., 1907, p. 483) suggested that similar ice-dammed lakes occupied the country in the neighbourhood of Trowbridge, and between Bath and Bristol, and that the gorges of the Avon between Bradford and Bath, and at Clifton, are the overflow channels from these lakes.

picturesque gorge of Tortworth, and so joins the waters of the Little Avon which falls into the Severn near Berkeley. Etheridge believed that the gorge was a faulted line, but careful examination shows that there are no dislocations of any importance, and that the defile is a denudation feature. When the river, whose drainage area has probably been materially decreased by the encroachment of the Frome basin, began to flow, the horse-shoe ridge was still buried beneath the Secondary strata over which the stream took its northward way in accordance with the slope of the surface as it then existed. And the gradual emergence of the old limestone ridge could do nothing to divert its well-established course.

But the same horse-shoe ridge is not only breached from within by an outward-flowing stream, but it is also cleft from the opposite direction by a tributary of the Frome near Chipping Sodbury. On either side of the old British encampment of Old Sodbury two streamlets have their source within a mile of each other; one flows to the east, the other to the west. The former is a parent stream of the Bristol Avon; the latter, of its tributary, the Gloucestershire Frome. The easterly rill, mingling its waters with those of the other streams, runs past Malmesbury, sweeps round by Chippenham, and flows in a bold curve through Trowbridge, Bradford, and Bath to Bristol, where it is joined by the waters of the other rill which have flowed through Chipping Sodbury, Yate, and Stapleton. Not only, therefore, does the lesser stream cut through the Carboniferous Limestone ridge, but the longer river threads its way through the Oolitic upland round Bath, here cutting boldly through the range of hills on the easterly dip-slopes of which it had its birth not many miles further north.

When we remember the length of time that has elapsed since these streams began to flow, and since the later denudation of the district began to carve the surface into sculptured relief, we shall cease to wonder at the depth of its gorges and the broad sweep of its more open valleys. And when we realize how diverse are the rocks which have been exposed to these long-continued erosive influences, we shall understand how it is that the Bristol Avon and its tributaries have been instrumental in producing such varied and beautiful scenery. Nor must we forget that during the vicissitudes of a changing climate, and in consequence of variations of relative level in sea and land, denudation may well have been often far more intense than it now is. The cliffs of the Avon Gorge did not always look down on a tidal mud-laden stream. There were once some hundreds of feet of descent between the present site of Bristol and the sea many miles distant. When the streams began to flow the climate was tropical, as the fossils of the Tertiary deposits of the London Basin show; a warm ocean current may have coursed through Asia to the Mediterranean, and through the heart of Europe to the London Basin; and a tropical rain-fall may have swept the valley slopes and swelled our streams. As Tertiary time elapsed this current was diverted, and the climate passed through successive phases of lowering mean temperature until the increasing cold culminated in the glacial epoch. Although there is no evidence

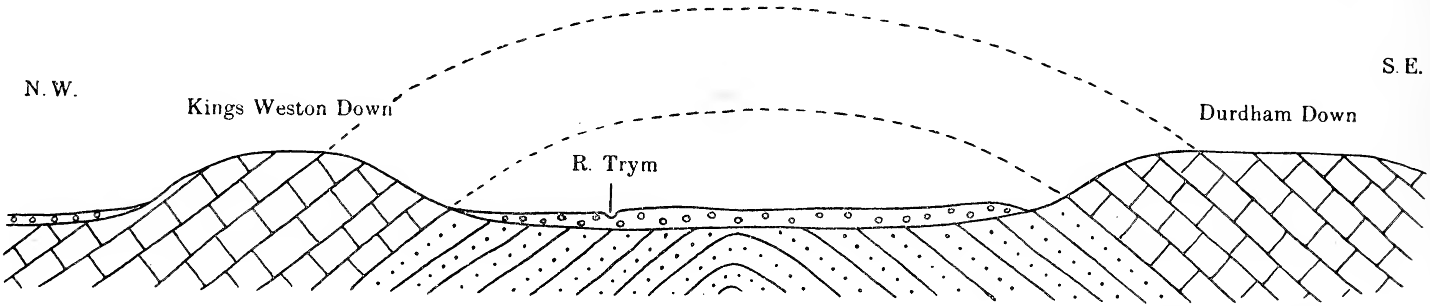


FIG. 4.—SECTION ACROSS THE TRYM VALLEY FROM KINGS WESTON DOWN TO DURDHAM DOWN, showing the pre-mesozoic erosion of the Palæozoic Rocks.

(Length of Section about $2\frac{1}{2}$ miles.)

Old Red Sandstone [· · ·]   Carboniferous [| |]   Trias [o o o] of glaciers in our district snow must have lain thickly on the hills in winter, and, when it melted, produced torrential floods.

The small streams of to-day must often have been swollen to many times their present dimensions, and exerted a denuding influence far in excess of its present amount. Geological uniformity does not exclude wide differences in intensity of action, and when we look down from the slopes above Limpley Stoke on the Avon creeping sluggishly seawards, we must not suppose that such was the stream that carved the valley through the Oolitic hills; not such was the stream that swept down the large rounded masses of grit and limestone which are found in the Twerton gravels, near Bath. No such stream as this could have produced the Avon Gorge at Clifton.

Some further allusion may here be made to a geological feature, which is particularly well illustrated in our district, namely, to the revelation by the later denudation of the sculptured surface which was produced in pre-Mesozoic times before the area was invaded by the salt waters of the Keuper lake, or was smothered beneath later Secondary strata. It is, no doubt, impossible to say for certain to what extent the ridges and valleys in the older Palæozoic rocks have been remodelled by the later erosion which has revealed their existence.

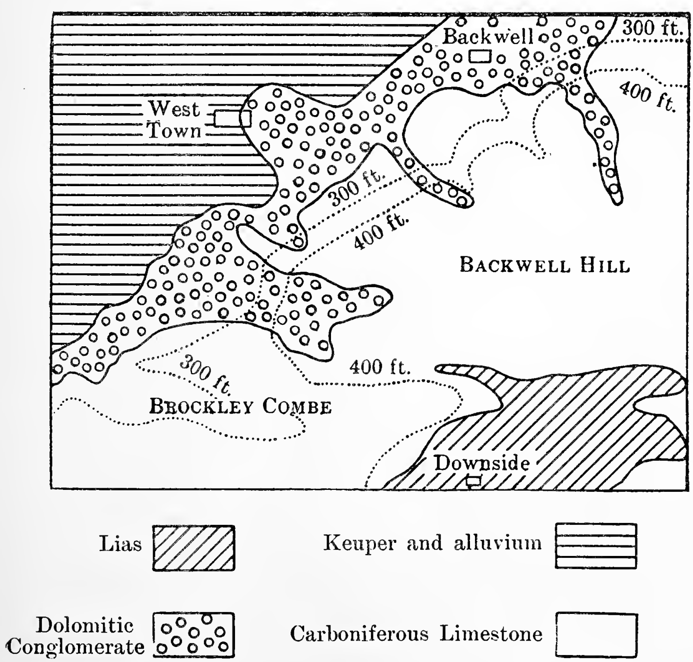
The valley of the Trym between Durdham Down and King's Weston Down (see fig. 4), which has been eroded in an anticlinal fold of Carboniferous and Old Red Sandstone rock, is clearly a pre-Mesozoic feature, as its lower portion is occupied by flat-lying Triassic beds, before whose deposition some 1500 feet of Old Red Sandstone, 2000 feet of Carboniferous Limestone, and 6000—7000 feet of Coal Measures must have been removed by denudation. Similarly, the horizontally-lying Triassic beds, occupying the valleys to the north and south of Broadfield Down, show that these hills are of pre-Mesozoic date.

At various points in the Bristol area, and notably on Durdham Down, in the neighbourhood of Sea Walls, the highly inclined beds of limestone have been planed off to form an almost absolutely level surface. Such a surface could not have been produced by subaeriel erosion, and it is probable that the final planing of the ridges was effected by the waves of the Jurasssic sea. On these planed surfaces, by further subsidence of the land, were deposited the somewhat abnormal Liassic strata, which, as has been already mentioned, are found on Broadfield Down and elsewhere, resting directly on the Carboniferous Limestone. It is inconceivable that these Liassic beds could have been preserved in their present position if the planed surfaces in their neighbourhood were the result of a post-Liassic denudation; and evidence of a similar kind is presented in such amount, and so well distributed throughout the district, as to justify the conclusion that the Carboniferous Limestone ridges, which form so marked a feature in our scenery to-day, are ancient denudation-features revealed by, and only to a small extent re-modelled by, the later forces of erosion.

The way in which it is possible to reconstruct some of the physical features of the ancient land surface, which the later erosion has revealed to us after so great a lapse of time, is peculiarly interesting. No doubt the uplands, before they were planed down by the waves of the Jurassic sea, may have been higher and more rugged than they now appear; but since, as they sank beneath the waters of the Triassic lake, their valleys formed creeks in which were formed marginal deposits of a tough and resisting nature, the tongues of these rocks, which run up into the limestone uplands, enable us to trace the old valley lines, and also to see their independence of the more recent gorges, which have been formed during the later denudation. This is exemplified in Fig. 5, representing the neighbourhood of Backwell on the northern slopes of the upland of Broadfield Down. It also introduces one of the patches of Lias, which have been already referred to as resting on the broad back of the Down. The manner in which the marginal deposits run up into the limestone along the lines of old creeks is clearly seen; and the comparative independence of the gorge of Brockley Combe, the product of later denudation, is also evident.

Fig. 5.—SKETCH MAP OF THE NEIGHBOURHOOD OF BACKWELL HILL.

Scale 1½ inch = 1 mile.



As has been already mentioned, there is no direct evidence available of glacial action anywhere in the Bristol district, but the occurrence of the Musk Sheep in the old gravels of the Avon at Freshford, of the Reindeer in the bone-cave or fissure, on Durdham Down, and of the Lemming and Arctic Fox in that of Walton, near Clevedon, indicate semi-arctic conditions, and it is not unlikely that when these animals lived in the south of England, northern Britain was still in the grip of the ice of the glacial period. A land connection with the continent still existed, and Britain received thence its earliest human inhabitants.

Owing to the numerous limestone hills, the Bristol district is exceptionally rich in bone-caves, which occur at Banwell, Cheddar, Hutton, Sandford, Uphill, and Wookey, in the Mendip district, and nearer Bristol, at Walton near Clevedon, and Durdham Down. The animal remains found in the majority of these bone-caves probably belong to a slightly later period than the old river gravel of Freshford. Prof. Boyd Dawkins gives the following vivid picture of the conditions of the Bristol area during this early Palæolithic period—"We may picture to ourselves a fertile plain occupying the Bristol Channel, and supporting herds of reindeer, horses, and bisons, many elephants and rhinoceroses, and now and then being traversed by a stray hippopotamus, which would afford abundant prey to the lions, bears, and hyænas inhabiting all the accessible caves, as well as to their great destroyer, man. . . . Hyænas were the normal occupants of the caves (*e.g.*, Wookey Hole), and thither they brought their prey. We can picture these animals pursuing elephants and rhinoceroses along the slopes of the Mendips till they scared them into the precipitous ravine (Cheddar Gorge), or watching until the strength of a disabled bear or lion ebbed away sufficiently to allow of its being overcome by their cowardly strength. Man appeared from time to time on the scene, a miserable savage, armed with bow and spear, and unacquainted with metals. Sometimes he took possession of the den and drove out the hyænas. He kindled his fires at the entrance to cook his food and to drive away wild animals; then he went away, and the hyænas came back to their abode."

In England there was a considerable break in time between the Palæolithic and the succeeding Neolithic occupation. Great Britain had become insular, and the Neolithic farmers and herdsmen must have crossed the Channel to reach our shores. They mined for flint, and often, but by no means always, ground and polished the surface of their implements. They introduced the stocks of the more important domestic animals, such as the dog, horse, sheep, goat, short-horned cattle, and hog, as well as many cultivated seeds and fruits. These members of (possibly) Iberian race, perhaps allied to the Basques of the Pyrenees, are the ancestors of such tribes as the Silures, of South Wales, who were driven to the mountain fastnesses by the Celtic Bronze folk, the early pioneers of the Aryan invasions of Britain.

Studies on the Occurrence and Reproduction of British Freshwater Algæ in Nature.[1]

2. *A five years' observation of the Fish Pond, Abbot's Leigh, near Bristol,*

By F. E. Fritsch, D.Sc., Ph.D., F.L.S.
(University and East London Colleges, University of London),
and Florence Rich, M.A.

A.—INTRODUCTORY.

THE study of freshwater algal biology is a fairly recent one. Its commencement dates some twenty years back,[2] when the methods of marine Plankton-research were applied to the study of freshwater Plankton with results that proved of sufficient value to stimulate a whole host of continental workers to take up this line of research. Soon afterwards the first contribution dealing with the biology of freshwater algal growth in general appeared in the shape of Chodat's well-known "Etudes de biologie lacustre,"[3] and a somewhat earlier paper by Schmidle[4] in the Flora for 1894. The first paper to deal seriously with the periodical phenomena of macroscopic algal growth was that published by one of us[5] in 1903; this was followed in 1906 by a more detailed discussion[6] of the chief problems awaiting solution in the realm of algal biology, the method of research and the main points brought forward in the paper being illustrated by a series of periodical observations made on a pond at Telscombe, near Newhaven. In the interval that elapsed between these two papers there appeared contributions by Norman Walker[7] on the Bramhope ponds, near Leeds, and by J. Comère[8] on the periodicity of the algal flora in the region of

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[1] The first paper of this series was published in Annals of Botany, Vol. xxi., July, 1907, p. 423—436.

[2] Hensen, Das Plankton der östlichen Ostsee und des Stettiner Haffs. 6. Bericht d. Commission z. wiss. Unters. d. deutschen Meere, 1890.

[3] Bulletin de l'Herbier Boissier, Vol. v., No. 5, 1897, and Vol. vi., No. 6, 1898.

[4] Schmidle, Aus der Chlorophyceenflora der Torfstiche zu Virnheim. Flora, Vol. lxxviii., 1894.

[5] F. E. Fritsch, Algological Notes.—IV. Remarks on the Periodical Development of the Algæ in the artificial waters at Kew. Annals of Botany, Vol. xvii., 1903, p. 277.

[6] F. E. Fritsch, Problems in Aquatic Biology, etc. New Phytologist, Vol. v., No. 7, 1906, p. 149, et seq.

[7] N. Walker, Pond Vegetation. Naturalist, October, 1905, No. 585, p. 311.

[8] J. Comère, Observations sur la périodicité du développement de la flore algologique dans la région toulousaine. Bull. Soc. Bot. de France, t. liii., 1906, p. 390, et seq.

Toulouse. In 1907 we published a paper[1] embodying a considerable number of observations on the occurrence and reproduction of *Spirogyra* in nature, in which material derived from the pond which forms the subject of the present communication was largely employed. Quite recently G. S. West[2] has published an interesting and detailed paper on the Algæ of the Yan Yean reservoir in Victoria, in which are embodied the results of a year's periodical observations. The method of observation and of recording results adopted in this paper quite accords with that outlined in the "Problems in algal biology" in 1906.[3]

Studies in algal biology were first commenced by one of us about seven years ago, but it was only by degrees that the work shaped out and took a definite form. During this period a very large quantity of material has accumulated, but for one reason or another its investigation has progressed but slowly, so that there has been great delay in publication. Samples of Algæ were first received from the Fish Pond, Abbot's Leigh, in January, 1904, and from that time up to June, 1907, they were sent regularly almost every month; since that time, however, they have come more intermittently, the last sample of the series being received in the autumn of 1908.[4] As far as we are aware, so systematic an investigation of the algal flora of a small pond has never yet been undertaken. We feel that a great deal of the credit for such results, as this work has afforded, is due to those who have so kindly furnished us with the necessary materials, and we desire to express our deep sense of obligation, first, to the late Mr. Brebner, to whom we owe the selection of so suitable a piece of water, and then to Mr. Hunter, and Mr. J. H. Priestley, B.Sc., who continued the arduous task of collecting the monthly samples. To Mr. Priestley we are also indebted for information concerning the character of the pond, and for certain meteorological data, and to Dr. Mill for valuable data on the rainfall of the Clifton district. Finally, we have to thank Mr. J. Salisbury, B.Sc., for the four photographs of the algal growth in the pond, which accompany this paper.

At the commencement of these investigations a study of the periodicity of the algal flora was the sole object, but as sample after sample was examined it soon became apparent that this method of observation was going to cast valuable side-lights on the inter-relations of the different members of the algal flora, and on the conditions influencing reproduction. Indeed, as the series of samples increased, the perspective became ever wider, and now there are so

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[1] F. E. Fritsch and F. Rich, Studies on the occurrence and reproduction of British Freshwater Algæ in Nature. I., Preliminary observations on *Spirogyra*. Annals of Botany, Vol. xxi., 1907, p. 423—436.

[2] G. S. West, The Algæ of the Yan Yean reservoir. A biological and œcological study. Journ. Linn. Soc., Botany, Vol. xxxix, 1909, p. 1, et seq.

[3] F. E. Fritsch, loc. cit.

[4] The actual dates on which the samples were collected are given in the temperature-table on p. 30.

many points of view involved in the investigation of this single pond that their complete elucidation would mean many years of detailed study. For the present we shall only attempt to give some idea of the life-history of the algal community that peoples the piece of water under consideration, and to indicate, as far as is possible, how this history is connected with seasonal changes and other external conditions.

The general method of collecting the samples is described on p. 162—163 of "Problems in Aquatic Biology,"[1] and need not be repeated here. We, of course, fully recognise the defects that are bound to accompany the observations in a research of this kind, but inasmuch as most of our conclusions are founded solely upon positive data we think that the errors can probably be neglected. Each sample sent by the collectors was accompanied by useful data as to the temperature of air and water at the time of collecting, the nature of the weather during the previous week or fortnight, and the amount and appearance of the algal growth present, data,—which will frequently be referred to in the course of the paper.

B.—GENERAL CONSIDERATION OF THE PHYSICAL FEATURES OF THE POND AND OF THE METEOROLOGICAL DATA.

The Fish Pond, Abbot's Leigh, is an old pond situated not very far from Leigh Woods, near Bristol. The pond is of no very considerable size (maximum length about 70 metres, maximum breadth about 40 metres, and maximum depth about $1\frac{1}{2}$ metres), although big enough to render collecting from the middle parts difficult, the samples being therefore derived from what can be reached from the sides. The pond is situated on the Old Red Sandstone, but water probably also drains into it from the Carboniferous limestone. The pond is surrounded on all except the south side by fairly steep and wooded slopes of no great height; on the south side water drains into it from an adjacent marsh. A small stream constitutes an outflow on the north side, while a pumping station (apparently very little used) is situated next to the roadway on the west side. The water-level is stated, as a rule, to remain practically constant. Shrubs and trees[2] extend down almost to the water's edge and at many points cast a deep shade over the littoral vegetation in the summer and autumn, while in the late autumn a quantity of dead foliage is found in the pond—a certain amount being invariably present. This, together with the remains of the rather abundant Phanerogamic

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[1] Fritsch, loc. cit.

[2] Pine, Spruce, Beech, Oak, Ash, Elm, Hazel, and Hawthorn.

aquatics (see below) must contribute considerably to the organic content of the water in the latter part of the year. The water of the pond is ordinarily quite clear, although somewhat dark sometimes from decaying matter. The floor is deep mud.

Of the meteorological data the most important are those concerning temperature and rainfall. The following table gives the temperatures of air and water (for the first four years) at the times of collecting each sample, the requisite data being supplied by the collectors themselves. The approximate hour at which each sample was collected is given, wherever such information was available.

TEMPERATURE OF AIR AND WATER AT TIME OF COLLECTION

(in degrees centigrade).

DATE.	Temp. Air.	Temp. Water.
Jan. 23rd, 1904 (3 p.m.)	3°	1°
Feb. 21st, ,,	9·7°	7·7°
Mar. 26th, ,, (4 p.m.)	6°	6·25°
Apr. 24th, ,, (3.30 p.m.)	13·5°	12·75°
May 29th, ,, (4 p.m.)	19°	19·5°
June ,[1] ,,	—	—
July 24th, ,,	19°	20·5°
Sept. 7th, ,,	16°	17°
Oct. 2nd, ,, (3.30 p.m.)	12°	12°
Oct. 30th, ,, (3.30 p.m.)	10°	9·5°
Dec. 4th, ,, (3 p.m.)	13°	8°
Jan. 1st, 1905 (1 p.m.)	2·5°	4°
Feb. 5th, ,, (4.30 p.m.)	9°	8°
Mar. 11th, ,, (3.30 p.m.)	9·5°	8°
Apr. 16th, ,, (12.30 p.m.)	14·5°	12°
May 14th, ,, (2.30 p.m.)	14·5°	15°
June 18th, ,, (4 p.m.)	18°	17·5°
July 9th, ,, (3.30 p.m.)	22·5°	21°
Aug. 13th, ,, (1 p.m.)	16·5°	18°
Sept. 10th, 1905 (4 p.m.)	14·5°	17°
Oct. 15th, ,, (1 p.m.)	12·5°	12°
Nov. 12th, ,, (12.30 p.m.)	9·5°	9°
Dec. 10th, ,, (1 p.m.)	5·5°	6°
Jan. 7th, 1906 (3 p.m.)	7°	6·5°
Feb. 18th, ,, (1 p.m.)	5°	6°
Mar. 18th, ,, (3 p.m.)	11°	9·5°
Apr. 15th, ,, (3 p.m.)	14·5°	14°
May 13th, ,, (3 p.m.)	23°	19°
July 2nd, ,, (1 p.m.)	18·3°	16°
Aug. 10th, ,,	17·2°	18°
Sept. 8th, ,,	28°	23°
Nov. 4th, ,,	8°	6·5°
Jan. 6th, 1907	8°	4°
Mar. 6th, ,,	10°	8°
May 1st, ,,	12°	15°
June 28th, ,,	16·2°	19°
Aug. ,[1] ,,	—	—
Oct. 4th, ,,	11·4°	11·35°
Nov. 18th, ,,	7·5°	7°

A scrutiny of this table shows that the temperature of the water follows the changes in the temperature of the air fairly closely, and

[1] On these occasions no temperature-data were obtained.

that, whereas during the winter months the temperature of the water is lower than that of the air, it is often the other way round in the summer. It is noticeable that only on three occasions did the temperature of the water exceed 20° C., so that the ordinary temperature of the water seems rarely to attain to the high summer temperatures characteristic of shallow ponds of this type; the average summer-temperature, judging by the figures before us, appears to be about 17° C. Attention may also be drawn to the following abnormalities:—a strikingly low temperature on January 23rd, 1904; relatively high temperatures on May 29th, 1904, December 4th, 1904, May 13th, 1906, and September 8th, 1906. Of the four years 1905 was therefore most uniform as regards temperature.

For the following table showing the monthly rainfall at Clifton we are, as already mentioned, indebted to Dr. Mill. The total annual rainfall is on the average (for the last 30 years) 35·45 inches, considerably more than half falling into the second half of the year. Special points calling for attention are the exceptionally heavy rainfall during the last four months of 1903 and 1907 as compared with other years; very low rainfall in January and February, 1905; May and July, 1905; June, 1908; and September of 1906 and 1907. The total annual rainfall was as follows:—43·65 in. in 1903; 32·22 in. in 1904; 26.36 in. in 1905; 32·06 in. in 1906; 35·25 in. in 1907. Of these five years the year 1905 thus had considerably the lowest annual rainfall, the amount being about nine inches below the average.

RAINFALL AT CLIFTON, GLOUCESTERSHIRE (in inches).

MONTH.	1903.	1904.	1905.	1906.	1907.	1908.	Average for last 30 years.
January ...		3·58	·68	4·95	2·11	1·76	3·07
February...		4·09	·86	2·53	1·81	1·80	2·44
March ...		2·17	4·74	2·81	1·14	3·06	2·28
April ...		2·29	3·16	1·36	3·95	3·04	2·21
May ...		3·19	·11	2·56	2·61	1·87	2·23
June ...		1·92	4·28	2·74	3·23	·71	2·29
July ...		4·40	·91	1·35	2·72	2·18	3·25
August ...	4·39	3·23	4·11	2·63	2·34	4·63	3·61
September	3·33	1·54	1·33	·82	·62	2·69	3·35
October ...	8·03	1·37	2·03	5·88	5·33	1·91	4·01
November	1·91	2·12	3·02	2·90	3·11	1·11	3·53
December	3·13	2·32	1·13	1·53	6·28		3·18

C.—THE MORE IMPORTANT CONSTITUENTS OF THE FLORA (BOTH CRYPTOGAMIC & PHANEROGAMIC).

The flora of the pond under consideration is certainly a rich and rather varied one, though subject to considerable fluctuations. From about March onwards till October or November floating aquatics play a great part, frequently (in the height of the summer) forming almost a complete covering on the surface of the water. Most important of these aquatics are *Potamogeton natans* and *P. crispus*—especially the former—and *Lemna minor*, which forms dense patches, particularly around the edge of the pond; *Callitriche* is frequently present, but not in large quantity, while submerged mosses are not at all uncommon. *Nasturtium officinale*, *Lythrum Salicaria*, and *Veronica beccabunga*, are the chief representatives of the marginal vegetation. During the winter months Phanerogamic aquatics are often completely wanting or merely represented by a few plants of *Lemna*.

The following is a list of the dominant species of Algæ that have been found in the pond:—

1. *Cladophora fracta*, Kütz.
2. *Spirogyra affinis* (Hass.), Petit.
3. „ *jugalis* (Dillw.), Kütz.
4. „ *longata* (Vauch.), Kütz.
5. „ *neglecta* (Hass.), Kütz.
6. „ *nitida* (Dillw.), Link.
7. „ *rivularis*, Rabh, ?[1]
8. „ *varians* (Hass.), Kütz.
9. „ *Weberi*, Kütz.
10. *Melosira varians*, Ag.
11. *Cocconema lanceolatum*, Ehrenb.
12. *Fragilaria virescens*, Ralfs.
13. *Cocconeis Pediculus*, Ehrenb.
14. *Synedra radians*, Sm.
15. „ *Ulna* (Nitzsch), Ehrenb.

Although present in very varying amount at different times of the year the species above enumerated are the character-forms of the algal vegetation of the Fish Pond. Such a grouping of *Cladophora* with *Spirogyra* and an abundance of free and epiphytic Diatoms we have observed also in other pieces of water, and it is not improbable that it marks a definite type of freshwater algal formation (or association). Side by side with the character-forms several of the following species are generally to be found:—

1. *Mougeotia* spec.
2. *Œdogonium* spec. (varying from 5-40 μ in thickness).
3. *Microspora* spec.
4. *Coleochæte scutata*, Bréb.
5. *Closterium moniliferum* (Bory), Ehrenb.
6. *Oscillaria* spec.
7. *Epithemia turgida* (Ehrenb.), Kütz., and other species.
8. *Navicula viridis*, Kütz., and other species.
9. *Gomphonema acuminatum*, Ehrenb.
10. *Rhoicosphenia curvata* (Kütz.), Grun.
11. *Cocconema prostratum* (Berk.), West.
12. „ *cymbiforme*, Ehrenb.
13. *Achnanthes* spec.

Some of these subsidiary forms may occasionally become dominant (e.g., *Œdogonium*, *Mougeotia*), but this is an exceptional condition

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[1] Diam. of filaments = 24-33 μ; three spirals.

found one year and not the next, and none of the species just enumerated are as characteristic of the flora as *Cladophora*, *Spirogyra*, etc.

Lastly, a large number of species (in great part unicellular or simple colonial forms) are only found in any quantity at irregular periods, or are never represented by more than a few individuals. These are :—

Vaucheria sessilis (Vauch.), D C.
Stigeoclonium spec.
Aphanochæte repens, A. Br.
Zygnema spec.[1]
Closterium acerosum (Schrank), Ehrenb.
,, *parvulum*, Näg.
,, *rostratum*, Ehrenb. ?
,, *Venus*, Kütz. ?
Cosmarium cyclicum, Lund.
,, *granatum*, Bréb.
,, *reniforme* (Ralfs), Arch.
,, *subcucumis*, Schmidle.
,, *undulatum*, Corda.
,, *undulatum* var. *Wollei*, West.
Pleurotænium Trabecula (Ehrenb.), Näg.
Protoderma viride, Kütz.
Pediastrum tetras (Ehrb.), Ralfs.
Characium spec.
Scenedesmus acutus, Meyen.
,, *quadricauda* (Turp.), Bréb.
Ankistrodesmus setigerus (Schröd.), West.[1]
Kirchneriella lunaris (Kirchn.), Moeb.
Chlamydomonas spec.
Volvox globator (L.), Ehrenb.[1]
Euglena spec.
Phacus pleuronectes, Nitzsch.[1]
Anabæna spec.[1]
Chamæsiphon spec.
Navicula granulata, Bréb. ?
,, *major*, Kütz.
,, *molaris*, Kütz.
Cymatopleura Solea (Bréb.), W. Sm.
Nitzschia sigmoidea (Ehrenb.), W. Sm.
Pleurosigma acuminatum (Kütz.), Grun.[1]
Amphora ovalis, Kütz.[1]
Surirella splendida (Ehrenb.), Kütz.[1]

The algal flora of the pond therefore, although including a large number of different species, bears a very definite stamp, which it retains even during the abnormal periods to be considered below. The abundance of the Diatom-flora is in accord with the fact that the temperature of the water is on the whole rather low (cf. p. 31.) In view of the geological formation on which the pond is situated[2] the scarcity of Desmids is noteworthy ; the number of individuals present is generally very small, and only the three genera *Closterium*, *Cosmarium*, and *Pleurotænium* were observed. This is no doubt due to the fact

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[1] These forms are rare and of rather isolated occurrence.

[2] cf. W. and G. S. West, "A Monograph of the British Desmidiaceae," Vol. I. (1904), pp. 14, 15. Desmids "only become generally abundant on the older Palæozoic Rocks, or on rocks of an igneous or metamorphic character."

that water containing carbonate of lime, which is known to be unfavourable for an abundant development of Desmids, drains into the pond. Finally it may be noticed that both as regards number of individuals and number of species the flora was richest in 1905; since that time there has been a steady decrease in both respects. It is not at all unlikely that the richness of the flora in 1905 is due to the uniform temperature of the water (cf. p. 31) and to the remarkably low rainfall of that year (cf. p. 31).

A few words may be added on the animal life found in the pond. Fishes would seem to be not uncommon, rudd and carp in particular being mentioned by those who collected the samples. We have also noticed *Dytiscus*, *Notonecta*, worms, Rotifers, *Vaginicola*, *Melicerta ringens*, and *Vorticella*.

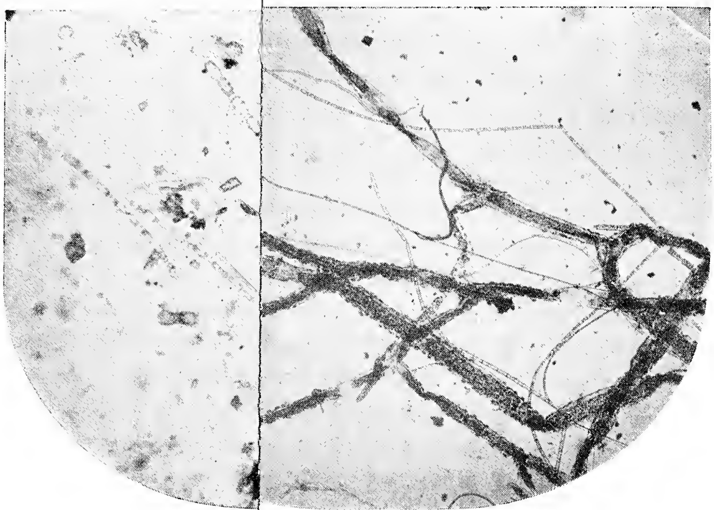
D.—GENERAL CONSIDERATION OF THE LIFE-CYCLE IN THE POND.

It has already been pointed out in the previous section that species of *Cladophora* and *Spirogyra*, and various Diatoms are the dominant constituents of the algal flora of the pond under consideration. We can roughly distinguish the following four phases in the annual cycle (*cf.* also the two charts and plate):—

(i.)—Winter-phase (from the middle of December to about the end of February):—At this time we have *Cladophora fracta*, *Melosira varians*, *Fragilaria virescens*, *Synedra radians*, and numerous other free Diatoms, the latter often being by far the most abundant forms. *Mougeotia* is frequently also quite common during the winter-phase. Its most striking characteristic is the enormous prevalence of filamentous and other free-living Diatoms, so that we might term this the Diatom-phase.

(ii.)—Vernal-phase (from about the beginning of March to the end of May or middle of June):—This abounds in species of *Spirogyra*, *Cladophora fracta* being a subsidiary form in the earlier part of the phase, but becoming more important in the second half. This might well be styled the *Spirogyra*-phase.

(iii.)—Summer-phase (from the first weeks in June to the middle of September):—This is stamped by the dominance of *Cladophora* with increasingly abundant epiphytes (especially *Cocconeis*, also *Epithemia* and *Synedra radians*, numerous others in smaller numbers). The aspect of the summer-phase alters slightly as the weeks pass on. At first we often still have *Spirogyra* competing with *Cladophora* for dominance; then we have *Cladophora* quite dominant, with many healthy young branches and a relative scarcity of epiphytes, but already in July the latter begin to spread to a marked extent, and towards the end of the summer-phase a large proportion of the surface of the *Cladophora* is covered with epiphytic growth. The summer-phase is really a *Cladophora*-phase with epiphytic Diatoms playing an



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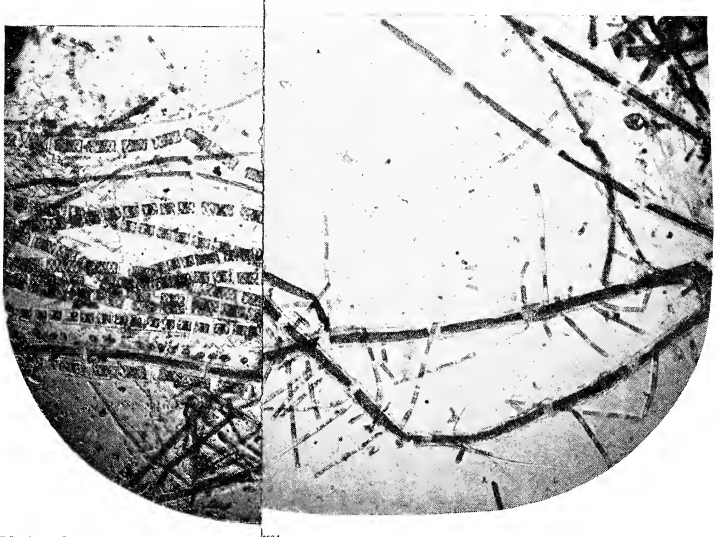

Photos. by E. J. Salisbury. *ry.*

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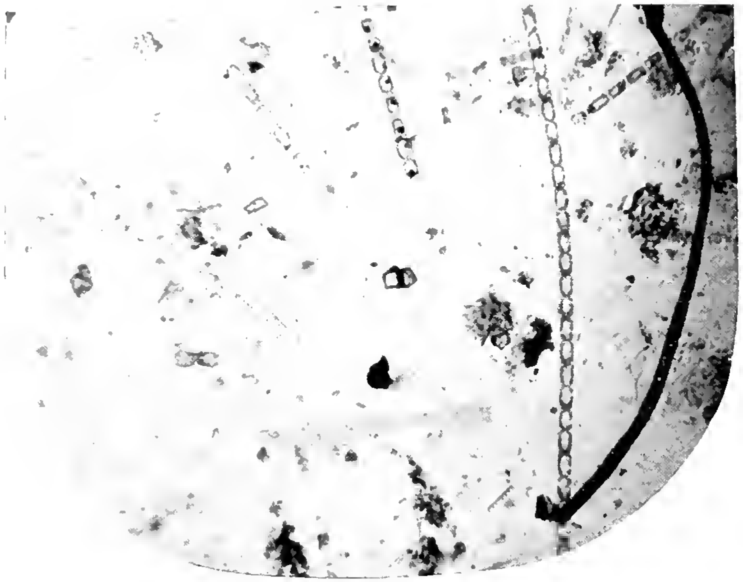

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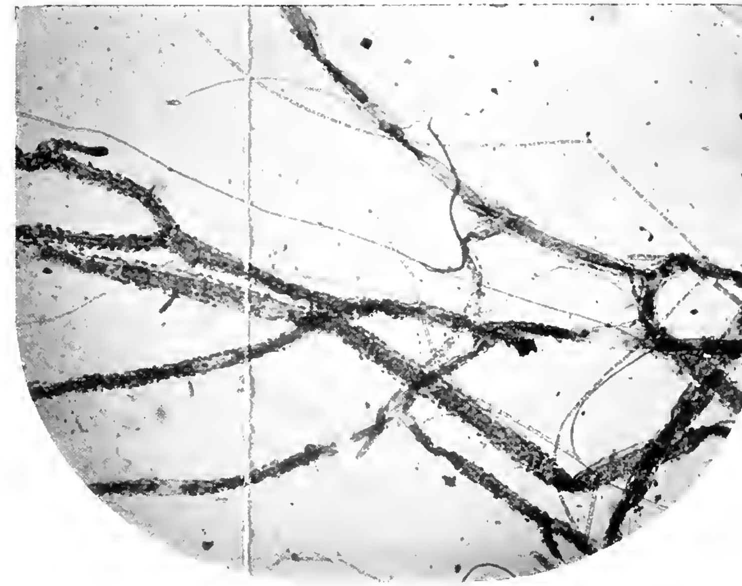
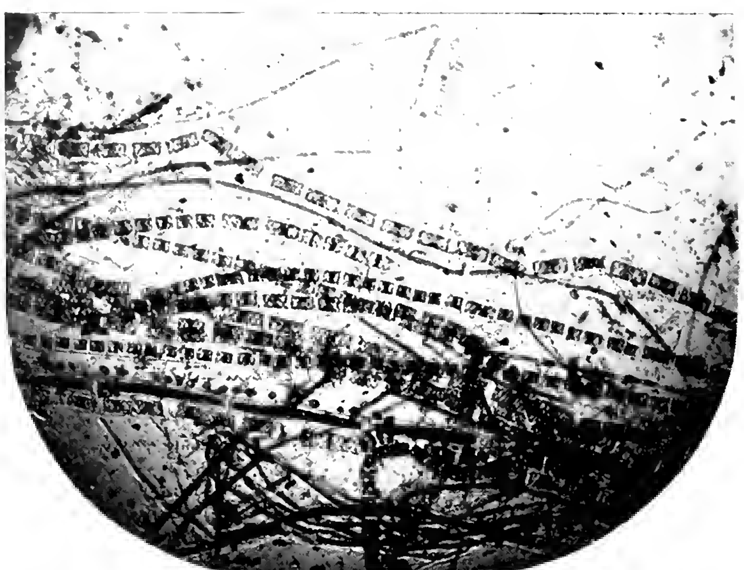
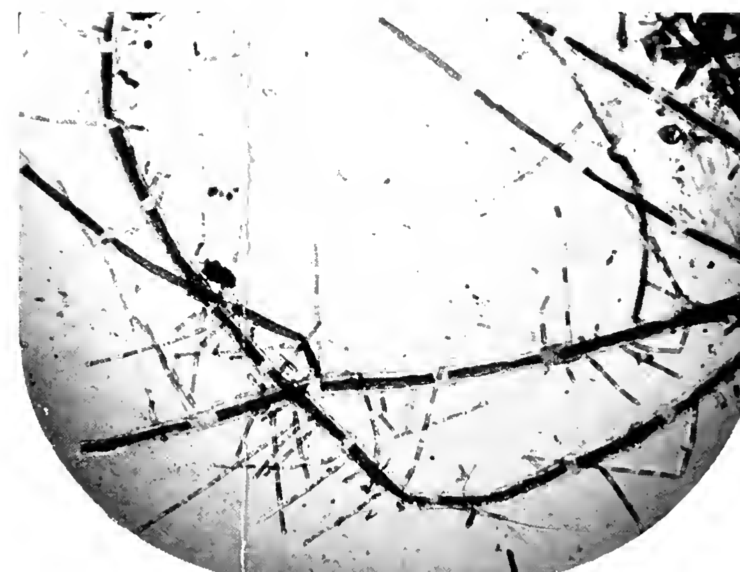


July 9th, 1905.



Photos. by E. J. Salisbury.

April 16th, 1905.



Photos. by E. J. Salisbury.

November 12th, 1905.

important part in the latter half. The summer-phase is also noticeable in showing an occasional prominent development of some other form; thus, in 1905 species of *Œdogonium* played quite an important part, in 1907 *Mougeotia* was well represented, while in 1904 and 1906 a species of *Stigeoclonium* was not at all uncommon.

(iv.)—AUTUMN-PHASE (from the middle of September to about the middle of December):—This phase is not nearly so sharply characterised as the other three, and it would be difficult to name it after any prevalent algal form. *Cladophora* is generally the most important form, but with it we often have a good deal of *Spirogyra*, *Œdogonium*, and sometimes a certain amount of *Oscillaria* and *Lyngbya*. There are at first a good many epiphytic forms on the *Cladophora*, but their number steadily decreases as the winter-phase approaches, while free Diatoms become more abundant. The autumn-phase is thus largely a period of transition between the summer- and winter-phases.

To put it briefly *Cladophora* is, as a general rule, the dominant form during the summer and autumn months, while *Spirogyra* is the most conspicuous Alga during the spring months, and Diatoms the most important forms during the winter. It is not only the change in actual composition of the algal vegetation that seems to us to justify the distinction of the above four phases, for the transition from one phase to another is marked also by changes in the amount of algal growth present. There is a very marked increase in passing from the winter- to the vernal phase, while at the end of the latter there is again a decrease, followed once more by an increase at the commencement of the autumn-phase. The decrease in actual amount of algal growth present in the summer-phase appears not to be so marked in the Fish Pond, Abbot's Leigh, as in many other pieces of water, and this is probably to be attributed to the water never becoming very strongly heated in summer (cf. p. 31).

The very pronounced dominance of *Spirogyra* during the vernal phase appears to be quite independent of the relative abundance of the other constituents of the algal vegetation, although it is not impossible that the immense preponderance of species of this genus during the spring months may tend to crowd out other forms to some extent. It is noticeable that the rise of the *Spirogyra*-curve (*see* chart I.) generally involves a fall on the part of that of *Cladophora*, and often of that of *Œdogonium* as well, but there are not sufficient data to enable one to come to any definite conclusion on this point. The amount of *Cladophora* on the other hand seems to bear a direct relation to the wealth of the epiphytic Diatom-vegetation, and it seems that there is a perpetual struggle between the two, which at one time of the year leads to the dominance of the one, at another time to the success of the other (cf. below, p. 41).

It is not always however that we get the normal succession of forms that has been outlined above. Both in 1904 and 1908 the *Spirogyra*-phase was as good as completely absent during the spring months, with the result that the winter-phase was prolonged and the summer-phase commenced much earlier than usual; the conditions which probably led to this abnormality are considered in detail below (*see* p. 38). Again, in the autumn-phase of 1904 *Spirogyra* played an important part, with the result that *Cladophora* was not as prominent as usual, while in the autumn of 1905 *Œdogonium* attained an exceptional development.

Of the subordinate constituents of the algal vegetation *Œdogonium* and *Mougeotia* are the most important. The former, which is represented by a number of species, is practically always present, though only rarely attaining any considerable development. *Mougeotia* is also generally to be found in small quantity, and tends to be rather commoner during the winter than the summer months (exception: June, 1907); in some years (especially 1906) it even becomes quite a characteristic form during December—February. The genus *Zygnema* is only a very occasional form. A species of *Microspora* is generally to be found during the greater part of the year (commonest during spring and early summer), but like the species of *Œdogonium* it rarely attains any pronounced maximum. The same may be said of the blue-green forms and of *Coleochæte scutata* (the latter mostly rare). Both *Vaucheria* and *Stigeoclonium* were very irregular in their occurrence, which in the former at least may possibly be due to its frequently having been overlooked in collecting.

The above remarks will have shown that there is a very definite periodicity in Abbot's Pool with a good deal of minor variation, while occasionally exceptional conditions lead to very marked abnormalities. In order to study the nature of the latter more completely, and to obtain some insight into the causes determining the normal periodicity, we propose now to consider the occurrence of a number of the more important forms separately.

(i.)—*Spirogyra*.

In the paper on the occurrence and reproduction of *Spirogyra* in nature, published by us two years ago,[1] a considerable number of the data brought forward were derived from the Fish Pond, Abbot's Leigh; since that time, however, further valuable points have been determined, which cast light on a number of the problems raised in that paper. As stated above, species of *Spirogyra* are, as a rule, quite the dominant feature of the algal vegetation from March—May. This is, however, not only true of Abbot's Pool, but of all other pieces of water of a similar kind containing *Spirogyra* that we have examined. In addition to this vernal phase many species of the genus also exhibit a (far less pronounced) autumnal phase. The latter is best shown by *S. affinis*, Petit, *S. jugalis*, Kütz. and *S. rivularis*, Rabh., whilst *S. varians*, Kütz. may be mentioned as an example of a species that appears to be quite confined to the vernal phase.

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[1] Fritsch and Rich, loc. cit.

TABLE SHOWING RELATIVE ABUNDANCE OF THE MORE IMPORTANT FILAMENTOUS ALGÆ IN THE FISH POND, ABBOT'S LEIGH, 1904—1908.[1]

		JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Cladophora	1904	rr	rr	rc	rc	c	c	c	0	c	rc	c	c
	1905	rc	rc	r	rc	c	c	vc	vc	vc	vc	vc	vc
	1906	c	rc	rc	rc	c	0	c	vc	c	0	vc	0
	1907	rc ?	0	rc	0	rc	vc	0	vc	0	c	rr	0
	1908	rr	0	rr	r	rr	0	0	0	rc	0	0	0
Spirogyra	1904	—	—	—	—	vr	rc	r	0	c	vc	rc	vr
	1905	rc	rc	vc	vc !	c !	vc !	r !	rc !	rc	rc	rc	rr
	1906	rc	vc	vc	vc !	vc !	0	c !	—	—	0	rr	0
	1907	rc	0	c	0	vc !	vc !	0	vr	0	rc !	—	0
	1908	vr	0	vr	vr	vr	0	0	0	—	0	0	0
Œdogonium	1904	rc	rr	rc	r	r	rr	r	0	rr	rr	rr	rc
	1905	r	rc	rr	r	rr	rr	c	c	rc	rc	! vc !	rc
	1906	rr	rc	rc	rc	r	0	rr	r	rr	0	rc	0
	1907	vr	0	r	0	r	rr	0	r	0	rr	r	0
	1908	rc	0	rr	rr	rr	0	0	0	vr	0	0	0
Mougeotia	1904	rr	—	r	r	—	vr	—	0	—	—	rr	rr
	1905	r	c	rc	r	r	rr	r	—	rc	rr	rc	rc
	1906	c	c	rc	rc	rr	0	r	rr	vr	0	vr	0
	1907	rc	0	r	0	vr	c	0	—	0	—	—	0
	1908	—	0	r	vr	r	0	0	0	—	0	0	0
Cyanophyceae (excl. *Chamæsiphon*)	1904	—	i	rr	rr	r	rr	r	0	r	vr	r	—
	1905	vr	rc	rc	rr	—	r	i	i	vr	—	r	vr
	1906	r	rr	vr	r	vr	0	vr	i	r	0	rc	0
	1907	—	0	—	0	—	—	0	—	0	rc	—	0
	1908	rc	0	rc	rc	rr	0	0	0	—	0	0	0

In an ordinary year the vernal *Spirogyra*-phase is such a feature in the Fish pond that its complete absence in two out of the five years that we have had the pond under observation is very striking. Both in 1904 and 1908, however, the vernal *Spirogyra*-phase was completely absent,[2] and the dominance of the Diatom-vegetation was gradually followed by dominance of the *Cladophora*. In the above-mentioned paper it was suggested that the absence of *Spirogyra* during the spring of 1904 was possibly due to the very excessive

[1] *vc*=very common; *c*=common; *rc*=rather common; *rr*=rather rare; *r*=rare; *vr*=very rare; *i*=isolated; *o*=no sample; — = absent. An exclamation mark indicates reproduction. We feel some doubt as to whether the January sample of 1907 was quite representative.

[2] The vernal *Spirogyra*-phrase was excellently developed again in the spring of this year (1909).

rainfall and lack of sunshine during the last four months of 1903. Whereas the total rainfall from September to December, 1903 amounted to 16·4 in.; that of 1904 for the same period was 7·35 in.; that of 1905, 7·51 in.; and that of 1906, 11·13 in. The total rainfall from September to December, 1907 was 15·3 in., *i.e.* again considerably above that in 1904, 1905 and 1906 and very near the amount for the same period in 1903. On both occasions, on which the characteristic vernal *Spirogyra*-phase was suppressed, we thus have an exceptionally heavy rainfall during the last four months of the preceding year. Moreover, the rather heavier rainfall at the end of 1906 (viz. 11·13 in. for the last four months), as compared with that in 1904 or 1905 also had an effect on the ensuing vernal phase, which commenced considerably later than usual in 1907 (also noticeable as regards the commencement of zygospore-formation[1]). Although the evidence therefore seems to point to the very marked effect of an abnormally high rainfall in the previous autumn on the vernal *Spirogyra*-phase, the direct cause is difficult to understand. Unfortunately we have no data as to the character of the algal flora in the pond during the latter half of 1903, while only two samples were collected in the autumn of 1907; these samples however, tend to show that the autumnal *Spirogyra*-phase, though developed quite normally in October, had completely terminated in November, so that the effect of the heavy rainfall in October seems to have made itself felt almost at once.

There is every reason to suppose that the vernal phase is due to the simultaneous germination of the zygospores formed in the preceding spring,[2] under the stimulus of a certain group of factors, and that from the end of one vernal phase to the commencement of the next the majority (if not all) of these zygospores pass through a period of rest. The effect of an excessive autumnal rainfall may either make itself felt as a factor affecting the zygospores during their period of dormancy, or more probably as a factor having some direct bearing on the germination of the zygospores. As regards the former possibility we are probably right in assuming that hand in hand with the heavy autumnal rainfall went dull days and general lack of sunshine, and it is possible that the consequent low intensity of the light operated in some way unfavourably on the resting zygospores. This, however, seems far less likely than the second possibility, which we will now consider. It may be suggested that one of the stimuli necessary for germination of the zygospores might be exposure for some time to a certain degree of concentration of the water, and that excessive rainfall, owing to its diluting effect, prevents the realisation of the necessary degree of concentration at the right time. In 1904 and 1908 the requisite concentration would then not have been attained until other conditions (light-intensity, temperature of the water, etc.) were unfavourable for the germination of the zygospores, so that the vernal phase was completely passed over, while in 1907 the necessary

[1] cf. also Fritsch and Rich, pp. 429 and 436.

[2] cf. Fritsch and Rich, p. 425.

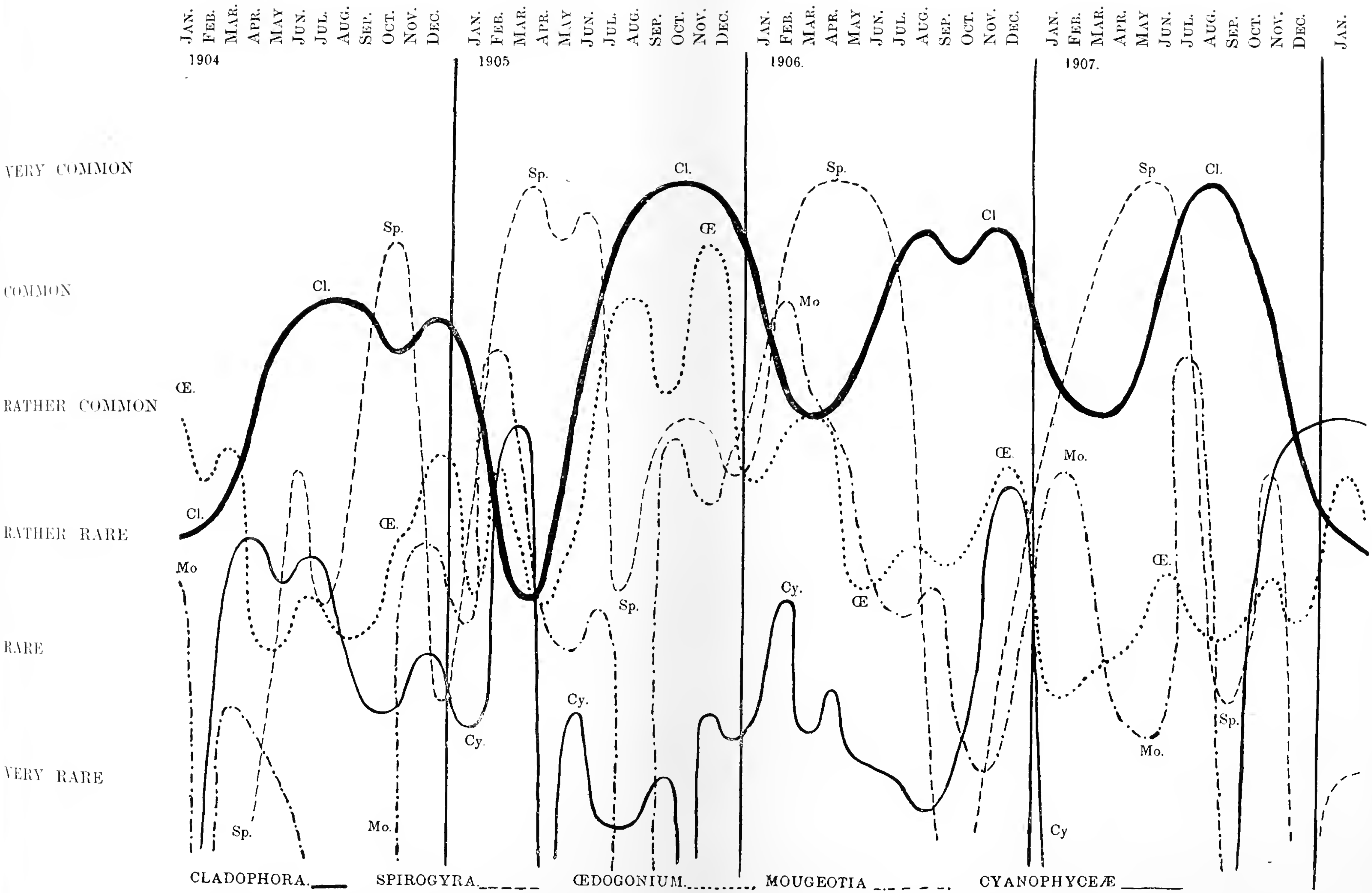

CHART I.—*Chart to show occurrence of principal filamentous Algæ in Fish Pond, Abbot's Leigh, during the years 1904-1907.*

concentration was still realised in time (though later than usual) so that the appearance of the vernal phase was merely delayed. An alternative possibility, which would, however, operate simultaneously with the other, is that the excessive rainfall during the last months of the previous year leads to such a rise of the water-level that the amount of light reaching the bottom of the water in the following spring is below the minimum intensity necessary for the germination of the zygospores. We have no record of a considerable change of water-level, although slight changes must certainly occur; in view of the steep sides of the pond, however, they might not be easily noticed. In connection with this second suggestion it may be pointed out that most of the species of *Spirogyra (S. affinis, S. nitida, S. rivularis)* commence their vernal phase already in January or February, whilst some *(e.g. S. varians)* only appear in March or April (cf. table on p. 47). This appearance of different species at different times may also be due to their zygospores requiring different light-intensities for germination.

It seems fairly certain, therefore, that a heavy autumnal rainfall has a direct bearing on the elimination of the vernal *Spirogyra*-phase in the following year, and it is not improbable that this may be due to the dilution of the water, or to decreased intensity of illumination at the bottom of the pond owing to higher water-level, or to both. This is very suggestive as to the conditions which determine the otherwise normally recurring vernal phase; they would include the realisation of a certain concentration of the water and of a certain light-intensity, both of which, in a normal year, would come as a matter of course during the spring-months. A certain temperature is no doubt also necessary, but inasmuch as this varies little during the spring-months of the five years of observation, we have no data to go upon; temperature is certainly not accountable for the almost complete absence of *Spirogyra* in spring of 1904 and 1908.

The autumnal *Spirogyra*-phase is generally rather insignificant as compared with the vernal one, which is further as a rule the only period of zygospore-formation. As there is usually a period of almost complete disappearance or anyhow of great scarcity of *Spirogyra* during the summer-months (July, August), its reappearance in the autumn must be due either to the germination of some of the zygospores formed in the spring or to the persistence of a certain number of filaments in the dormant condition at the bottom of the pond during the period of apparent absence. The latter seems to be more likely,[1] for it is difficult to understand why, if some of the zygospores germinate, all do not do so. Vegetative reproduction is moreover at times so prolific in *Spirogyra* that persistence of a few filaments would easily account for an autumnal phase. The conditions necessary for the development of the autumnal phase are by no means always realised, and a species present in the autumn of one year may be absent in that of the next, *e.g. S. jugalis* present in autumn of 1905 and 1907, but

[1] *See*, however, Fritsch & Rich, loc. cit., p. 425, and footnote 1. Further consideration has led us to modify the view there expressed.

absent in autumn of 1906.[1] *S. rivularis* on the other hand was found in the autumn of all three years.

There is undoubtedly also in many years a decrease in the quantity of *Spirogyra* in midwinter, but if there is a proper vernal phase in the following year some species of the genus are always to be found throughout the winter-months. In this respect Abbot's Pool differs from certain other ponds we have examined in which there is often an almost complete disappearance of *Spirogyra* during midwinter between the autumnal and the ensuing vernal phases.

In our earlier paper on *Spirogyra* it was suggested that the realisation of a certain group of conditions was necessary for the development of the autumnal phase, and that one of these was dilution of the water back to its ordinary degree of concentration.[2] In support of this the late and scanty appearance of *Spirogyras* in the autumn of 1906 was brought forward, and this was correlated with the occurrence of a very dry and hot summer, with rain only setting in at a late date. Although this particular feature was not as noticeable in Abbot's Pool as in certain other ponds, it was sufficiently pronounced to lend further support to the view that the amount of rainfall has an important, though probably indirect, bearing on the occurrence of *Spirogyra* in nature (cf. p. 38).

(ii.)—*Cladophora*.

As above indicated *Cladophora fracta* is to be found in the pond under consideration all the year round, and this would appear to apply with equal truth to any other pond containing species of this genus. It decreases in amount very considerably at certain times of the year, noticeably during the winter and early spring, while its period of maximum abundance falls into the summer and autumn. During the winter, and to some extent also during the spring-months, the filaments of the *Cladophora* are in what may be called the winter-condition; they are not very prominently branched, and the cells have thick stratified walls, dark green contents loaded with starch, and often show a somewhat irregular inflated shape. In the latter part of the spring, however, numerous young green branches having a healthy, normal aspect are put out;[3] these branch themselves, and thus we find in the summer months a richly branched growth of healthy bright green *Cladophora* (the summer-condition). This prominent development of *Cladophora* during the warmer months of the year is, in our opinion, due to the fact that the water of the Fish Pond does not become very strongly heated in the summer; for data are rapidly accumulating to

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[1] This may have something to do with the hot weather prevalent during August and September of 1906. The weather for the previous fortnight in the two cases is described by the collector as "fine on the whole, very warm," and "very fine and hot, with very little rain."

[2] Fritsch & Rich, p. 427.

[3] cf. Comère, loc. cit., p. 399.

show that *Cladophora* (if present at all) is at its minimum during the summer in all pieces of water which attain a high summer temperature and are not artificially ærated.[1] To understand the marked decrease of the *Cladophora* during the winter it is necessary to notice the relation between it and the epiphytes which it bears.

The most important epiphytes borne by the *Cladophora* are Diatoms (*Cocconeis Pediculus*, *Synedra radians*, *Epithemia turgida* (Ehrenb.), Kütz., *Achnanthes*, &c.) and occasionally species of *Chamæsiphon*. We may first notice the relation between the *Cladophora* and *Cocconeis*. The latter shows its maximum development almost at the same time as the *Cladophora*, although the curve of the latter generally commences to rise before that of the former. Some *Cocconeis* is nearly always to be found on the *Cladophora*, but it is generally least prominent during midwinter. Very soon after the *Cladophora* commences to put out fresh branches the *Cocconeis* begins to spread, and as it were to colonise the new ground. During the summer-months there appears to be a kind of struggle for supremacy between the *Cladophora* and the *Cocconeis*, the former continually putting out fresh branches and the latter soon afterwards settling down on them. At first the *Cladophora* gains ground, but subsequently it comes to be quite overgrown by the *Cocconeis*, which is generally accompanied by other epiphytic forms (*Achnanthes*, *Chamæsiphon*, *Epithemia*, *Gomphonema*, *Synedra radians*, &c.[2]) This dense covering of epiphytes must have a very deleterious effect on assimilation (and possibly also on other functions of the *Cladophora*). As long as the *Cladophora* is still able to put out numerous fresh branches, which are not immediately taken possession of by the epiphytes, these young branches can probably do all the assimilation necessary for the existence of the overgrown portions, but when this formation of branches ceases the *Cladophora* comes to be badly situated, and whole portions of it die away. This is, in our opinion, the explanation for the relative scarcity of *Cladophora* in the Fish Pond during the winter-months. *Cladophora* and the epiphytic forms just considered constitute something in the nature of a competitive association.[3]

Certain other of the epiphytes found on the *Cladophora*, however, have a somewhat different relation to their host. This is notably the case with *Synedra radians*, which as a rule occupies the *Cladophora* during the winter-months (*i.e.* at the time of greatest scarcity of the latter) and is generally not very prominently developed in the summer; it probably completes the damage done by the *Cocconeis*. This matter will be further considered below (*see* p. 42).

As a consultation of the table (p. 37) and chart I. will show, *Cladophora* presents far more regularity in its annual cycle than does *Spirogyra*, and abnormalities, such as those shown by the latter in 1904

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[1] cf. Fritsch, New Phytologist, Vol. v. (1906), p. 153; also Proc. Roy. Soc. B., vol. lxxix. (1907), p. 230, and Annals of Botany, Vol. xxi. (1907), p. 248, et seq.

[2] cf. Comère, loc. cit., p. 398.

[3] Fritsch, loc. cit., pp. 161, 162.

and 1908, are not exhibited by the *Cladophora*. In fact, were it not for the abundant epiphytic growth at certain times of the year, the annual cycle of *Cladophora* would probably be still more uniform.

(iii.)—*The Diatomaceæ of the pond considered as a whole.*

Diatoms play such an important part in the flora of the Fish Pond that it will be worth our while to consider them in some detail. We may distinguish between the free forms and the epiphytic forms, both of which are important elements in the flora, though dominant at different times in the annual cycle. The free forms are chiefly represented by *Melosira varians*, *Fragilaria virescens*, *Cocconema lanceolatum*, and *Synedra ulna*, but numerous others (e.g. *Navicula* spec., *Cocconema prostratum*, *C. cymbiforme*, etc.) occur in smaller numbers. These free Diatoms all show a well-defined maximum during the winter-months, whilst during the summer-months they are rare and occasionally completely absent. Their abundance during the winter is probably to be explained as due to the low temperature of the water, and the fact that the latter does not become very strongly heated in summer is no doubt responsible for these Diatoms not completely disappearing during the warmer portion of the year. Nevertheless, if we compare a summer with a winter sample the difference is very striking (cf. Plate); in the latter chains of *Melosira* and *Fragilaria* with numerous unicellular Diatoms intermingled fill the field of view under the microscope, while in the former free Diatoms require to be sought for. It is noticeable that of the two filamentous forms *Fragilaria* generally commences to increase a little later than *Melosira*, while the latter begins to decrease before the former (*cf.* the table, p. 43). *Fragilaria*, too, is on the whole the more abundant form of the two during the summer months, all this tending to indicate that it is not as susceptible to the temperature of the water as is *Melosira*. The species of the genus *Cocconema* (the third most important genus of the free Diatoms) on the other hand have a still more limited maximum than the other two genera, and have altogether decreased materially in importance since 1905.—It is of course not altogether out of the question that the very marked decrease in number of free Diatoms with the advent of the spring may stand in relation to the sudden increase of *Spirogyra*, followed by *Cladophora*, but, since the majority of Diatoms are known to favour cold water, the rise of temperature in the spring seems the more plausible explanation.

Of the epiphytic Diatoms *Synedra radians* behaves much in the same way as the free forms just discussed, generally showing a maximum during the cold months of the year, although this form exhibits occasional marked irregularities, which we are at present not in a position to explain. Thus for some unknown reason *Synedra radians* was very abundant during June and July of 1905, and common in May of 1908. There is possibly, however, some not yet understood relation between the species under discussion and the other epiphytes which inhabit the surface of the *Cladophora*, for normally (*e.g.*, 1904 and 1906) *Synedra* is more or less at a minimum, during the period in which *Cocconeis*, for instance, is at a maximum; and certain exceptional conditions may have led to their simultaneous dominance in June and July of 1905.

TABLE SHOWING RELATIVE ABUNDANCE OF THE MORE IMPORTANT GENERA OF DIATOMACEÆ IN THE FISH POND, ABBOT'S LEIGH, 1904-1908.[1]

		JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Melosira	1904	vc	vc	vc!	rc	rr	rr	rr	0	r	rr	r	rc
	1905	vc	vc!	vc!	r	r	rr!	—	r	rc	rc	c	c
	1906	vc	c	rc	rr!	r	0	rc	rr	rc	0	vc!	0
	1907	rc	0	rc	0	—	r	0	rr	0	r	rr	0
	1908	vc!	0	rc	rr	rr	0	0	0	rr	0	0	0
Fragilaria	1904	rc	c	vc	rc	rc	rc	rc	0	r	r	r	rr
	1905	vc	c	c	rr	r	rr	c	rr	rc	rr	rc	c
	1906	vc	c	rc	rc	r	0	rc	rc	rr	0	rr	0
	1907	—?	0	rr	0	i	rr	0	r	0	rr	rc	0
	1908	c	0	rc	rc	rr	0	0	0	—	0	0	0
Cocconema (*Encyonema*, *Cymbella*).	1904	vc	c	c	rr	r	rr	rr	0	rr	r	rr	rr
	1905	c	c	c	rc	rc	rr	rr	—	r	vr	r	r
	1906	rr	vr	rr	r	vr	0	rr	—	vr	0	r	0
	1907	—?	0	—	0	—	r	0	—	0	r	—	0
	1908	rr	0	rc	rr	rc	0	0	0	vr	0	0	0
Cocconeis.	1904	rc	rr	rr	rc	c	c	c	0	rr	rc	r	c
	1905	—	rc	rc	rc	c	vc	vc	vc	c	vc	vc	c
	1906	rc	c	rr	rc	rc	0	c	c	rr	0	rc	0
	1907	—?	0	rc	0	r	c	0	c	0	rc	vr	0
	1908	—	0	rr	rc	c	0	0	0	rr	0	0	0
Synedra radians.	1904	vc	vc	vc	c	c	rc	rc	0	rc	rr	c	c
	1905	vc	c	rc	rr	r	vc	vc	—	—	rr	rc	rc
	1906	rc	rr	r	rr	r	0	r	r	vr	0	c	0
	1907	r?	0	rc	0	r	rr	0	rc	0	—	r	0
	1908	vr	0	rr	rc	c	0	0	0	r	0	0	0
Epithemia	1904	—	—	—	vr	vr	—	vr	0	—	—	—	—
	1905	—	vr	—	i	vr	—	i	vr	rr	rc	c	r
	1906	rr	—	—	i	i	0	c	rc	vr	0	rc	0
	1907	—	0	rc	0	—	—	0	vc	0	c	rr	0
	1908	rr	0	rr	i	r	0	0	0	—	0	0	0

Cocconeis, as already indicated above (p. 41), certainly attains its maximum development in the warm months of the year simultan-

[1] *vc*=very common; *c*=common; *rc*=rather common; *rr*=rather rare; *r*=rare; *vr*=very rare; *i*=isolated; *o*=no sample; —=absent. An exclamation mark indicates reproduction. We feel some doubt as to whether the January sample of 1907 was quite representative.

eously with the increase of *Cladophora*, and remains a dominant form up to the late autumn. The same is true to a lesser extent of *Epithemia* and *Achnanthes*. These genera, therefore, do not seem to be so susceptible to summer temperatures as the forms previously discussed. There do not appear to be any obvious climatic factors that would account for the scarcity of these forms during winter and early spring, and it seems more probable that their relative scarcity during these latter periods is due to their killing a large portion of their substratum (*Cladophora*, *cf.* above) and to the dying away of other parts of it (namely the Phanerogamic water-plants). Very probably also *Synedra radians*, which seems to flourish best in the colder months, and during that period occupies a good deal of the surface of the *Cladophora* (*cf.* above), crowds out the *Cocconeis* to a considerable extent. There would thus be competition between the *Cocconeis* and the *Synedra* for the occupation of the surface of the *Cladophora*, which is itself endeavouring to escape from its epiphytes.

(iv.)—*Œdogonium.*

The genus *Œdogonium*, although rarely a dominant feature of the vegetation of the Fish Pond, is almost invariably to be found intermingled with the other forms, and may therefore be briefly considered. It is apparently represented by a considerable number of different species, but as none of them have reproduced sexually during the period of observation, it has not been possible to determine them. The diameters of the filaments vary between 6 μ and 41 μ, and between these limits filaments of practically every width are found. It does not appear that any particular width of filament is especially prominent at any definite time of the year.

The species of the genus in question are generally rather more abundant in the colder months of the year (November to February or March) and are always least conspicuous during the spring months, the latter phenomenon being possibly due to the crowding out influence of the then dominant *Spirogyra*. We have, however, not yet undertaken a sufficiently detailed study of the genus *Œdogonium* to be able to say anything as to its normal annual cycle, and must leave that to a later communication. The only time at which *Œdogonium* played a really prominent part in the algal flora of the Fish Pond was during the last six months of 1905. Already in July and August of that year it was an important form, *i.e.* at a time when it is usually quite at a minimum. We are unable to offer any explanation for this, but it may be noticed that 1905 altogether showed an exceptionally rich development of the algal flora in the pond we are discussing (*cf.* p. 34).

(v.)—*Cyanophyceæ.*

The Cyanophyceæ are, on the whole, very subordinate constituents of the algal flora of the Fish Pond, but as they show one or two points of interest, they may just be briefly touched upon. At most times of the year blue-green algæ are present only in very small numbers, and

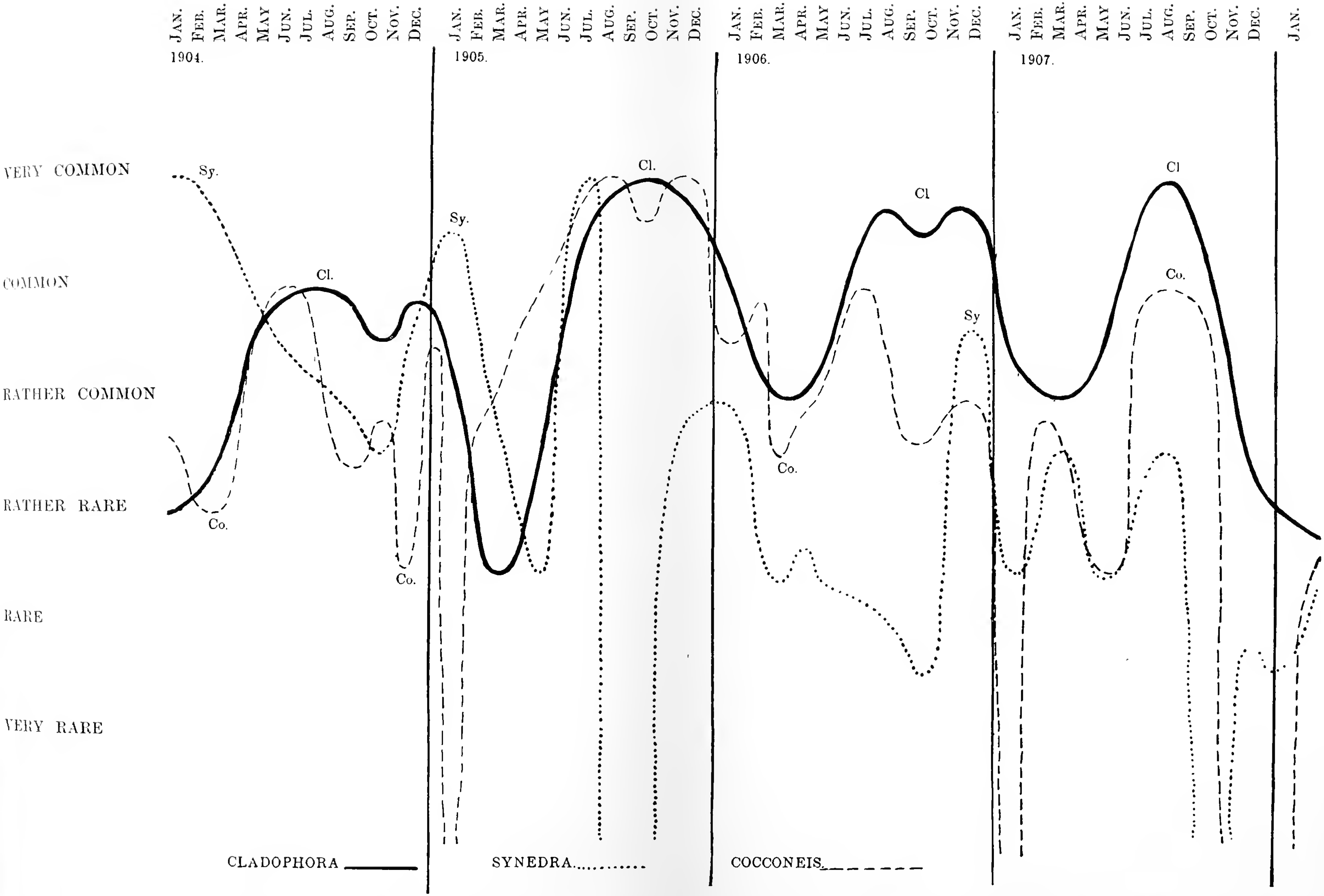

CHART II.—*Chart to show relation between Cladophora and its two most important epiphytes (Cocconeis, Synedra radians) in the Fish Pond, Abbot's Leigh, 1904-1907.*

it is only during the colder portion of the year that they ever occur in any noticeable quantity. They are represented chiefly by species of *Oscillaria*, the few other genera present being very scanty in point of individuals. The normal increase in amount during the winter months was apparently not exhibited in 1904 and in 1906 for some at present incomprehensible reason. Species of *Oscillaria* are known to get on best when there is a considerable amount of organic matter dissolved in the water, and this is no doubt the case in the late autumn and during the winter months (cf. p. 30); possibly some change in this factor was responsible for the small amount of *Cyanophyceæ* in the winter of 1904 and 1906.

E.—GENERAL CONSIDERATION OF REPRODUCTION IN THE POND.

Although Abbot's Pool has furnished abundant material for the study of reproduction in *Spirogyra*, it has not been favourable for similar observations on other forms. Reproduction in *Cladophora*, *Œdogonium*, *Mougeotia*, and *Microspora* seems to have taken place only asexually during the period of observation, although it is possible that the occurrence of sexual reproduction in the first of these genera has escaped our notice. But even of asexual reproduction by zoospores we have seen very little in *Cladophora*, and it almost seems as though the reproduction of this genus in Abbot's Pool were almost wholly vegetative, *i.e.* by a process of breaking up of the filaments. The same seems to apply to the *Microspora*, while the *Mougeotia* (since no zygospores were observed) must have reproduced wholly by vegetative means. The apparently complete absence of sexual reproduction in the different species of *Œdogonium* is very striking, as this genus is so commonly to be found with oogonia and oospores. Asexual reproduction by zoospores (of which the abundant young plants bear testimony) takes place freely at certain times of the year, but for some reason or other the stimulus necessary for the sexual process is never given. We are inclined to associate this with the rather uniform conditions[1] in the pond, which lead to the uniform occurrence of species of the genus all the year round, but we do this with reserve, and hope on some future occasion to be able to cast more light on the matter. The periods of vegetative and asexual reproduction in the genera just considered naturally correspond to, or immediately precede, their periods of chief abundance (*e.g.*, numerous young plants of *Œdogonium* in the autumn of 1905); we have however been able to make so few observations on possible determining conditions that we prefer to leave any discussion of this matter to a later communication.

In every year in which the normal *Spirogyra*-phase occurred in the spring, reproduction of diverse (not all) of the species of this genus was a great feature in Abbot's Pool; and we may now proceed to consider this important point. In the first paper of this series[2] we have

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[1] cf. Oltmanns, Morphologie u. Biologie d. Algen. Vol. II. 1905, p. 248.

[2] Loc. cit., p. 429 et sq.

emphasised the marked vernal reproduction of *Spirogyra* in ponds of S. England, and suggested as possible influencing factors "the increased intensity of light, the small percentage of dissolved salts in the water, the rising temperature, and (?) the decrease in amount of dissolved gases." It is interesting to note that G. S. West[1] in his recent paper on the "Algæ of the Yan Yean Reservoir" finds that the Zygnemaceæ are dominant and almost all in a fruiting condition in November, and to a less extent in December, and that "this commencement of the fructiferous state simultaneously with a rising temperature is strictly comparable with what occurs in the southern and south-western counties of England." We are not inclined to attribute this commencement of sexual reproduction solely to a rising temperature, but believe that the other factors above-mentioned also play an important part; such evidence as is available for this view is stated on pp. 431, 432 of our paper. West finds the Œdogoniaceæ reproducing simultaneously with the Zygnemaceæ, a feature which we have noticed in several other ponds,[2] but which, as above-mentioned, is not the case in the pond we are considering. This indicates that the sexual reproduction of Zygnemaceæ and Œdogoniaceæ is not influenced by quite the same set of factors, and that in the case of Abbot's Pool the factors necessary for such reproduction in *Œdogonium* have not been realised during the period of observation.

As stated in our previous paper the prevalent reproduction of *Spirogyra* during the vernal phase might be due either to an inherent tendency or to the regular occurrence of certain combinations of external conditions in spring. The former suggestion was considered unlikely in view of what is known about algal reproduction in general, but the possibility of some of the species being biennial, as far as their reproduction was concerned, made it impossible to disprove absolutely the existence of such an inherent tendency.[3] Since then, however, we have additional data, which show that a biennial condition does not obtain. Thus in the case of *Spirogyra affinis* and *S. Weberi*, both of which formed zygospores in the spring of 1906, but not in 1905 (in 1904 there was no *Spirogyra*, cf. above, p. 37), it seemed possible that zygospore-formation took place only every two years; since then however both have been found with zygospores in the spring of 1907, and this of course absolutely disproves the biennial theory in the case of these two species. Under these circumstances we are therefore confronted with the fact that some species of *Spirogyra* (like *S. varians*) form zygospores whenever they are present in spring, whilst others (like *S. affinis* and *S. Weberi*) do so in some years, but not in others; others again (like *S.*

[1] Loc. cit., p. 32.

[2] *e.g.* in a pond at Telscombe, near Newhaven, in 1904; cf. Fritsch, in New. Phytol. Vol. V. (1906), p. 163 et sq.

[3] cf. Fritsch and Rich, loc. cit., pp. 430, 431.

rivularis, cf. also *S. jugalis*) never form zygospores.[1] This is only capable of explanation if we assume that the conjugation-process and zygospore-formation depend on the occurrence of certain combinations of external conditions, which are different for the different species.

TABLE OF NORMAL OCCURRENCE AND REPRODUCTION OF SPIROGYRA IN THE FISH POND, ABBOT'S LEIGH.

S. affinis (Hass.), Petit....	Present during the greater part of the year, but generally absent in August. Reproductive: April to July, 1906; and May, June, October, 1907.
S. jugalis (Dillw.), Kütz.	Present during the greater part of the year, but generally absent in midwinter and during July or August. Never reproductive, although commencement of conjugation-process observed in April, 1905.
S. longata (Vauch.), Kütz.	Forming zygospores in May, 1907.
S. neglecta (Hass.), Kütz.	Normally present from April to August, but absent during the remainder of the year (possibly present in October, 1907). Reproductive: in 1905 and 1906 during the greater part of its period of occurrence.
S. nitida (Dillw.), Link....	Present from January to June of 1905, and from April to July, 1906. Reproductive: May, 1905.
S. rivularis, Rabh. (?) ...	Present during the greater part of the year, but absent during some of the summer months. Never reproductive.
S. varians (Hass.), Kütz.	Present from about March to May in each normal year, and quite absent during the remaining nine months. Reproductive: during the greater part of its period of occurrence.
S. Weberi, Kütz.... ...	Present during the first half of the year in 1905, 1906, and 1907, also in September, 1905. Reproductive: April to May, 1906, and June, 1907.

[1] It is interesting to compare these species with the species of *Œdogonium*; like the latter, *S. rivularis* is present all the year round (though never in very large amount), and it may be that the uniformity of conditions which leads to this constancy is responsible for the non-occurrence of conjugation.

Having thus disposed of the possibility of vernal reproduction in *Spirogyra* being due to an inherent tendency, we may briefly consider the conditions influencing the reproductive process. In the first place it is important to note that the necessary combination of conditions is almost without exception realised only in the spring, and that, when (as in 1904 and 1908) there is no vernal *Spirogyra*-phase, zygospore-formation does not take place at all,[1] even in species, like *S. varians* and *S. neglecta*, which seem to reproduce with the greatest ease in a normal year. This seems to us to indicate that change of the factors in the direction of intensification is the essential stimulus for conjugation in *Spirogyra*, and such a change is in a normal year likely to occur only in spring.[2] If therefore the genus is not present at that time zygospore-formation does not occur in that particular year. The only exception to the exclusive reproduction of *Spirogyra* in spring in Abbot's Pool is furnished by *S. affinis*, which was found with zygospores in October of 1907. In considering this case attention may be drawn to the fact that *S. affinis* (the same applies to *S. neglecta*) is a species in which the reproductive period tends to be of rather longer duration than in most other species of the genus. This may well indicate that the reproductive process in this case is not dependent on so restricted a range of factors as in other species, and there is therefore more likelihood of these conditions being realized at other times of the year. The autumn of 1907 was in many respects like a second spring; after a very dull and cold summer there came a spell of three or four weeks of almost uninterrupted sunshine and high temperature with little rainfall. As a result there must have been in September, 1907 a general intensification of influencing conditions (viz. increased light and temperature, increased concentration of water owing to evaporation, probably also relatively less dissolved gases than in the previous months) rather similar to that ordinarily taking place in spring, and this is in our opinion very probably the explanation for the reproduction of *Spirogyra affinis* in the autumn of 1907. In our previous paper on *Spirogyra* we dealt with another abnormal case of reproduction of this genus in the autumn (in a pond at Telscombe, near Newhaven)[3]; there were two species concerned, one of them again being *S. affinis* (the other was *S. catæniformis* (Hass.), Kütz.), so that this species certainly seems to have a tendency towards autumnal reproduction. In this case full meteorological data were available, showing that in the months preceding the autumnal reproduction of these species there was considerably less rainfall than usual and considerably more hours of sunshine than the average, so that there was no doubt again a general intensification of all the factors concerned.

A study of these two abnormal cases thus gives a good deal of justification for the view that it is the general intensification of those

[1] cf. however the remarks on *S. affinis* below.

[2] Fritsch and Rich, loc. cit., p. 431.

[3] Loc. cit., p. 433.

conditions, which are liable to change in spring, that is the cause of the prevalent vernal reproduction of species of *Spirogyra*. It remains to support these theoretical conclusions by experiment, and it is hoped to do this in the near future.

Apart from *Spirogyra* we have observed sexual reproduction only in *Vaucheria*, which was found with sexual organs from August—November, 1905. The genus was also observed, though not in a reproductive condition, in 1904, but has not been seen since 1905. Although, as mentioned above, we consider that it may have been overlooked in collecting, it is not likely that it was ever present in any quantity in the pond after 1905. The year 1905 was altogether a phenomenal one for the algal flora of the Fish Pond (cf. p. 34), *Œdogonium*, for instance, also attaining its most prominent development, during the whole period of observation, in that year. It seems, therefore, that the conditions were particularly favourable for algal growth, and these may have called forth a more abundant development of *Vaucheria*, and led to its reproducing sexually, but it is quite impossible at present to say anything as to what the influencing conditions were; this occasional occurrence of a particular form (sometimes even in great quantity), followed by complete disappearance for a prolonged period, is a feature we have frequently observed in different ponds, and is at present one of the most puzzling problems confronting the student of algal biology.

It remains to say a few words about the reproduction of *Melosira*, the only Diatom in which we have noted anything but vegetative division.[1] Auxospores were found on the *Melosira* in March, 1904; February, March, and June, of 1905; April and November, 1906; January, 1908. As there were usually not a very large number of individuals bearing auxospores, it is quite possible that such may have been present in other months also; nevertheless, the evidence that we have points quite clearly to the fact that auxospores tend to form during the winter-months, and especially towards the end (*i.e.* February and March) of the period of chief abundance of the *Melosira*. The presence of auxospores in November of 1906 tallies with the fact that this was the period of maximum development of *Melosira* during the winter of 1906-7 (cf. table on p. 43), and that after November, 1906, there was a marked decrease in the amount of this Diatom present (see especially January of 1907). The development of auxospores in the June of 1905 is thus the only abnormality, and is another of the special peculiarities which were so evident in the algal flora of the Fish Pond during 1905. It may be noticed that there was a slight increase of *Melosira* in June of 1905 (note the exceptionally heavy rainfall during that month!) as compared with the preceding two months, and that auxospore-formation went hand in hand with this increase, while it was followed by temporary complete disappearance of the Diatom.

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[1] All the other Diatoms appear to persist all the year round in small numbers, so that their reappearance is due to rapid division of these persisting individuals.

In conclusion, we may once more survey the reproductive processes in the pond as a whole. The two most prominent periods of reproduction are that in which *Melosira* and that in which *Spirogyra* is the reproductive form; of these the latter is far more striking, and constitutes a very definite feature in the annual cycle in a normal year. In both cases we have the formation of resting-spores preceding a period of very diminished occurrence of the form involved. Apart from these two cases,[1] however, all the reproductive processes in the pond are purely asexual and vegetative, and do not lead to the formation of resting stages. This period of asexual and vegetative reproduction is generally most noticeable in the late summer and in the autumn, when there is a general increase of the different forms present in the summer, following on the summer-period of relative inactivity.[2] This reproductive phase was especially noticeable in 1905. The formation of the winter resting-condition on the part of the *Cladophora* (cf. p. 40) may perhaps be regarded as marking a fourth period. The rather uniform conditions of temperature, etc., in Abbot's Pool are probably responsible for the limited number of genera forming resting-stages.

F.—EPIPHYTIC FORMS.

There is such an abundance of epiphytic growth in Abbot's Pool that a few general remarks about it may well be added. As a general rule it may be said that epiphytes, although present in considerable quantity all the year round, are at their maximum during the warmer months of the year, this being particularly obvious during the midsummer of 1905. The epiphytic growth consists largely of Diatoms (*Synedra radians*, Sm., *Cocconeis Pediculus*, Ehrenb., *Rhoicosphenia curvata* (Kütz.), Grun., *Achnanthes* spec., *Epithemia turgida* (Ehrenb.), Kütz., *Gomphonema acuminatum*, Ehrenb., etc.), but other forms (such as *Aphanochæte*, *Protoderma*, *Characium*, *Coleochæte scutata*, and species of *Chamæsiphon*) also occur.

The principal hosts are *Cladophora* and the Phanerogamic aquatics, when present. At certain times of the year, as already stated, *Cladophora* is practically concealed by a dense growth of *Cocconeis* and *Epithemia*, and it is only during its vigorous period (late spring and early summer) that we find many branches, which are quite clear of epiphytes. Next to *Cladophora*, *Œdogonium* seems to be the best host; we have found it bearing *Synedra radians*, *Achnanthes*, *Gomphonema*, *Characium*, *Chamæsiphon*, and *Aphanochæte*, but *Cocconeis* and *Epithemia* do not occur on it. Both of these last-named forms are such as are attached by a broad base, and it seems likely that the small width of the *Œdogonium*-filaments does not afford a

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[1] *Vaucheria*, being only occasionally represented, is here left out of consideration.

[2] *Spirogyra* is probably also at this period increasing by purely vegetative means (cf. p. 39).

convenient substratum. *Vaucheria*, when present, is often abundantly covered with *Cocconeis Pediculus* and some *Coleochæte scutata*, but the other epiphytes do not appear to occur on it; this may, however, be due to the fact that they are not very abundant at the times at which the *Vaucheria* was found. *Melosira* often bears occasional tufts of *Synedra radians* and *Achnanthes*, but the other forms do not occur on it, and there is never much epiphytic growth. The same may be said of *Microspora*, on which only *Epithemia* has been found. *Spirogyra* and *Mougeotia* were both quite free of epiphytes.[1]

G.—SUMMARY AND GENERAL CONCLUSIONS.

We may briefly summarise the previous considerations as follows :—

(i) The algal flora of the Fish Pond, Abbot's Leigh, is dominated by a successive association (formation?) of *Cladophora*, *Spirogyra* and abundant Diatoms (both free-living and epiphytic), while the principal subsidiary forms are *Œdogonium*, *Mougeotia*, and *Cyanophyceæ*. The algal flora shows a well-marked periodicity.

(ii) Four phases are distinguishable in a normal annual cycle (see Plate and p. 34), viz. :—

- *(a)* Winter-phase with an abundance of free Diatoms.
- *(b)* Spring-phase with dominant *Spirogyra*.
- *(c)* Summer-phase with dominant *Cladophora*, and abundant epiphytes.
- *(d)* Autumn-phase, chiefly characterised by renewed activity after the inactive summer-period, often with a prominent development of *Spirogyra*, *Œdogonium*, or some other form.

(iii) The majority of the species of *Spirogyra* present in the pond are found in some quantity, both in the spring- and autumn-phase, but some only occur in the former. The spring-phase is their period of maximum abundance and also their period of zygospore-formation. In two out of the five years, owing to abnormal conditions, *Spirogyra* was practically unrepresented during the spring-phase. A consideration of these abnormal conditions leads one to the view that the otherwise normally recurring *Spirogyra*-phase in the spring may be due to gradual concentration of the water, increased intensity of light, and the realization of a certain temperature. The autumn phase is then probably dependent on the simultaneous occurrence of the same conditions, and according as they are developed it is well or badly represented. The vernal reproductive process is considered to be due to a general intensification of the factors, liable to change in spring. This view finds support in the meteorological conditions preceding an abnormal case of zygospore-formation on the part of *S. affinis* in the autumn of 1907.

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[1] cf. Comère, loc. cit., pp. 398, 399.

(iv) The genus *Cladophora* is to be found in the Fish Pond all the year round, although in varying quantity. It reaches its maximum in the summer and its minimum in January and February. The small amount present in the winter is considered to be due to the deleterious influence of the rich growth of epiphytes found on the *Cladophora* in the latter half of the summer and in the autumn, while the relative abundance of this Alga in the warmer months is ascribed to the fairly low average temperature of the water.

(v) Diatomaceæ are very important constituents of the algal flora. We may distinguish two phases: One in which the free-living forms (*Melosira*, *Fragilaria*, *Cocconema*, also the epiphytic *Synedra radians*) dominate, and the other in which the epiphytes (*Cocconeis*, *Epithemia*) dominate. These two phases are the winter- and summer-phase respectively. *Cladophora* with its epiphytes (*Synedra radians*, *Cocconeis*, *Epithemia*) constitutes a competitive association.

(vi) The reproductive processes in the pond show considerable uniformity, which is ascribed to the rather narrow range of temperature of the water. Resting-stages have only been observed in four forms (*Spirogyra*, *Melosira*, *Vaucheria*, and *Cladophora*), all the other species (*e.g.* of *Mougeotia*, *Œdogonium*, *Microspora*, etc.) apparently regenerating by vegetative or asexual reproduction of a few persisting individuals. In the case of *Spirogyra*, *Melosira*, and *Vaucheria* the formation of resting-stages immediately precedes a period of very diminished occurrence of the form in question, while in the case of *Cladophora* dormant filaments are the winter-condition. Asexual and vegetative reproduction (in *Œdogonium*, *Mougeotia,* etc.), naturally precedes and coincides with an increase in amount of the form concerned. Auxospore-formation in *Melosira* often coincides roughly with the end of the winter-phase, zygospore-formation in *Spirogyra* with the end of the vernal phase, while the assumption of the winter-condition on the part of the *Cladophora* indicates the approaching end of the autumn-phase; the commencement of the autumn phase is marked by extensive vegetative and asexual reproduction (in *Spirogyra*, *Œdogonium,* etc.).

(vii) The epiphytic algal vegetation, which is so richly developed in the pond, finds its chief host in *Cladophora* (also the Phanerogamic aquatics). *Œdogonium* comes second, but only bears forms attached by a narrow base (*i.e.* it lacks *Cocconeis* and *Epithemia*), while *Cocconeis* is the most abundant epiphyte on the broad filaments of *Vaucheria*. The Conjugates bear no epiphytes.

(viii) The entire algal vegetation was most strikingly developed in the year 1905, which was characterised by uniformity of temperature and abnormally low rainfall.

One of the most salient features in the annual cycle is the struggle between *Cladophora* and its epiphytes; these constitute one group of forms, apparently little influenced in their development by any others.

A second group of forms are the species of *Spirogyra*, whose annual cycle also seems little affected by that of the other Algæ in the pond; and the same may be said of the third group, constituted by the free-living Diatoms. These three groups of forms, which apparently have an independent development, may perhaps be looked upon as *sub-associations*; these form an integral part of the whole algal association (formation ?) in the pond, although not much connected with one another owing to the fact that they succeed one another in time. For this reason the whole algal flora of the pond is above described as a *successive association* (formation ?). Our study of the other algal constituents has not been based on sufficient data to enable us to say whether they work in with one or other of the three sub-associations distinguished above, or themselves constitute further sub-associations. We should restrict the latter term to a group of forms which in their relative development influence one another (*e.g. Cladophora* and its epiphytes) or flourish simultaneously apparently in response to the same group of influencing factors (*e.g.* the free-living Diatoms), but except in the three cases above noted such relations have been very difficult to determine. *Cladophora* and its epiphytes may be described as a *competitive sub-association*, while the other two cases are examples of *non-competitive sub-associations.*

The factors operating in the pond are of three kinds—seasonal, irregular, and correlated,[1] and in the preceding pages we have discussed many of them. The seasonal factors are mainly constituted by changes in the concentration of the water, in the temperature of the water, in the quantity of dissolved gases and the amount of organic substance in the water, and in the light-intensity. The irregular factors comprise abnormal periods of low and high temperature, periods of drought or heavy rainfall, and abnormal spells of dull weather. The correlated factors are no doubt numerous, but we have only been able to clearly recognise the competition between *Cladophora* and its epiphytes. All the numerous changes in the vegetation of the pond must be due to the simultaneous operation of a number of these factors, and in many cases we have at least been able to suggest the factors that may be responsible.

Frequently, no doubt, the condition of all but one factor is suitable, and the given change has to await the realisation of the necessary condition of this limiting factor before the change takes place. As already pointed out in our earlier paper,[2] all our observations tend to indicate that the doctrine of limiting factors[3] will probably be found to underlie the whole scheme of intricate changes that are so striking a feature of freshwater algal vegetation.

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[1] cf. Fritsch, in New Phytol., vol. v., 1906, p. 161.

[2] Loc. cit., p. 432.

[3] cf. F. F. Blackman, Optima and Limiting Factors, Ann. of Bot., vol. xix., 1905, pp. 281—295.

DESCRIPTION OF PLATE.

Four microphotographs (by E. J. Salisbury), illustrating the character of the algal vegetation in the four phases.

FEBRUARY 5TH, 1905 (WINTER-PHASE). Filaments of *Melosira* and *Fragilaria* are most conspicuous, but also unicellular forms like *Synedra*, *Cymatopleura*, etc.

APRIL 16TH, 1905 (SPRING-PHASE). Numerous filaments of *Spirogyra*, some with zygospores. *Cladophora* at the upper end of the photograph.

JULY 9TH, 1905 (SUMMER-PHASE). *Cladophora*, bearing abundant *Cocconeis*.

NOVEMBER 12TH, 1905 (AUTUMN-PHASE). *Cladophora* bearing numerous young plants of *Œdogonium*.

DESCRIPTION OF CHARTS.

I.—Chart to show occurrence of principal filamentous Algæ in Fish Pond, Abbot's Leigh, during the years 1904-1907.

II.—Chart to show relation between *Cladophora* and its two most important epiphytes (*Cocconeis*, *Synedra radians*) in the Fish Pond, Abbot's Leigh, 1904-1907.

The Mammals of the Bristol District.

By C. King Rudge, L.R.C.P., M.R.C.S. (Lond.), and
H. J. Charbonnier.

THE district in which the species recorded in this list have been found, lies within the following boundaries: on the north, a line drawn eastward from the Severn, near Berkeley, through Dursley to the boundary of the County of Gloucestershire, near Badminton; on the east, a line drawn from Badminton to Shepton Mallet; on the south, from Shepton Mallet to Stert Point; on the west, the coast line from Stert Point to Berkeley. This area is practically the same that was used for the list of Birds, and for the Flora of the Bristol Coal Fields, which have already appeared in our proceedings.

The country within this area is of a very varied character, and includes a long coast line, with rocks, mud-banks, and estuaries; the hill-ranges of the Mendips and part of the Cotteswolds; moors and downs, woods and valleys, and the whole district is well watered with rivers and streams.

This list includes 37 species out of 63 recorded for Great Britain.

Owing to the high state of cultivation and the absence of forests, the carnivora are naturally scarce, and rapidly becoming scarcer, owing to the constant war waged against them by the gamekeeper and poultry farmer; for instance, the Wild Cat and Pine Marten that used to occur in the district have not done so for nearly a century.

The Bats are fairly well represented, 8 species out of 12 really British species; there is no doubt that a more systematic search of the district would lead to the discovery of species not on the present list; the "Serotine," Daubenton's, and the "Hairy-armed" Bat, should more especially be looked for.

Some of the species now found have been introduced from other countries, as the Black Rat, in the 15th century, the Brown Rat about 1728. The Ship Rat, and the House Mouse. The Mammalia are a much neglected group, perhaps owing to the small number of species, and the fact that they are nearly all nocturnal in their habits, and difficult to observe; but there are many points in their life histories which are still unknown and that would reward patient observation.

The principal writers on the Mammals of the district are—

Smith, "History of the 100 of Berkeley" (1600).
Knapp's "Journal of a Naturalist" (1838).
Baker, Proc. Somerset Archl. and N.S. Society (1849-50).
Farebrother, "History of Shepton Mallet" (1856).
Charles Terry, "Wright's Guide to Bath" (1864).
Witchell, "Fauna and Flora of Gloucestershire."
J. Compton, "A Mendip Valley" (1892).
E. Wilson, B. Nat. Soc. Proceedings (1885).
H. Percy Leonard, B. Nat. Soc. Proceedings (1891).

C. Lloyd-Morgan and H. J. Charbonnier in "British Association Handbook" (1898).
T. A. Coward, F.Z.S., Proceedings Zool. Soc. (1907).
Do. "Manchester Memoirs" (1908).
"Victoria History of Somerset."
"Victoria History of Gloucestershire."

CHIROPTERA.

THE GREATER HORSE-SHOE BAT.—*Rhinolophus ferrum-equinum* (Leach.)

Frequent in the towers of Bristol and Wells Cathedrals, also in numbers in the Mendip caves at Cheddar and Burrington, and at Westbury-on-Trym, and Clevedon. For account of the life history of this species from observations made at Cheddar, *see* T. A. Coward, F.Z.S., Proceedings Zool. Society, 1907, and Manchester Memoirs, 1908.

THE LESSER HORSE-SHOE BAT.—*Rhinolophus hipposideros* (Leach.)

Generally distributed in caves at Dundry (in April), caves at Westbury-on-Trym (in March), and with the previous species at Cheddar and Burrington; also at Shepton Mallet (*see* also account as above, T. A. Coward, F.Z.S.)

THE LONG-EARED BAT.—*Plecotus auritus* (Linn.)

Generally distributed. This species is of a gentle disposition, and lives well in confinement; it becomes very tame, and comes to a call; its way of folding back its long ears, and leaving the tragus projecting when at rest, gives it a very singular appearance.

THE NOCTULE, OR GREAT BAT.—*Vesperugo noctula* (Schreber.)

Generally distributed, and sometimes abundant; this species frequents hollow trees, oftenest old ash trees, living in colonies of from 20 to 60 individuals. Such a colony found in June was composed of all females. In captivity this bat is savage and bites readily; they feed on cockchafers, dorbeetles, tipulidœ, and noctuid moths, and consume an immense amount of food, they drink milk readily, and have a curious habit of throwing the head back whilst devouring an insect, which they can seize readily on the ground. Their value to the farmer and gardener is great, as they destroy vast quantities of insects like the "turnip moth," that by their nocturnal habits escape other insectivorous creatures. The male is constantly smaller than the female, this latter often measures up to 14-inches in expanse. Mr. C. Oldham, F.Z.S., states that this Bat generally comes out for an hour or two at dusk, and again for an hour or two at dawn.

THE PIPISTRELLE OR COMMON BAT.—*Vesperugo pipistrellus* (Key.)

Common, resorting to old buildings and caves, but rather scarce in some parts of the district. Our earliest Bat to appear in spring, and not unfrequently to be seen hawking about in bright sunshine. A beautiful "white-winged" variety of this species was obtained at Frampton Cotterell in September, 1891. It was an adult female measuring 8½-inches in expanse; the wings and ears were white, like white tissue paper; the legs, arms, digits and tail, as well as the nose and chin were pinkish flesh colour; the head and body only slightly lighter brown than normal *(Zoologist, October, 1901).*

THE WHISKERED BAT.—*Vespertilio mystacinus* (Leisler.)

Sometimes abundant in old roofs, and occasionally in caves and quarries. "A colony of nearly 100 was found at Willsbridge in July, 1888, all females, many with young; these were naked with flesh-coloured bodies and black heads and wings, and appeared blind, and measured 2½ to 3-inches in expanse" *(Victoria History of Somerset).* These Bats have also been found in April, in the Dundry caves.

THE REDDISH-GREY BAT.—*Vespertilio nattereri* (Kuhl.)

This Bat has occurred in caves near Bath, and in Gloucestershire, so there seems no doubt that though probably very rare, it does occur in the district.

THE BARBASTELLE.—*Synotus barbastellus* (Keys.)

This is another very rare species; a specimen was picked up in 1898 near the Tramway Centre in Bristol, and it has occurred at Stroud, so it may be confidently expected to turn up again in the district.

INSECTIVORA.

THE HEDGEHOG.—*Erinaceus europæus* (Linn.)

Common in suitable localities, is nocturnal, and is partial to eggs and young birds, which has given it a bad name with the farmer and gamekeeper; swims well. A captive female littered on the 24th of June and had three young.

THE MOLE.—*Talpa europæa* (Linn.)

An abundant species. A pale salmon-tinted variety is not infrequent in some parts of the district; there is also a variety black and white in patches; the white patches having slightly longer fur; also a "chinchilla" grey variety.

THE COMMON SHREW.—*Sorex vulgaris* (Linn.)

A very common species, often found dead. Owls consume numbers of them.

THE PYGMY SHREW.—*Sorex minutus* (Linn.)

This, the common Shrew of Ireland, is uncommon with us, but it has occurred in the Leigh Woods and a few other localities.

The Water Shrew.—*Crossopus fodiens* (Wagl.)

Local, but not uncommon; sometimes seen far from the water, as in Leigh Woods. Occurs in most of the streams, as the Froom at Frampton Cotterell, the Yeo at Nailsea, and the Trym at Westbury. In some specimens the under parts are dusky and shade gradually into the dark upper parts.

CARNIVORA.

The Fox.—*Canis vulpes* (Linn.)

In those parts of the district where the Fox is preserved for sporting purposes it is plentiful. These animals were formerly destroyed as vermin: the Clifton Parish Accounts between the years 1720 and 1761 have several entries of 1/- having been paid for "killing a Fox."

The Polecat.—*Mustela putorius* (Linn.)

Almost extinct in the district, but a specimen still turns up occasionally: one at Portbury, 1879-'80; one at Coalpit Heath, 1872; and a few others at long intervals since. A friend has mentioned his father's seeing several of these animals together, hunting in a pack, during intensely cold weather near Frampton Cotterell many years ago. Whether this was a case of migrating in company, or of hunting in a pack, we cannot now say, and the species is too rare now ever to be seen in packs; but this habit has been recorded of the Stoat.

The Stoat or Ermine.—*Mustela erminea* (Linn.)

Fairly common. It is a curious fact that in this district specimens in almost white coat appear at the same time as brown coated ones; for instance, one at Clevedon in January, 1892, and another three miles north of Bristol in February 1896, having but a trace of brown left—and this after exceptionally *mild* weather! Others being seen during the same months and in the same localities in the ordinary brown coat: the explanation seems to be that indigenous specimens do not turn white in winter, and that the white fellows are migrants from further north, where the species all turns white in winter.

The Weasel.—*Mustela vulgaris* (Erxl.)

Common throughout the district, and though sometimes destructive to game, yet a most useful little fellow who destroys an immense number of mice and voles.

The Badger.—*Meles taxus* (Bod.)

Maintains its numbers in a few places, but it has disappeared from many of its old haunts. A captive female littered in February and had four young, blind and nearly naked. Parish Accounts shewing many entries of 1/- for killing a Badger prove that it was quite common at one time, even on our downs.

THE OTTER.—*Lutra vulgaris* (Erxl.)

The Otter is still fairly common in the Bristol Avon and the Axe, and the smaller streams like the Yeo are still its haunts; it must have been at one time common in the lower reaches of the Avon.

THE COMMON SEAL.—*Phoca vitulina* (Linn.)

An accidental visitor. "One was shot at Clevedon in March, 1874" (*Victoria History of Somerset*).

RODENTIA.

THE SQUIRREL.—*Sciurus vulgaris* (Linn.)

This elegant little animal is plentiful wherever woods and plantations are found. The Squirrel may often be seen in the woods round Henbury and Kingsweston. "Some years ago I kept two Squirrels, they were taken from the nest when very young, a cat becoming their foster mother; they were exceedingly tame and made charming and interesting pets" (*Victoria History of Gloucestershire*).

THE DORMOUSE.—*Muscardinus avellanarius* (Kaup.)

Fairly common, but local, mostly in nut woods.

THE BROWN RAT.—*Mus decumanus* (Pallas.)

This destructive animal is far too abundant; its cunning and ferocity are well known. I knew an instance of a Brown Rat biting a sleeping person through the lip.

THE BLACK RAT.—*Mus rattus* (Linn.)

It still occurs, sometimes commonly, in Bristol warehouses and factories.

THE ALEXANDRINE OR SHIP RAT.—*Mus Alexandrinus* (Geof.)

Not common, but often on board ships and about the harbour and docks at Bristol. It breeds freely with the Black Rat, and produces hybrids combining the markings of both species. It seems probable that *Mus rattus* is a melanic form of *Mus Alexandrinus*, which is the common form in Southern Europe, Egypt, &c., and that these two are not true species, but are related forms like *M. decumanus* and its melanic form *M. hibernicus*.

THE HOUSE MOUSE.—*Mus musculus* (Linn.)

This species is too common everywhere.

THE LONG-TAILED FIELD MOUSE.—*Mus sylvaticus* (Linn.)

This wide ranging species is very common throughout the district; and where over abundant very destructive. In captivity it becomes very tame and attached to its cage; it makes a most interesting pet; it is very active and takes the most astonishing leaps.

THE HARVEST MOUSE.—*Mus minutus* (Pallas.)

This is rare and local. In captivity this mouse is the tamest and most interesting of its tribe (*see* Percy Leonard in *Proc. Bristol Nat. Society, 1891).*

THE WATER VOLE.—*Microtus amphibius* (Schrank.)

Very common in our rivers and streams. I once saw one attack a small rabbit that had ventured to the edge of the Trym, but I do not think it had any intention of eating it; the rabbit screamed and struggled away.

THE COMMON FIELD VOLE.—*Microtus agrestis* (Lataste.)

A very common, and, when swarming, as they do sometimes, a very destructive species; it is of a gentle disposition and makes an interesting pet.

THE BANK VOLE.—*Microtus glareolus* (Lataste.)

Hardly uncommon, but local; has occurred at Leigh and at Frampton Cotterell.

THE COMMON HARE.—*Lepus europœus* (Pallas.)

Generally distributed, but not very common.

THE RABBIT.—*Lepus cuniculus* (Linn.)

Very common. Many varieties occur, but seem to be due to escaped tame rabbits crossing with the wild species.

CETACEA.

THE BOTTLE-NOSE WHALE.—*Hyperöodon rostratus* (Bell.)

A very occasional visitant. One at Aust in 1840, whose skeleton is in the Bristol Museum; one at Weston-super-Mare about 1857 (*Winscombe Sketches).*

THE GRAMPUS OR KILLER.—*Orca gladiator* (Gray.)

Locally known as "Herringe Hogge." A very occasional visitor. An occurrence is mentioned "in the Severn" in 1639, and there are other records from the Severn and the Bristol Channel above and below our district, as well as two Whales, probably of this species, at Clevedon, in 1866 (*Victoria History of Somerset).*

THE COMMON RORQUAL.—*Balænoptera musculus* (Bell.)

For an instance of a specimen of this Whale, 66 feet long, coming ashore at Littleton, Pill, in 1885, *see* Bristol Nat. Soc. Proceedings. Vol. IV.

THE COMMON PORPOISE.—*Phocœna communis* (Less.)

Frequently seen in the Bristol Channel and in the Severn pursuing the shoals of fish.

Notes on Bristol Plants.

By James W. White, F.L.S.

THOSE Members who study the distribution of flowering plants around Bristol meet with many surprises in the discovery of species whose existence in this well-worked district had never been remarked by their predecessors—acute and able though they were. A number of noteworthy additions to the Bristol flora were described in the last number of the Society's Proceedings; and already, in the short time that has elapsed since its publication, our field-botanists are able to report some equally valuable finds.

Myosurus minimus, the Mouse-tail. An unassuming but most interesting plant, in which the receptacle that carries the achenes extends as they mature into a tail-like process often three inches in length. It had been repeatedly searched for in our cornfields, but remained unknown both in West Gloucester and North Somerset until the Spring of 1908, when Miss Hill and Miss Peacock, hunting in company, found it in good quantity on alluvial clay by the Bristol Channel, not far from the village of Portbury. This species is peculiar for its vagabond habit, as it is known rarely to stay long in one place. Even at Portbury, although still fairly abundant in the same large enclosure where it was first observed, it no longer grows on the ground where it was discovered during the preceding Spring. This nomadic trait, taken with the tiny stature, unobtrusive habit, and early appearance of the plant, sufficiently accounts, perhaps, for its having escaped notice in some large areas of cultivated land.

Polygala calcarea. Hitherto the nearest stations for this Milkwort have been at Maiden Bradley in Somerset, and on the Cotswold Hills about Stroud. Between those localities there intervened a space of some forty miles—with Bath and Bristol near the centre—from which the plant had never been reported with certainty. A few weeks ago Mr. F. Samson brought specimens from a hillside between Bath and Combe Hay, where he had found an abundance. This species is distinguished by its umbellate flowering stems, that spring from rosettes of large obovate leaves. Its habit is entirely distinct from that of *P. depressa*, and it grows in close brilliant patches that are rendered conspicuous by the beautiful bright blue tint of the flowers, How it escaped recognition by all the keen Bath botanists of past generations is a mystery. Mr. Samson's discovery at a point about midway between the widely separated localities above mentioned gives a most welcome addition to our district list.

Moenchia erecta. This is one of the rarities which at one time flourished on Brandon Hill, in those old days when that "drying ground" was covered with flowers and brambles, and no decent person dare walk upon it after dark! Specimens from the Hill are extant, gathered from 60 to 70 years ago; but probably the plant had disappeared before Swete's time, for he makes no mention of it in the *Flora Bristoliensis.* I understand that when the site of the Blind Asylum was excavated an enormous mass of earth, etc., was tipped on to the upper part of Brandon Hill, and with that material the present broad walk was constructed. It seems likely enough that the *Moenchia* was thus buried. No other locality for this species was known in the County of Gloucestershire until last May, when Mr. Cedric Bucknall found it on Yate Common. He reports it to be fairly plentiful on bare sandy soil.

Carex elata All. (*C. stricta* Good.) It is pleasant to note that this very rare sedge is present with us in larger quantity than was at first estimated. Still, it is confined solely to one spot. And *Carex vesicaria* remains safe on its river-bank, although in peril last autumn from the spade of the ditcher.

The construction and traffic of our Dock extensions, with the accompanying railways, granaries, and corn-mills, that deal with imported grain, continue to be answerable for the introduction of many alien species. These may have no connection with the primitive vegetation of the district; yet, as they will be always with us so long as our cereals and fodder are largely sea-borne, they must be taken into account by the student of plant distribution. A number of them are unable to ripen seed and so gain permanence, but in consequence of frequent re-introduction they maintain themselves in our flora. Thus we now find yearly specimens, few or many, of such rarities as *Adonis, Roemeria, Sisymbrium Sophia, Trifolium resupinatum, Caucalis daucoides, C. latifolia, Carum Carvi, Asperula arvensis,* and the two species of *Apera*, with a quantity of foreigners whose names do not appear in the "London Catalogue of British Plants." Some of the latter travel here from countries so remote and so little known, botanically, that expert botanists in our National Herbaria fail to recognise them.

I have lately learnt that Dillenius, first Sherardian Professor of Botany in Oxford (1734), left the following note among his MS.—"*Pulsatilla vulgaris, flore majore* . . . semina habui inter Bathoniam et Bristoliam lecta, e quibus haec species in Horto Oxoniense crevit."[1] Should any reader be able to throw the least light on this reported occurrence of the Pasque flower in our district I shall be very glad to have the information.

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[1] From *The Dillenian Herbaria* by Druce and Vines. Oxford, 1907.

Reports of Meetings.

For the Year ending 31st December, 1908.

THE Presidential Address by Mr. J. W. White, F.L.S., entitled, "The History of Bristol Botany," Part I., was given upon January 23rd. Other meetings were held as follows:—

Feb. 6th.—A. B. Prowse, M.D., F.R.C.S., "Dartmoor."

Mar. 5th.—Miss I. M. Roper, "The Blossoming of the Trees."

" 23rd.—Exhibition Meeting, arranged by the Entomological Section.

April 2nd.—G. C. Griffiths, "Variation and Dimorphism in Butterflies."

May 7th.—J. H. Priestley, "Further Experiments upon the application of electricity in Horticulture and Agriculture."

Oct. 8th.—P. A. Thompson, A.M.I.C.E., "Siam."

Nov. 5th.—J. McMurtrie, F.G.S., "Physical Disturbances in the Somersetshire and Gloucestershire Coal Fields."

Dec. 3rd.—Short papers—W. A. Smith, M.B., "The Ornithorhynchus." Miss I. M. Roper, "The Cotton Grasses." J. H. Priestley, "Light Lenses of the Leaf."

At the General Meeting held on April 2nd the following Resolution was passed unanimously:—

"That this General Meeting of the Bristol Naturalists' Society cordially supports the movement for the establishment of a University in Bristol, and is of opinion that a local University will be of the highest value in furthering the development of those branches of education and research in which this Society has for forty-six years shown its deep interest."

The following exhibits were shown by members at the ordinary meetings of the Society:—

Jan. 23rd.—T. D. Nicholson, M.D., Ed. Stone with depression tradition stated to have been occupied by a toad.
J. McMurtrie, F.G.S. Fossil Plants from the carboniferous formation.

Mar. 5th.—C. K. Rudge, L.R.C.P., M.R.C.S. Specimens of balls of vegetable fibre rolled by the winds or waves, collected from sea-water and from a fresh-water lake.
W. H. Wickes. Crystalline carborundum from the electrical works at Niagara.

April 2nd.—Miss Roper. Specimens of brown fibre found in large quantities on the shores of the Spencer Gulf S. Australia, and consisting of the fibrous remains of the leafsheaths and bracts of Posidonia australis, Oct. 8th.—A. B. Prowse, M.D., F.R.C.S. Cladonia pyxidata in fruit from Dartmoor.

The Hon. Secretary. Rhamnus catharticus in fruit.

Miss Florence Prowse. The Snake Nut.

The President. Festuca arundinacea, a grass newly found in the district.

BOTANICAL SECTION.

On the 15th February of this year a meeting was held at University College to discuss the re-establishment of this section of the Bristol Naturalists' Society. After the discussion, it was unanimously decided to reform that section, and ten members were enrolled. It was thought that much valuable work might be done to unravel some of the many problems of Ecology and of the Geographical Distribution of vegetation, especially of the Bristol and district flora.

The systematic work needed in the section will be greatly helped by the fact that several members have volunteered to act as "Referees" for the different groups of plants, so that any member wishing to have identified or receive information upon any particular species may forward it to the referee within whose group it falls for that information. A kind of exchange bureau has been established to facilitate the interchanging of specimens for identification, &c.

With regard to the field operations in Ecology, although Dr. E. E. Moss has worked out in a very able manner the plant ecology of Somerset, yet there is more than abundant scope for the members in this direction. Indeed, several members have promised to work out certain areas and report upon the work done at subsequent meetings.

Already much mapping of the vegetation in these areas has been accomplished, especially in the Portishead and Aust districts by J. H. Priestley, and in Tickenham and Nailsea districts by F. Beames.

Since the Section's Revival on the 18th February, four meetings have been held. At the second monthly meeting, Miss E. Hill, of Portbury, showed specimens of the Common Mousetail (Myosurus minimus) from a field at Portbury. This is the first record of the plant being found in North Somerset. Mr. J. H. Priestley showed specimens of a fungus, Morchella elata, from Long Ashton Cider Institute. This is also a record for the same district.

The other meetings have been spent in discussion upon the very interesting specimens brought by the different members, and also upon the observations and records of the field workers in Ecology.

The attendance at the meetings has been good.

J. W. EVES, *Hon. Sec.*

GEOLOGICAL SECTION.

I AM pleased to report there has been an increase of eight in the membership since my last report, the number now being 48 against 40 last year.

There have been seven meetings, when the following papers were read :—

Jan. 16th.—"Fossils Reptiles" (illustrated by lantern slides). Prof. S. H. Reynolds, M.A., F.G.S.

Feb. 25th.—"Physiography of the Avon." Prof. C. Lloyd Morgan, F.R.S., F.G.S.

Mar. 26th.—"Pebble-swallowing animals" (illustrated by specimens). W. H. Wickes.

May 21st.—"Further work on the Geology of the Tortworth inlier" (illustrated by maps and specimens). Prof. S. H. Reynolds, M.A., F.G.S.

Oct. 15th.—"The Geology of the Girvan district of Ayrshire" (illustrated by lantern slides). Prof. S. H. Reynolds, M.A., F.G.S.

Nov. 19th.—Exhibition Meeting.

Dec. 17th.—"The Strata exposed in constructing the Filton to Avonmouth Railway." J. W. Tutcher.

The Financial Report shows a total receipt of £8 6s. 8d., including a balance of £2 7s. 8d. brought forward from last year, and an expenditure of £5 0s. 3d., leaving a balance of £3 6s. 5d. to be carried forward.

I trust the members will continue to bring the Society to the notice of their friends, so that the membership may reach and exceed that of former years.

B. A. BAKER, F.G.S., *Hon. Sec.*

ENTOMOLOGICAL SECTION.

JANUARY 21st.—Annual Meeting. Mr. Charbonnier reported having submitted the specimens of *Epidapus scabii* (discovered by him in Narcissus bulbs at Clifton) to Mr. J. E. Collins, F.E.S., who confirmed the species as an American one, and described by Mr. A. D. Hopkins, of West Virginia Experimental Station, in 1894, the larvæ attacking potatoes. Mr. Charbonnier exhibited specimens of *Callosomia promethea* bred from cocoons of *Telea promethea* from Philadelphia.

Mr. C. Bartlett exhibited a box of lepidoptera, &c., taken at Harlyn Bay.

Nov. 17th.—Dr. Rudge exhibited specimen of *Sesia bembeciformis* from the Wyndcliff, Chepstow. Mr. Griffiths showed a large number of British and Foreign lepidoptera including *Leucania vitellina* and dark vars. of *Macaria leturata*, from Cheshire. Mr. Smallcombe, a visitor, exhibited a splendid specimen of *Zygæna filipendulæ*, var. *chrysanthemii*, and three var. *flava* taken in 1907 near Bristol.

CHAS. BARTLETT, *Hon. Sec.*

"The Blossoming of the Trees."

(Abstract of Paper read by Ida M. Roper, F.L.S., March 5th, 1908).

TREES have always been objects of wonder and admiration to the dwellers in town and country, but too little attention is generally given to the blossoms of our native ones, because they are mostly inconspicuous compared with the more showy or fragrant flowers of other species introduced for decorative purposes into our parks and plantations.

The number of trees indigenous to Great Britain is about eighteen, belonging to half-a-dozen natural orders, including those trees that were introduced so many hundreds of years ago as to be now thoroughly at home in their surroundings. The flower-buds are formed late in the autumn, and after lying dormant through the winter, protected by a thin covering of bracts or scale-leaves, begin to develop and enlarge as spring-time approaches. When the flowers expand these bracts are often shed in large quantities and become very noticeable under such trees as the beech and elm.

The trees can be roughly divided into four groups :—

1. In which simple flowers are developed without coloured perianths, blooming early before the leaves expand, such as the Elm and the Ash.

2. In which the inflorescence takes the form of catkins, and also becomes perfect before the leaves open, such as the Alder, Hazel, Poplars, and some of the Willows.

In both of these groups fertilisation is effected mainly by the pollen being carried by the wind from tree to tree.

3. A catkin-bearing group, which flowers later in the season, when the leaves are more advanced, and includes the Hornbeam, Birch, Oak, Beech, and many Willows.

4. The most showy group with white or coloured flowers usually in perfection after the leaves are well expanded, whose fertilisation depends chiefly upon the visits of insects to the attractive, fragrant, or honey-bearing blossoms. In these the pollen adhering to the insect is brushed off against the stigmas of the next flower visited. The chief examples are the Hawthorn, Lime, Cherry, Apple, and Pear.

In considering the members of each group in detail it is interesting to note that the Elm gives the name to many places. In Domesday Book there are recorded no fewer than forty hamlets in which elm formed part of the name, as for instance Great Elm, near Radstock.

The Ash is usually diœcious and has three kinds of flowers, some with stamens only, others with pistils only, whilst others again are perfect.

The Alder prefers to grow by the banks of streams, but does well on rocky ground. Its cone-like fruits are persistent, often remaining attached to the tree until the next season's flowers are well developed.

The Hazel is rarely more than a bush. Towards the end of February the deciduous yellow catkins, composed of tiny flowers, each with eight stamens, sheltered by tufts of hairs and a single bract, and the crimson stigmas of the immature nuts are very noticeable.

The Willow tribe is a large one, with about eighty varieties—invariably diœcious. The catkins of some, chiefly *Salix Caprea* and *S. cinerea*, are attractive at the end of March with showy masses of stamens and silky greyish hairs. The flowering branches do service as "palms" on Palm Sunday.

The seeds of both Poplars and Willows have at their base a fringe of fine hairs by means of which the wind carries them long distances.

The Silver Birch, the two varieties of Oak, and the Beech are amongst the catkin-bearing trees, whilst the Sycamore and Maple bear their yellowish green flowers of both sexes in drooping racemes.

The Apple is the only British tree to possess a coloured corolla, the other fruit trees and the Hawthorn have white petals. In the structure of their fruits these trees present some special points of interest that illustrate the characters of the great sub-division *(Calyciflorœ)* to which they belong.

Physical Disturbances in the Somerset and Gloucestershire Coalfield.

(ABSTRACT OF PAPER BY J. MCMURTRIE, F.G.S., READ ON NOV. 5TH.)

MR. McMURTRIE briefly referred to the various exposures of the Palæozoic rocks which surrounded the coalfield, dealing first of all with the Mendip range and its far-reaching extensions to Pembroke on the one hand, and the Continental coalfields on the other. Passing on to Broadfield Down and the exposures of the older rocks northwards, he pointed out how the coalfield had thus been surrounded as by a ring fence on its southern, western, and northern margins, while certain isolated areas of Mountain Limestone at Doynton, Wick, and Beech, served as boundary stones to indicate its eastern border. With the help of numerous diagrams he then described the sectional structure of the district, with its overlying formations from the Great Oolite down to the New Red Sandstone, the Coal measures, with their three-fold division into upper Coal measures, Pennant rock, and lower division, together with the older rocks which underlie them, including the Millstone grit, Mountain Limestone, and Old Red Sandstone, to which Professor Reynolds had added the Silurian, which he had lately discovered on the Mendip Hills. The overlying formations, with their level structure, stood out in strange contrast with the Coal measures which lay beneath in a great basin, the sides of which rose at a high angle, so that the overlying rocks lay unconformably on the upturned edges of the older rocks.

Mr. McMurtrie then dealt with the Mendip Range, with its central mass of Old Red Sandstone, from which the Mountain Limestone and Millstone grit dipped north and south at a high angle, with indications of folding over on its northern flank. The adjacent Coal measures had been completely inverted for a distance of four or five miles between Nettlebridge and Mells, and dipped at varying angles towards the hills, instead of from them, while resting on the crest of this fold were three remarkable outliers of Mountain Limestone, which thus lie above the coal strata, instead of far beneath them, and at a distance of from 600 to 1900 yards from the parent rock on the Mendips, of which they once formed a part. The effect of this inversion had been very different on the various groups of coal measures. The massive sandstones of the Pennant and New Rock series had been folded over bodily, and were almost normally regular, while the shales of the Vobster series had been contorted and broken up in a way difficult to describe. Conterminous with this great physical movement there existed four miles away, in the interior of the coalfield, at Radstock and Writhlington, a great overlap fault by which an upper slice of the Radstock Coal measures had been thrust bodily forward a distance of 350 yards on the three lower seams, and from 250 down to 140 yards on the three upper seams of that group.

Mr. McMurtrie then pointed out that all these great earth movements he had described were only separate links in one greater physical disturbance, to account for which various theories had been suggested at different times. The view now generally accepted was that all these phenomena had been primarily caused by some enormous lateral pressure, probably the result of a contraction of the earth's crust, which had operated from south to north, as had happened under like conditions in the Belgian coalfield. The strata on the Mendips had thus been raised to a great elevation, probably accompanied by a certain amount of folding over. The adjacent Coal measures had been inverted as described, while the upper Coal measures of Radstock had been thrust bodily forward on the plane of the overlap fault, but with a narrower lap on the three upper veins, which rather suggested that the elevation of the Mendips had begun towards the close of the coal measure period, and before these upper seams had been deposited. Enormous denudation must have followed the upheaval of the Mendips, the strata so removed having been estimated by Sir Andrew Ramsay at from 4000 to 6000 feet, but judging from the thickness of strata from the upper Coal measures down to the Old Red Sandstone, which had then disappeared, it had led to the conclusion that the denudation could not have fallen short of 13,000 feet. Unless, therefore, the elevation and denudation were coincident, which seemed unlikely, the summit of the Mendips might once have been an ice-field, from which glaciers descended to the seas, which broke upon a shingly beach along their flanks, the evidence of striation having afterwards been destroyed. In the Bristol and Gloucester end of the basin the older rocks had been elevated in a line at right angles with the Mendip Hills, and ranged north and south, possibly indicating a southern extension of the great Pennine Chain, which traversed the centre of England, dividing its coalfields in two great parallel areas. This upward movement and subsequent denudation had been contemporaneous with the other physical disturbances already described, and the force must in this case have operated from west to east. Its effect was shown by diagram sections of the Old Red Sandstone at the Horse Shoe Bend on the Avon, also in the Mountain Limestone of the Avon Gorge, with its great slide fault, all this speaking of great lateral pressure. Of the faults in the interior of the Somerset basin, the most notable were the great 100 fathom fault, a downthrow west which ranged north and south through Radstock; the Clutton Union fault, which ran east and west, lifting up the Pennant Sandstones through the New Red marls of Hallatrow, into the picturesque elevations of Highbury Hill and Temple Hill; and the Farmborough fault, of unknown extent, ranging east and west between Farmborough and Timsbury, which had stopped the development of the coalfield northwards, so that not a single colliery now existed between it and Kingswood Hill. In the Gloucester end of the coalfield the predominant disturbances were the Kingswood anticlinal, ranging eastward from Bristol to Wick; the Soundwell fault ranging parallel with it on its northern flank; and the great 100 fathom fault running north and south through Parkfield basin. A notable circumstance connected with it was that the Coal measures north of the Kingswood anticlinal had evidently been raised to a higher level than those of Somerset, and they had suffered more from denudation, the Radstock series, if it ever existed there, having been washed away, greatly to Gloucester's loss.

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The Flower of Bristowe.

(By Ida M. Roper, F.L.S., read October 7th, 1909).

In the formation of a University many details have to be thought out and arranged, and not the least amongst them is the colour of the Academical hood to be worn by its graduates. Universities sprang up throughout Europe in the 15th and 16th centuries, and various articles of dress were looked upon as appropriate to add to the dignity of the graduates and to mark their various degrees. These distinctive insignia were of different material, such as woollen, fur, or silk, and from a modification of one of the cloaks or gowns of those times has come down to us the modern hood with its varied colours. As all the hoods are now similar in shape, each University seeks to confer a special honour by its hood of a distinctive colour different from all others. But the multiplication of modern Universities and the limited number of colours make it necessary to select a special shade or tint, and the choice often proves a matter of difficulty, except when history or sentiment can guide the decision.

It came to my knowledge that Mr. E. Sibree drew the attention of the Sub-Committee of the University to the fact that the name of Bristol is associated with a plant called the "Flower of Bristowe," and he suggested that its colour might well be fixed upon to give an historic meaning to the academical hood.

As the identity of this "Flower of Bristowe" is unknown to many, I have brought together all the information about it that I have been able to glean from various sources, and only regret that it is so meagre.

The plant that has received the honour of being called the "Flower of Bristowe" is the Scarlet Lychnis, an old-fashioned flower familiar to most of us in herbaceous gardens; and it is the brilliant colour of its blossom, which is the shade of scarlet, that the University could adopt if it decides to use this flower as a guide.

It is a perennial belonging to the order Caryophyllaceæ—the pink family—and, growing about two feet high, produces in July and August flat corymbs made up of small five-petalled florets. It is known to the botanist as Lychnis Chalcedonica, and to the old herbalist as "Nonesuch" or "Flower of Bristowe," whilst the cottager gives it the name of "Scarlet Lightning."

Inquiring into the history of the Scarlet Lychnis, we find that the philosopher Theophrastus, nearly 400 years before the Christian era, and the Greek physician Dioscorides, living about A.D. 60, both mention in their writings a plant which they call Lychnis, but we cannot be sure of its identity. The first actual record in any book of the plant we now know as the Lychnis is by Ulyssus Aldrovandus, an Italian, who visited many countries in search of plants, and who wrote largely on natural history about A.D. 1570, forming a museum at Bologna, his native place. He calls the Lychnis Chalcedonica by the name of "Flos Creticus," the "Flower of Candia."

Next we come to Gerard's "Herball," written about 20 years later, in which he gives an illustration, clearly describes its botanical characteristics, and states that it was common in English gardens at that time. This puts us on a surer foundation, and we are able to trace the plant through a number of references down to the present time. Gerard tells us that in the Latin tongue used by the educated men of Europe its name was Lychnis Chalcedonica, and, further, that in the English language it is usually called Nonesuch, Flower of Bristowe, and Flower or Campion of Constantinople.

From these names of Candia and Constantinople we can recognise that the same plant was well known to the Continental nations, and the names thus given to it suggest that the first introduction of the Lychnis to the West of Europe was brought about during the Crusades, because it is called in French, Spanish, Norman-French, and German, "Cross of Jerusalem"; in Italian, "Cross of the Knights"; and in Portuguese, "Cross of Malta"—names which all tell of its association with the religious orders that had their origin in the defence of the Holy Land. It is probable that the flower known by these names of the Levant was regarded as specially connected with the Knights of Malta, otherwise called the Knights of St. John of Jerusalem.

It will be remembered that this was a celebrated military and religious Order which was founded at Jerusalem about the time of the Norman Conquest to maintain a hospice for receiving the pilgrims from Europe on their way to visit the Holy Sepulchre. This work was carried on for nearly 500 years at Jerusalem and in the Island of Rhodes, and the Order became likewise a great military one, nearly equalling the Knight Templars in importance. It had also hospices at the chief ports in the Mediterranean where pilgrims stayed, but after A.D. 1530 it had Malta as its head-quarters. During these centuries many pilgrims must have seen this Lychnis—a plant hitherto unknown to them—and when describing the wonders of the East, on their return to their native countries, must have spoken of the plant by the name of the place in which they saw it growing.

From what earlier writers state, it is clear that the name of "Flower of Malta" had an additional association. The petals of the Lychnis are forked at the ends, and so arranged in the flower as to appear to the casual observer as an exact representation of the familiar Cross of Malta, the badge worn by the Knight Hospitallers and the Knight Templars. In reality the blossom is composed of five petals. There is nothing, however, in all this to tell us why, at the end of the 16th century, when Gerard published his Herball, the plant known as Lychnis Chalcedonica, called in the English tongue Campion or Flower of Constantinople, was in addition named Nonesuch and Flower of Bristowe.

Campion is a general name given to various species of Lychnis, and is thought to have its origin in the fact that the flowers were used in the chaplets with which the champions at the public games were crowned. Chalcedonica and Flower of Constantinople suggest that the plant might have been introduced into England from Constantinople or from the Asia Minor town of Chalcedon, although we know from all books on gardening that this Lychnis is a native of Russia. Hence we see that in England, just as amongst the Continental people, it was not the place of its origin that impressed the popular mind in those times, but the name of the seaports whence it was known to be brought into England.

The Crusades being nearly forgotten as the centuries rolled on, we find that in England the plant takes on names derived from a different source, while still retaining those associated with its Eastern origin, and it is interesting to try and trace out this change to Nonesuch and Flower of Bristowe.

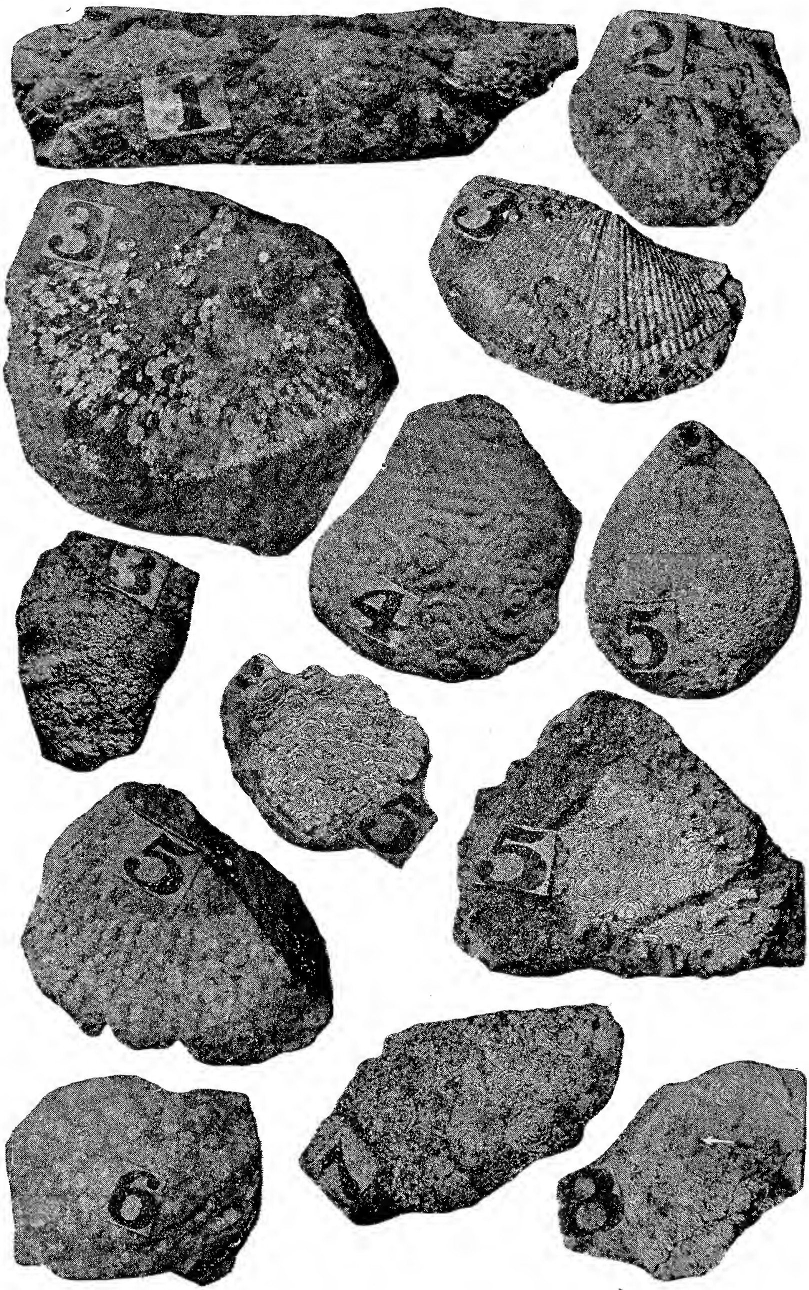
The etymological meaning of Nonesuch is "a thing that has no equal," is "unrivalled," "incomparable," and in this case must refer to the colour of the flower. The absence of scarlet amongst English wild flowers is very noticeable, there being but three—the scarlet pimpernel, the poppy, and the pheasant's-eye Adonis—so that the brilliancy of the Scarlet Lychnis struck the English people, and they regarded it as incomparable and nonesuch.

This still leaves unexplained whence came the popular name of Flower of Bristowe. Working from analogy we can only think that the plant must have been introduced during the 16th century freely and repeatedly into English gardens through the great port of Bristol, then the second trading place in the kingdom. That being so, it is clear that something about the plant—I have suggested it was its colour—made a great impression on the popular imagination, and caused it to be commonly and persistently regarded as the Flower of Bristowe, whereas other plants imported through the different trading centres of England acquired no such lasting fame.

It is not surprising that the plant should have often come into this country by way of this city, because we know from local records how regular and important was the trade to and fro between Constantinople, the Levant, and Bristol, during the 15th and 16th centuries. I need only recall that John Cabot, about A.D. 1475, came to Bristol from Venice, when the Italian ports were engaged in such great traffic with Western Europe in the products from the East. This trading continued to increase in importance till some time after Gerard wrote describing this flower. At length, in the 17th century, the Merchant Venturers of Bristol decided to enter into competition with the Italian States, and send out their own ships direct to the Ionian Islands and the Levant, to trade independently of traffic passing through Italian merchants.

Strong support to the supposition that the name of the plant was derived from its colour comes from quite another source. Many years before Gerard wrote in A.D. 1597, different towns were celebrated for the coloured woollens which they produced for common wear, and it is known that Bristol was associated with the colour red, because in a book on general information, published A.D. 1530, it is stated that "at Brystowe is the best water to dye red." What more natural, therefore, than that the people accustomed to get their red colours from Bristol traders should regard the brilliant scarlet of the Lychnis as the unrivalled or Nonesuch red, and that plant, and that alone, as the Flower of Bristowe.

I think there can be no doubt that this is how the Scarlet Lychnis came to be known widely amongst the English, and that it owed its special favour amongst them to its easy propagation and the brilliancy of its colour. If we can go back for from 300 to 400 years and find the popularity of this particular shade of scarlet associated with Bristol, surely we may argue in this present year that, if it should be again brought prominently before the people of England as belonging to this city, it will continue to attract them, and serve as an incentive to many students to gain the honour of wearing a scarlet academical hood of the University of Bristol.



British Beekites.

Beekite.

By W. H. Wickes.

THIS beautiful and interesting mineral is local to Bristol in a two-fold sense, being found in several places in the district, and also deriving its name from that of a former Dean of Bristol. This should render it worthy of more attention than it has hitherto received, as it does not appear to have been described in the past proceedings of this Society.

The name "Beekite" is useful, and replaces in a convenient form the more cumbrous ones previously used, either of "Orbicular Silex" or "Annular Chalcedony."

Before proceeding with a description of the mineral, it may be of interest to give a few particulars of the person after whom it is named. Henry Beeke, born 1751, died 1837, was at Oxford (Oriel, 1775, and Corpus Christi, 1776—Vicar of St. Mary-the-Virgin, 1782, and Professor of Modern History, 1801). In 1814 he was promoted to the Deanery of Bristol, which he appears to have held for the remainder of his life.

In Latimer's "Annals of Bristol," under the date of 1834, appears as follows, "The Dean, Dr. Beeke, then in his 84th year, was a finished scholar, and before age disabled him, an energetic promoter of literature and science in the City. His only short-coming, apparently, was his stature; Sydney Smith alleging that if Bishop Gray stood on the Dean's shoulders, their combined height would not equal that of the Archbishop of Canterbury."

Stanley Hutton says—"Henry Beeke was a great authority on Finance, was consulted by William Pitt, and assisted him in his Income Tax Bill, of which according to some, he was the original suggestor. His chief work, 'Observations on the produce of the Income Tax,' was eulogised by McCulloch as the best example of statistical reasoning in Finance that had then appeared.*

Whether this phase of his ability will tend to endear his memory, is a little doubtful. But he seems to have been a man of more than average intelligence, and it is rather curious that so little is known about him or his writings. But for the fact that his name was given to the mineral under notice, he would probably be entirely forgotten. As it is, all we are informed is that "it is named after Dr. Beeke, who first called attention to it." But in what manner he did so, or who invented the name, no record has, as yet, been found. Probably the sponsor was one of the grand group of "old masters" who did such fine and lasting work in our district about that time.

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* Bristol and its Associations."—page 537.

From the list of subscribers to the "Natural History of the Crinoidea," by J. S. Miller, published in Bristol in 1821, it appears H. de la Beche was then residing in Clifton, the Rev. J. C. Conybeare, at Batheaston, the Rev. W. D. Conybeare, at Brislington, with Dean Buckland and Professor Sedgwick as frequent or occasional visitors; while W. Lonsdale was at Bath, and doubtless took part in many of their excursions. It is evident, therefore, that the men with whom Dr. Beeke mixed were of no mean status in the geological world.

The statement that Dr. Beeke was the first to call attention to this mineral is not strictly correct, for one of our members (Mr. Upfield Green) has unearthed several extracts showing that certain Continental geologists had speculated about it as far back as 1751. Walch, of Jena,* describes and figures certain fossils which are undoubtedly Beekised, "one is a sponge from the 'Birse' near Basle, the whole surface of which is covered with knobs, or delicate discs enclosed in curved, sometimes spiral lines. So much is certain these do not belong to 'Fungiten' structure as they are found also on other fossils as Terebratula, Belemnites, &c. Some consider them to be Ostracites or Vermiculites—see Gueltard, Memb. of l'academie Royal des Sciences, Paris, 1751—also D. Hofmann, Actis Acad. Mogunt. (Mayence). He describes them as "Vermiculos orbicularis planos constantes, ex quatuor vel pluribus spiris sive circulis concentrices."

Probst Geuzmer, of Stargard, says in a letter to him, dated 6 July, 1769—"I believe them to be a hardened secretion of the organism in which they occur, as if they were vermicular they would increase not only in size and length, but in width, and would have to form "lineam spiralium" and not "circulos concentrices in semel ipsos revertantes." They are also formed between the Tunicis and Lamellis of which the shell of oysters and other shells consist. This could not be the case if they were owing to the adhesion of an outside worm, as the Tunica and Lamellæ are formed from inside and therefore they must be formed by a secretion during the building up of the shell itself. Professor Annone says of one of them, "This is a most perfect and delicate coralline sponge, shaped like a conical hat, the surface of which is covered with countless small discs similar to those on No. 2. Another writer considers the markings to be the roots of abraded spines, especially when found on Gryphites (or Productus?)."

These remarks and speculations of the older geologists are interesting, but beyond showing that it had been noticed at the dates given, do not throw much light on the subject. One important omission characterizes their writings, and that is no one seems to have noticed the fact that all these rings were *silica.*

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* Natural History of Petrifactions, Nurnberg, 1769.

Possibly it might have been the discovery of this by Dr. Beeke, which led to his name being associated with the mineral. Coming to a more recent date, we find a description and several plates in an "Album of remarkable petrifactions," by Leopold von Buch, Berlin, 1831. The plates, which are very well executed, show three specimens of Gryphæa columba, one of G. secunda, and two silicified oysters (unnamed), apparently all are from the Greensand, or lower chalk, but the exact formation is not given (though the great resemblance to the specimens found in the Chloritic sands of Antrim is a strong clue to their probable horizon). They all show well formed and easily recognisable Beekite, although this name is not used in the text, which is as follows—

"Silicification of Shells.

"The silicification of the calcareous test only takes place when there has been pre-existent animal matter. In this matter a small globule of hydrated silica forms, which rises and extends and probably changes its viscous state to another more solid, without however becoming perfectly hardened; another globule attaches itself to the first, and pushes it from all sides forward similar to wave action. Other globules follow and surround the former ones, producing a similar wave effect. A system of waves is thus produced with a raised centre, and this meeting with any system of the same description forms a series of knobs or nipples rising one above the other. The calcareous portion of the shell is dissolved and carried away in solution, having been broken up by the siliceous intrusion, which occupies a larger space than the organic matter which attracted it, and now replaces the original shell, retaining its form."

(It will be noticed in the foregoing extract that the siliceous nature of the depcsit is now fully recognized. This was not the case in the earlier extracts. Whether this was due to Dr. Beeke does not appear, as his name is not mentioned).

The next paper is that read to the Geological Section of the British Association at Cheltenham in 1856, "On the Beekites found in the Red Conglomerates of Torbay," by Wm. Pengelly, F.G.S. This paper is too long to quote *in extenso*, but a synopsis of the salient points may be given. He says, "The pebbles in the conglomerates of Torbay are principally calcareous and trappean; very many of the former contain fossils, all of them identical with those of the Devonian system, hence it may be inferred that these pebbles were derived from the adjacent limestone rocks, the red rocks are remarkably poor in organic remains. . . . Perhaps the most interesting things found in the conglomerates are the Beekites. . . . Without being closely examined they would probably be confounded with the pebbles with which they are associated and which they resemble in form and dimensions. They vary in size from half an inch to a foot in diameter, the common dimensions being from 3 to 6 inches. The surfaces are covered with *Chalcedony*, generally arranged in tubercles, each of which is not unfrequently surrounded by one or more rings; and occasionally the same ring invests two or more tubercles. The tubercles vary in size from a small pin's head to a moderately sized pea. Occasionally the Chalcedony seems arranged on two different patterns or types, or more correctly, the same type on two different scales. When broken the Beekite is found in the interior to be calcareous . . . occasionally only a few grains of matter remain within the crust, in which case the Beekite will float on water.

I have never met with a nucleus which was not a fossil; occasionally a doubtful specimen has presented itself, but the organic structure has been readily displayed by the action of muriatic acid, or by having the nucleus cut and polished. The fossils are all of Devonian age, and are either sponges, corals, or shells. . . . Even when the nucleus is found resolved into dust, the structure of the extinct sponge or coral (of which it is the frail memorial) has sometimes been quite evident on it. . . . Frequently the organic structure is also preserved on the inner, or concave surface of the enveloping crust; it is no rare occurrence to find the crust broken, and the nucleus gone, but still to be able to read the nature of the organism by the characters traced on its inner surface. . . . In most cases the outer surface of the crust is destitute of any organic traces, though specimens are found in which the character of the enclosed nucleus is quite evident on the exterior."

The writer then goes on with sundry speculations as to the deposit of the Beekite, but ingenious as they are, they are all founded on misconception and therefore not of any service. It is a curious thing that while the earlier part of his paper could not have been better stated, the last few pages go off the track, mainly through his taking too local a view of the evidence. It is strange that although other specimens were shown him (from Scotland, Somerset, &c.) he appears to have ignored them, and instead of following up this clue, based his conclusions on the mistaken idea that Beekites could only be found in any quantity in the conglomerates of his particular district! His main theory is the decomposition of calcareous pebbles in water containing soluble silica, but how or why it occurs only on pebbles containing organic remains is not explained. In his conclusion he remarks, "In accordance with these opinions, Beekite can only be expected in conglomerate rocks which contain decomposing calcareous pebbles, and through which water charged with Chalcedony passes. A collection of circumstances which is probably not frequent; and hence the apparently limited distribution of Beekites."

Unfortunately it never occurred to Pengelly to follow up another clue which he notes in his paper, and then drops, *i.e.*, that all the Beekites were on a fossil nucleus, and further, the fossils were recognised by him as Devonian! Had he examined some of the corals, &c., in his own district with the same care he took with the *derived* Livermead specimens, he would soon have discovered scores *in situ* that were heavily Beekised—while had it been known at the time that the neighbouring county of Somerset was in many places in the Mendips, Dundry Hill, &c., well peppered with thousands of Beekised fossils—*all in situ*—the concluding part of his paper would have been worded in a very different manner, and we should also have been spared the numerous theories and speculations of subsequent writers, all more or less founded on the supposed "Conglomerate" origin of Beekite! (It is but fair, however, to these writers to point out that most of their papers were written 40 or 50 years ago, when geologists had not the same travelling or postal facilities that we now enjoy. Yet it is somewhat surprising that none of them appear to have made any attempts to follow up the obvious clues given in Pengelly's paper *(Philosophical Magazine, 1862, vol. 23, page 95)*.

Professor Church (in addition to quoting from Pengelly) says it is an interesting problem, being not a mineral merely, but a fossil more or less completely mineralized—or again, it is not merely a fossil, but an incrustation of Chalcedony upon a nucleus of coral, &c. He also notices the tendency to deposition in a circular form seen in many varieties of silica. He made several analyses of Beekite, of which the following is a rough average—Silica, 91 to 93; Lime (as Silicate), 2 to 3; Iron, 2 to 2·5; Water, 1 to 2; Carbonic Acid and Organic Matter, 1·5 to 2·5, with traces of other constituents such as Phosphates, Iodine, &c.

Sufficient matter having been quoted from previous papers, it may be as well at this point to go on to the fresh evidence which has come to hand during the last few years. Some time ago while collecting in the Carboniferous of Burrington and other sections it was noticed that a large number of the fossils were disfigured with circular markings; on testing with Acid these proved to be Beekites; shortly afterwards similar markings were noticed in the Upper Coral Bed of Dundry Hill (classed as "Bathonian," by Buckman and Wilson).

Feeling sure from this that there must be more of it about than was generally thought, it was resolved to circulate specimens among friends in various localities, and request them to examine their fossils for Beekite. The results were surprising—as no sooner was attention called to it, than it began to be found in many localities (notably in Antrim—where Mr. R. Bell discovered numerous fine specimens in the Chloritic Sands). These discoveries, added to our local researches, enabled the following provisional list of localities to be drawn up. With the exception of those found in the Permian Conglomerates, all these are on fossils, found *in situ*, and in the formation or zone to which they belong. This list alone should effectually disprove the theory that Beekites can only occur in conglomerates!

Formation.	Locality.	Fossils Affected.
Cambrian Durness Limestone	Durness, N.B. ...	Orthoceras
Silurian ... ... Wenlock Series ...	Sedgley ... ... May Hill	Heliolites porosus Halysites catenularius
Devonian	Torquay ... ... Totnes ... ... Plymouth ...	In certain zones most of the corals and Stromatoporids
Carboniferous Limestone ...	K 2 Clevedon ... Failand ... Z Burrington ... Avon Gorge Caldy Island S 2 Burrington ... Ebbor rocks Beaumaris ... D 2 Wrington ... Oswestry, &c. Bolland, &c. D 3 Pendleside ...	Spirifer (common), Leptena, Athyris, Syringothyris, Productus, Orthotetes, &c., and nearly all the corals and encrinites Cyathaxonia, &c.
Trias or Permian Conglomerates	Torbay ... ... Exeter	Molluscs, Corals, &c., all derived from Devonian
Lower Lias	Shepton Mallett ... Wells (near) ...	Lima gigantea
Bajocian	Cheltenham ...	Terebratula, &c. (Sauzei zone)
Bathonian ... ... (Upper Coral Bed)	Dundry Hill ...	Nearly all the corals, with Terebratula, Rhynchonella, Lima, Pecten, Ostrœa, &c.
Portlandian	Teffont ... ... Chilmark	Pecten lamellosus, Ostrœa, &c.
Cretaceous ... ... (Upper Green Sand)	Haldon Hills ... Dinton, Wilts. ...	Orbitolina, Pecten, &c. Exogyra conica
Chloritic Sands ... Yellow Sands ...	Antrim ... ... Do.	Exogyra conica, E. columba, Inoceramus crispi, &c. Rhynchonella latissimus Pecten quadricostatus
Chalk	Purley, Surrey ... Rickmansworth ... Antrim	Sponge flints Belemnites

Also reported as occurring in the Carboniferous of Scotland and Flintshire, in the Trias of Jersey, and in the Chalk and Norwich Crag of Norfolk. To this may be added a few of the foreign localities reported by various writers, showing how wide is the range (the formations are given where mentioned, but many have omitted them); Cretaceous : Basses-Alpes, Mecklenburg, and near Geneva. Corallian : Wurtemburg. Oxfordian : Ardennes, also Vallecas (near Madrid), Island of Harö (Norway), Mantua Downs (Queensland), Rhodesia, Punjab (Hindostan), Connecticut Valley, and Clarke County (Indiana).

There is but little doubt that both the home and foreign lists could be indefinitely extended, but the localities named are ample to dispose of the idea that it is at all limited in occurrence either geographically or stratigraphically.

As to the fossils affected, a few important points have been noted, one of which is, that different organisms are not equally liable—in other words some are very susceptible to Beekite, while others, in the same zone, seem to be practically or entirely immune. The organisms which are the chief sufferers are as follows :—Corals, Stromatoporids, Sponges, some Brachiopods (especially Spirifer, Productus, Terebratula, and Rhynchonella), Lamellibranchs (such as Pecten, Lima, Ostrœa, &c.), a few Gasteropods (Murchisonia, &c.), and nearly all the Encrinites.

Coming to those apparently immune we have not as yet found it on any of the following, with the few exceptions specified—Crustacea, Echinodermata, Cephalopoda (with a few exceptions in Orthoceras and Belemnites), Brachiopods (except those already mentioned).

It has been suggested that this liabllity or immunity might be due to the nature of the shell or skeleton, some being composed of Calcite, and others of Aragonite. Dr. H. C. Sorby, in his Presidential Address to the Geological Society, enters into the subject of the microscopical structure of shells, &c., and classifies them as follows—Corals, all Aragonite ; Lamellibranchs and Gasteropods—mostly Aragonite, except Ostrœa and Pecten, which are Calcite ; Cephalopods—mostly Aragonite ; Crinoids, Echinoderms, and Brachiopods—nearly all Calcite.*

It will be seen from the foregoing that the list of those liable to, or immune from Beekite, does not agree in many points with Dr. Sorby's classification—as Ostrœa, Pecten, and certain Brachiopods, which he states have Calcite shells, are frequently Beekised—and sometimes heavily. This matter is, however, being looked into by Mr. James Strachan (Belfast Field Club). It is a slow process, requiring great patience and careful observation, and may therefore require some time before any definite report is made.

* Quart. Jour. Geol. Soc., Vol. XXXV., 1879.

This question, while it may explain the reason why some fossils are more susceptible than others, does not seem to throw any light on the origin of this peculiar deposit. Before going on with this point it may be as well to mention certain other features connected with its mode of occurrence.

(1) That the rock in which it is found most freely always shows signs of an excess of Silica in the form of masses of Chert, Flint, Chalcedony, &c., indicating that Silica was present to a considerable extent.

(2) That the Beekite occurs in varying grades or degrees, from a few isolated dots and rings up to a complete silicification, and sometimes obliteration of the fossil nucleus, which then consists mainly of knobs or warts of Silica.

(3) That different localities show it in various degrees, *i.e.*, the Dundry Beekites are largely in the earlier stages, while those at Torquay are nearly all in the last stages, with the Antrims coming somewhat midway. This applies to the average finds, as many places (such as Dundry) have it in all degrees.

(4) So far as is known at present Beekite is a marine product —that is, of the numerous specimens examined not one (as yet) has been noted on any fossil which can be allotted to a fresh water deposit. Neither has any occurred on vegetable remains.

(5) Another peculiar feature of Beekite is that it follows, or is influenced by, the structure of the fossil on which it forms. Thus in the interior of a coral or stromatoporid, it appears in a granular, stringy, or thread-like form, whereas on a shell, the rings are predominant—while on certain shells, such as "Lima lycetti" it is usually oval in shape.

(6) When Beekised fossils (especially corals) are immersed in acid, there is almost always an odour given off suggestive of decaying organic matter, similar to that frequently noticed on the sea shore at low tide.

In considering the origin of the Beekites, there is one point which stands out more prominently than others, that is, they are always associated with fossil remains of some organism or other. W. Pengelly asserts in his paper that he had never found one which was without a fossil nucleus, and this observation of his (which was founded on "derived" specimens from the Torbay district) is fully corroborated by the numerous examples found *in situ* in various formations during the last few years. Of those examined, to the number of over three thousand, not one has yet come to hand which is not on a distinct fossil. In most cases the organism can be at once detected and named, some require the use of acid to remove the enveloping matrix, but the fossil is always to be found!

Further, the organic remains on which the rings, &c., occur, are always those that are natural to the formation in which they are found, and not derived from other rocks (as in the case of the Torbay conglomerates).

Now the fact that there is always an organism present whenever we get Beekite, and further that it shows a distinct preference for certain fossils, gives a very good clue to the origin of this peculiar mineral, a clue which it is somewhat surprising to find has not (apparently) been followed up. The most possible explanation is, that the various writers on the subject accepted Pengelly's dictum as to its occurrence only in conglomerates as final, and were probably unaware of its being found in so many formations *in situ*.

It is also curious that the earlier Continental writer (nearly a century before Pengelly's paper) appear to have worked on *in situ* specimens, and to have attributed the origin to worms or other organisms. In this they came much nearer a feasible solution of the question than those who followed the conglomerate theory!

After discovering that the Beekites had such a wide range and could be traced through so many formations, the suggestion naturally arose of the probability that something of the same kind might be going on at the present time.

Anyone examining the common objects on the sea shore would notice the numerous shells with holes of various sizes and shapes bored in them. Many of these are simple pits or trenches, which were probably made by small animals requiring lime, or making refuges for their habitation—these do not affect our question. But there is another kind of boring, that which goes right through the shell. These are of various sizes, the large ones being made by carnivorous univalves, mostly of the whelk type, well known for their destructive habits in the oyster beds, but it is not these we have to consider in this paper, rather with those of the small-bore type, that is, shells riddled with scores of minute perforations, of which many may be found on most sea-beaches. These holes have been attributed to various organisms, and may be caused by worms, such as "Polydora ciliata," or sponges, such as "Cliona," or some other boring creature. That the attack was frequently made during the life of the victim is shown by the fact that shells are not uncommon in which the mollusc has defended itself against these borers, sometimes with success, by throwing out a hasty deposit of nacre, or shell-forming material, and that this is laid down in a hurry is evident by its rough and uneven character, differing entirely from the beautiful smoothness usual in the interior of a sea shell.

The effect of a successful attack of these small sea pirates would be the death of the mollusc and subsequent decomposition of some of the animal matter. In ordinary sea-water nothing unusual would result, only one more of the bored shells frequently found on our coasts. But if the water contained an abnormal amount of Silica in solution, the putrefying matter issuiug from the bore-holes would tend to attract the Silica, which would be deposited and form a ring round each orifice, and as Silica has a habit or tendency to repeat, or follow, any particular shape it may originally form, these rings would be repeated and augmented as long as the process continued, this might be for an indefinite period, depending largely on the amount of Silica forthcoming. Therefore we may assume that the formation of Beekite is due to three factors, or causes, (1) The presence of a calcareous organism, as a nucleus or base; (2) An attacking force of boring worms, or sponges, and (3) the presence of Silica in solution in the water in sufficient quantity to admit of deposition. A combination of these three features is necessary for the production of Beekite, and as this does not occur commonly, it explains why the mineral is only noted in certain zones, as should one of the three causes be absent Beekite would not be formed.

Following on the idea that Beekite, or something of a similar character might probably occur in modern times, a considerable number of recent shells were examined, for some time with negative results, but lately a large specimen from New South Wales, of "Haliotis giganteus" turned up, which appears to come very near to this mineral. This shell has been the victim of a heavy attack of borers, which it has resisted by throwing out a considerable amount of nacre or shell-forming matter, apparently with success (most of the bore holes being plugged or screened), but the appearance of the outside of shell is strongly suggestive of an initial or early form of Beekite, especially as some of the holes are surrounded by rings of mineral matter.

It certainly looks as if here we have, if not actual Beekite, a preparatory or early stage of it. Probably when this matter is more fully investigated some locality will be found where recent Beekite will be discovered in process of actual formation.

The theory that Beekite is of very slow production, or deposited ages after the period of the calcareous nucleus, is not supported by the evidence. Not only do the fossils and the Chalcedonic rings appear to be of the same age, but there is also direct evidence that they are so. It is well known that in "dead shells" on the sea shore a very short time elapses before they are settled upon and tenanted by small organisms, such as Serpula, Bryozoa, &c. Now several specimens have been found at Dundry and the Vale of Wardour showing these small "squatters." If the Beekite were deposited after these creatures attached themselves we should expect it to cover or at least encroach on them. If, however, we find the shell covered with the mineral and the Bryozoa, &c., resting over the Beekite and untouched by it, it is a fair presumption that the mineral deposit was there before the Bryozoa, &c., came. This is the case with some specimens, and it shows that the formation of Beekite must have been a fairly rapid process. As regards the rapidity of deposit of minerals, the following remarks by Sir Charles Lyell are noteworthy.

In discussing the mineralisation of organic remains, he writes, "The student may, perhaps, ask whether on chemical principles we have any ground to expect that mineral matter will be thrown down precisely in those spots where organic decomposition is in progress? The following curious experiments may serve to illustrate the point. Professor Göppert, of Breslau, with a view of imitating the natural process of petrifaction, steeped a variety of animal and vegetable substances in waters, some holding siliceous, others calcareous, others metallic, matter in solution. He found that in the period of a few weeks, or sometimes even days, the organic bodies immersed were mineralised to a certain extent." He further says, "The late Dr. Turner observed that when mineral matter is in a 'nascent state,' that is to say, just liberated from a previous state of chemical combination, it is more ready to unite with other matter and form a new chemical compound. Probably the particles or atoms just set free are of extreme minuteness and therefore move more freely and are more ready to obey any impulse of chemical affinity. Whatever be the cause it clearly follows, as before stated, that where organic matter, newly embedded in sediment is decomposing, there will chemical changes take place most actively." *

Theories and speculations on the subject of the deposition of Silica are as plentiful as blackberries (and many are equally wild), and time will not allow of their discussion, but the central facts will be quite as much as required for this paper, (1) That organic remains are mineralised, and (2) that the mineral is frequently Silica. These two points are indisputable, being proved by countless specimens from every part of the globe.

These are the main facts respecting Beekite; in collecting them several thousands of specimens have been examined, and numerous friends enlisted in the search. The minerals which are of organic origin are comparatively few in number, so if we can add another one to the list, and also enlist your interest in this beautiful and peculiar mineral, the efforts of the writer and those who so kindly assisted him in the matter will not have been in vain. The search is still incomplete, many likely localities and formations being as yet unrepresented (for instance the Tertiary formations and others). It is confidently expected that now attention has been called to the matter many of the gaps will be filled up.

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* Students' Elements, 1878, p. 45.

SUMMARY.

1.—The mineral called "Beekite" (after a former Dean of Bristol), occurs plentifully in several zones *in situ* in our district.

2.—It is a variety of Chalcedony in the shape of dots and rings, or in other terms Orbicular and Annular.

3.—It occurs only on calcareous organisms, either those having tests (Molluscs), or skeletons (corals, encrinites, &c.)

4.—It is found *in situ* in a considerable number of formations and localities, both British and foreign, on fossils belonging to such beds, and therefore the theory of its only occurring in rocks of a conglomerate character is absolutely untenable,

5.—That the persistent connexion of this peculiar mineral with organisms is a strong indication of its origin being organic.

6.—The most probable causes of its formation are three in number, (1) an organism having a calcareous shell or skeleton; (2) an attacking force of boring creatures, such as worms, sponges, &c., and (3) a sufficient quantity of dissolved Silica in the water to be attracted by the decomposing animal matter, and deposited on and around the bore-holes in the form of globules and rings.

7.—The process would start as soon as decomposition commenced, therefore Beekite would be formed shortly after the death of the victim and would probably be a fairly rapid deposit.

8.—Once fairly started the deposit might continue for an indefinite period, which would be determined by the amount of Silica forthcoming.

9.—Given a combination of the three causes (mentioned in Clause 6) there is no reason why Beekite should not be deposited at the present time, in fact there is already evidence that it is forming in certain localities in Australia, &c., and it is confidently expected that further examples will be noted as soon as more attention is given to the subject.

Thanks are due to numerous helpers in the search for specimens and information; among them the following may be named:—Drs. G. Abbott, A. Vaughan, and Wheelton Hind, Professor Reynolds, Messrs. Upfield Green, H. B. Woodward, C. D. Sherborn, F. G. Collins, L. Richardson, B. Lightfoot (Edinburgh), R. Bell (Belfast), and especial thanks to Mr. James Strachan, and Mr. J. W. Tutcher, for the excellent lantern slides so kindly provided.

EXPLANATION OF PLATE.

BRITISH BEEKITES.

FORMATION.	LOCALITY.	FOSSILS.
1. Cambrian	Durness, N.B. ...	Orthoceras
2. Carboniferous ...	Clevedon, Som. ...	Spirifer
3. do. ... (Z Zone)	Burrington, Som.	Orthotetes, Spirifer, and Zaphrentis
4. Permian ... ... (derived Devonian)	Torbay	Stromatopora (rolled)
5. Bathonian... ... (Upper Coral Bed)	Dundry Hill, Som.	Terebratula, Pecten, Plicatula & Ostræa
6. Portlandian ...	Chilmark, Wilts.	Pecten lamellosus
7. Cretaceous ... (Chloritic Sands)	Antrim	Exogyra columba
8. Bathonian... ...	Dundry Hill ...	Avicula with Bryozoan grown *over* the Beekite

Bristol Botany, 1910.

Sketch of a year's work.

By James W. White, F.L.S.

AT the close of a season of successful field-work the botanical reporter records his results with proportionate satisfaction, mingled with the merest trace of justifiable feeling that credit may be claimed by his co-workers and himself for accomplishing something of moment in a district so long and diligently worked upon as that of the Bristol Coal-fields. The following survey will certainly shew that there has been no pause of late in our progress towards an adequate knowledge of the local flora, and that many matters of real interest in connection with the distribution of plants in our area have recently been dealt with.

The necessity for breaking new ground has been kept in mind. In so large a breadth of country it is never difficult to espy some portions which have remained hitherto without any definite records. However unpromising and unattractive a locality may seem to be upon a map it will always yield something of value to a systematic search. This consideration serves to explain the noticeable fact that many of my notes for 1910 are derived from outlying places at some considerable distance from the city. The increased facilities for exploration that have been provided during the last few years now render it comparatively easy to visit most of the parishes in West Gloucester and North Somerset. There are still a few tracts, however, unserved by any public conveyance, too remote for the average pedestrian, where a stranger is seldom seen—spots, in the hill country it may be, of exquisite rural beauty and charm of scenery ; or, on the other hand, dreary beyond measure in the marshland flats that border our tidal Severn. For enabling us to make acquaintance with these havens of peace and rest we bless the invention of the bicycle. By its help we reach any desired centre and ramble at discretion.

Not long since, it was mentioned in the report of an excursion by the Cotteswold Field Club that a fine colony of Danewort *(Sambucus Ebulus)*, a rarity with us, had been noticed on the ascent to Hawkesbury Upton, a village on that high ridge which runs for miles due north from Lansdown along the eastern border of our district. We found it easily, extending fifty feet or so on the top of a roadside bank, and flowering splendidly. Close at hand, on the other side of the way, and again by a farmstead below, nearer Hawkesbury, grows Good King Henry or Wild Spinach *(Chenopodium Bonus-Henricus)*, less often met with in

Gloucestershire than in North Somerset. Like some other plants of the same natural order, Wild Spinach has been widely cultivated as a pot-herb, and has not long disappeared from gardens. Its use seems to have been practically universal throughout Europe. In the mountain valleys of France, Switzerland, and Austria, it occurs nearly everywhere by waysides and dwellings, following man's steps to the highest elevations. On this same Hawkesbury steep there is an ancient quarry, from whence stone for the Somerset Monument that stands above may have been taken ; and in it, among a wild tangle of undergrowth, are large patches of a North American Aster *(A. Novi-Belgii)*, evidently of many years standing, and now firmly established.

Two miles or so to the northward Hillsley lies under the same range, at the mouth of the charming little Kilcott valley, which, unluckily, is out of bounds, for the botanizing there is excellent. A large pasture on the west of this hamlet contains the Martagon Lily in most unusual quantity. Early in the year, when first seen by Mr. Bucknall, he considered there were quite 200 plants. Later, when we went to get it in flower, nearly the whole had been mown or spudded, only a few stems on the brink of a sunken lane had escaped destruction. No vestige of a garden could be detected at the spot, nor do any suspicious flowers accompany the Lily. As a rule *L. Martagon* occurs in woods and copses which are often of undoubted age, and, in this instance, it may be assumed that, if not native, the plant is a denizen of like antiquity.

Crossing an intervening stretch of better land we come to the poor clay of Inglestone Common, where Cammock *(Ononis spinosa)* flourishes in profusion ; and to the Wickwar woodland, chiefly noteworthy for an abundance of Butterfly Orchis and sweet-scented *Gymnadenia*, with a fair sprinkling of the Service Tree *(Pyrus torminalis)*, and betony and saw-wort everywhere along the grassy rides. South-west of Wickwar the country takes on a rather different character. An extensive tract of unproductive soil upon the coal measures, now cultivated, but not long enclosed—"robbed from the poor in 1811," said a cottager to me—and in fact comprising Engine Common, Yate Lower Common, with sundry deserted collieries, stretches as far south as the Frome at Stover, and becomes coterminous with the wide expanse of Yate Common. Notwithstanding that much has been done to destroy its wilder aspect, this district contains some excellent plant localities, furnishing good species that make it especially attractive. Among them have been noted *Viola canina* var. *lanceolata*, *Lepidium heterophyllum*, *Trifolium medium*, *Rubus imbricatus* in abundance, *Epilobium parviflorum* var. *rivulare*, *Achillea Ptarmica*, *Erigeron acre*, *Bidens tripartita*, *Senecio erucifolius*, *Carduus pratensis*, *Populus tremula* and *Chara fragilis* var. *delicatula ;* the last a new plant for the county. But by far the most interesting spot here-about is the Leechpool, an extensive swamp, probably still in much the same condition as in Saxon times, when the Royal Forest and Chase of Kingswood covered the whole area. Here we have been introduced by Miss Roper and her brother to two marsh plants, unknown elsewhere in our Gloucestershire division—the Buckbean (*Menyanthes*) and the Lesser Water Plantain (*Alisma ranunculoides*)—both in great plenty. In addition, the swamp yields an abundance of *Oenanthe fistulosa, Helosciadium inundatum*, and *Scirpus fluitans*, with *Veronica scutellata* more sparingly, and many sedges. The past summer must have been in some way peculiarly favourable to the Veronica. It was believed to be entirely absent from the country lying between Bristol and the Cotswolds, and yet in 1910 it turned up in the three widely separated localities of the Leechpool, Lyde Green, and Siston Common. The last mentioned habitat had been walked over dozens of times before the Misses Cundall detected the plant.

The good things just enumerated, the Buckbean in particular, are somewhat early flowerers, and are not to be reckoned among the charms of Autumn, for at the end of September they lie sleeping "in their grassy tombs." Yet at so late a season such a swamp as this is not devoid of interest to a keen observer, imbued with the spirit of enquiry. Some days of October—the month in which I write—had gone by when Mr. Bucknall, searching around the tussocky margin of the pool, discovered a nice clump of the rare and little known Rush, *Juncus diffusus;* an intermediate, and possibly a hybrid, between *J. effusus* and *J. inflexus*. With this, my friend has made another important addition to the Bristol list of West Gloucestershire species.

As regards that rich botanical depository, Yate Common itself, its treasures appear to be inexhaustible, partly, I suppose, because they need a good deal of looking for. It was from one of the boggy pits, which are frequent on the Common, that Mr. Bucknall obtained the first Gloucestershire specimens of *Polygonum minus.* This summer he has taken from a neighbouring pond another good plant (*Nitella opaca*), quite new both to the county flora and to that of the Bristol Coal-fields. The associated water plants are *Ranunculus peltatus, Callitriche intermedia,* and *Scirpus fluitans* with its variety *terrestre,* a condensed cæspitose form peculiar to wet mud.

It is necessary here to make a brief allusion to a small stream that drains an area east of the Frome valley. For some distance below its source the Boyd runs through a flat and pastoral country, and in a meadow between Hinton and Pucklechurch its waters encompass a solitary growth of the true Bulrush (*Scirpus lacustris*), a plant of rare occurrence about Bristol away from the river Avon, and first noticed in this new locality by Mr. F. Samson.

Turning once more towards the West, the easy ascent of Tytherington Hill by a new road becomes an invitation. The grassy limestone slopes are not conspicuously rich in species, though they carry a profusion of *Anthyllis* and *Geranium columbinum*; but the delightfully fresh air and extensive prospect over the entire Vale of Berkeley, which are to be enjoyed on the flat summit, compensate to some extent for the poverty of the flora. The pure white state of the common Self-heal *(Prunella vulgaris)* may catch the eye amid the upland turf, and should the observer be a reader of the *Saturday Review* he will remember an instructive article on albino variations, which appeared in that Journal a short time since, from the charming pen of Canon Vaughan. From this bold outcrop the ground falls but little towards Milbury Heath; in fact, as the road passes on to the New Red Sandstone it rises to an elevation of 350 feet above the sea. No heath, in the literal sense, now remains; for the land is enclosed and arable. The weeds of cultivation, however, are of value. That lover of a sandy soil, the rare Night-flowering Catchfly *(Silene noctiflora)*, occurs thinly scattered among the crops; together with the curious crimson-haired variety of the Corn Poppy (var. *Pryorii)* also confined, with us, to the same formation. Far more rarely we meet with Poppies whose peduncles are clothed in pink or orange; but neither of these forms, so far, has been deemed worthy of a scientific name. Early in the life of these plants, before the unopened flowers rise upright in expansion, the tinted hairs are crowded up together, and then are much more readily observed than at maturity, when the lengthening flower-stalks have placed a perceptible interval between each individual hair.

And here I am reminded that those corn-field weeds, the Fumitories, common enough in arable land and gardens elsewhere throughout the country, are singularly scarce in the neighbourhood of Bristol. Even that one known by the name of Common Fumitory *(Fumaria officinalis)* is somewhat rare; while such other species as we possess—*F. densiflora*, *F. purpurea*, *F. Boraei*, *F. confusa*, and *F. pallidiflora*, occur either as single plants or in trivial patches, isolated and fugitive, repressed by some inexplicable adverse influence. For example, the present distribution of *F. Boraei* in the district is as follows:—one tiny plant near Iron Acton; one at Fishponds; another, just as small, among mangolds at Clapton-in-Gordano; and a fourth near Wrington.

On the descent to the ancient and still thriving little town of Thornbury there stands, as I write, a wide field of Sainfoin, interspersed with luxuriant tufts of a rare foreign grass—the *Bromus patulus*. No doubt it was sown with the crop, and with it will be likely enough to disappear; for these aliens, when they gain a temporary foothold on our soil, seldom ripen seed and become established.

The sandstone series of rocks continues beyond Thornbury as far as Oldbury, Littleton, and Hill; and then we pass from well-wooded hills to the alluvial flats which fringe the Severn Sea.

This belt of reclaimed salt-marsh was at one time liable to inundation by every brimming tide, and the rich green meadows we now see owe their sole protection from similar visitations to the strong sea banks raised for many miles along the shore. Numerous rhines and roadside ditches, full and stagnant, give evidence on the former condition of the country; while tortuous lanes wander from farm to farm by devious courses perplexing to the traveller, who loses his bearings hopelessly if he be without a guiding map. The flora is characteristic of marshy lowland, and affords interesting aquatic and paludal species. The willow bushes in many places are very picturesque, and luxuriant growths of sedges line the margins of the pools.

A few weeks ago, passing along a ditch near Nupdown, not far from Sheperdine and that quaint hostelry the Wind-bound Inn, I came upon some tufts of *Carex axillaris*, a rare sedge, growing with its supposed parents, *C. vulpina* and *C. remota*. A curious feature of this hybrid deserves attention. While both *vulpina* and *remota* are stiff enough to stand erect until they wither, the much longer stems of *axillaris* are too weak to sustain their heads, and so bend over to the ground until the panicles rest upon and are hidden among the adjacent herbage. In consequence, the hybrid may not be noticed unless specially looked for where-ever the parent sedges are seen to be growing together. Some authors consider that it is *C. muricata*, and not *vulpina,* which has a part in the production of *axillaris*, and certainly there is no reason why this may not be possible. I believe, however, that it is not so here at Bristol, where the hybrid is always found in close proximity to *C. vulpina* rather than to the other. There have appeared to be secondary hybrids on the *remota* side associated with *axillaris* in some instances, but of this I am not sure.

On gaining the exposed sea bank one is conscious of having passed to another climate. There is refreshment in the keen salt breeze, and novelty and charm in the fine view that opens over the broad estuary to the distant hills of Wales and Monmouthshire; while some miles to the southward the dark cliff of Aust is outlined hard and sharp against the sky. The green lawns of Sea Meadow-grass *(Glyceria maritima)* and Sea Plantains, that foot the bank, are dotted with hundreds of Sea Starwort *(Aster Tripolium)*, the purple-rayed and rayless plants appearing in equal numbers; and a fine shrubbery of Sea Wormwood *(Artemisia maritima)* occupies a mass of old masonry where the bank has a sheltered bend. The outer slope is adorned with a profusion of Ox-tongue *(Helminthia echioides)* and *Ononis spinosa*, with an occasional pale blue Succory; and the Strawberry-headed Trefoil roots freely along the base. These contrast strongly with the sombre Atriplices that form a fringe along high-water mark. The remaining vegetation is a disappointment. There is no Thrift, no Sea Lavender or Sea Purslane, no Eryngo or Horned Poppy.

All these have ceased a long way lower down ; and the zone of Salicornias cannot thrive so far from the open sea.

The preceding notes have entirely related to Gloucestershire botany, but the southern division of the Bristol district has been by no means neglected. Indeed, there could not be the slightest excuse for so doing, seeing that to many of us, all things considered, there is no country like that of Somerset, wherein the surface features are so varied and delightful, and the production of good plants so bountifully liberal.

One or two of the most interesting items among our records for 1910 resulted from a Spring day's ramble, by Mr. Bucknall and myself, from Twerton, by Englishcombe and Duncorn Hill, to the village of Dunkerton, where the swiftly flowing Cam, a pleasant brook beloved of anglers, passes on its picturesque course to Midford and the Avon. Our local wealth in *Geraniaceæ* was lavishly represented on hedge-banks of the sunken lanes by four uncommon species—*pyrenaicum*, *rotundifolium*, *lucidum*, and *columbinum ;* and a woodland swamp below the Wansdyke displayed an abundance of the scarce and handsome sedge, *Scirpus sylvaticus.* The tulip fields near Combe Hay were, as usual, flowerless : not one plant among the hundreds showed a sign of having blossomed. With great labour two bulbs were raised from their clayey bed with a view to their proving fertile in the garden at home. Curiously enough, we found that each of these was concealing a bud closely sheathed below the surface, to be developed, it may be, next April.

Much of the old disused coal canal has been obliterated in constructing a new railway from Camerton. There is, however, a portion still containing water, and from this my friend raked up a Chara *(C. contraria)*, previously unknown in the district or in the county of Somerset. In the shallows, where exposed to full sunshine, the plant was full of fruit : longer in stems, darker in tint, and less fertile in a deeper shaded pool. Not far off, near the Radstock Road, but not in very close association, we got new localities for *Saponaria, Melissa,* the Periwinkle, and the Leopard's Bane *(Doronicum Pardalianches) ;* all as "wild" as they ever are in this country, but of course at some period they must have escaped from cultivation. When returning along the Wellsway, some three miles out of Bath, a fine patch of colour on the border of a field introduced us to a new variety of Winter-cress *(Barbarea vulgaris).* This plant has leaves differing markedly from type in the shape of the terminal lobe, and length of the linear lateral ones, thus taking a step or two towards *B. intermedia.* Surmising that it might be the var. *transiens,* I got a supply in fruit some weeks later, and on a good example being submitted to Mr. Claridge Druce, he agreed that it was his variety so named in the *Flora of Berkshire.*

Another variation of a well-known species has been observed on Chelvey Batch, a bit of wild limestone woodland on high ground beyond Backwell. This is var. *splendens* of *Cratægus Oxyacantha* —the common Hawthorn—characterized by fruit of unwonted size, about four times heavier than that of the type. In 1909, when all the trees flowered and fruited in unexampled profusion, the branches of this thorn bent down under the weight of haws just as those of orchard trees often do when crops are plenteous. Six ripe fruit weighed seven grammes, while six ordinary haws of average size were under two grammes. The measured dimensions averaged 15 mm. by 12 mm., against 9 by 8 in type *monogyna*. Doubtless this is the *Oxyacanthus folio et fructu majore* from Oxfordshire in Merret's *Pinax* (1667); and the *Oxyacantha vulgaris pomo majore* found by Sherard in Northamptonshire.—*Ray Syn.* ed. iii., p. 454 (1724). One other tree of *splendens* has been reported by Miss Livett from a low cliff at Walton-by-Clevedon. It was undoubtedly by good fortune that these remarkable thorns were noticed at the right season; when they, in common with most others, had over-bloomed themselves. Only a small handful of flowers, on the topmost branches, came out this year, followed, of course, by a corresponding failure of fruit.

From the Backwell range, as we look across the wide valley at a point where the New Red Sandstone gives place to the Coal-measures of Nailsea, an extremely fine view can be enjoyed of the Tyntesfield domain, Wraxall Hill and Church, the slopes of Cadbury and the Clevedon hills. A central object is the Church, beautifully situated on the hillside opposite, amid much woodland, a good deal of which is open to those who care to ramble so far afield. Most varied and interesting is the vegetation about Wraxall. At one spot on a wood-border grows a quantity of the Stinking Hellebore (*Helleborus foetidus*), almost certainly indigenous; and the Rectory Wood contains an abundance of Madder, Spurge Laurel, and Gromwell (*Lithospermum officinale*). Above the wood there is some open ground, a barren stony warren, redolent of thyme and marjoram and sustaining a close-ranked crop of Ploughman's Spikenard (*Inula Conyza*) with other xerophilous species. Beside the Common Thyme, and equally aromatic, is the rarer *Thymus ovatus*, one of the new segregates with which we shall have to become familiar. The Autumnal Gentian (*Gentiana Amarella*) is scattered around. Would that someone could produce a Bristol specimen of *G. campestris!* Among plenty of Common Centaury (*Erythræa Centaurium*), a much smaller plant of bushy habit, with a smaller corolla and flowering a fortnight later, is fairly frequent. This is *E. pulchella*, or *E. ramosissima* as the name now stands in our lists; a submaritime species not often found far from the salt spray. A new and unexpected inland locality is right welcome; compensating so far as this plant is concerned for its loss on the Berrow dune-marsh, now converted by the golfers to a smooth and level lawn.

E. pulchella occurs also on some upper slopes of the adjacent West Hill, again associated with Gentian and Yellow-wort as well as with some peculiar aliens, which probably have been introduced with foreign corn in poultry food. The Pheasant's Eye (*Adonis*) has appeared in this way; and two other interesting introductions are *Sideritis montana*, a pretty Labiate with small yellow corollas shorter than the calyces; and *Plantago arenaria*, whose branching habit and verticillate stem-leaves separate it widely from British plantains. At one time this was abundant on coast sands near Burnham, but has not been seen there lately. Firmly rooted in chinks of the solid rock, both here and lower down towards the Battleaxes Inn, are gnarled old bushes of the small-leaved Cotoneaster (*C. microphylla*), possibly sown by birds at some remote period. We find this shrub in a number of places here and there on the local limestone, from Brean Down to the Gully near Sea Walls.

From the base of these Wraxall hills issue some fine springs that irrigate the rich meadow land of the moors, and are accompanied by several of the rarest plants in the district. Around one clear pool are tussocks of *Carex elata* (*C. stricta* Good.)—the sole locality within many miles of Bristol—mingled with fronds of the creeping Marsh Fern (*Lastrea Thelypteris*). Here too is Buckbean in small quantity; and at the proper season the marsh is gay with purple spikes of the Broad-leaved Orchis (*O. latifolia*).

The mention of an Orchid brings to mind a secluded dell far down at the back of the Mendips near an old-world village, where stands an ancient Inn full of quaint old-world chattels—the neatest and most spotless house of call within my restricted knowledge. On one bank of this sequestered hollow we have rejoiced to find about a dozen stems of the rare *Epipactis media;* and on the other, as if to make easy a comparison of characters, a like number of *E. latifolia*, a far more robust and more frequent plant.

The banks of our streams and ditches, here as elsewhere, are commonly adorned with luxuriant masses of Willow Herb (*Epilobium hirsutum*). This plant is noteworthy for having a pilosity of two distinct kinds; long patent hairs more or less sparsely set at rather regular intervals amid an extremely short and dense glandular pubescence. Between these there are no intermediates. The general aspect of hairiness is due to the long patent hairs, and on their amount depends a very considerable variation in appearance. The whole plant may be quite shaggy or hoary from their abundance (var. *villosissimum* Koch); or comparatively glabrous with dark, bright green foliage, "plante d'un beau vert," *Rouy*. The latter state is var. *subglabrum* Koch (*virescens* Haussk.) An extreme form of the latter, in which the pods were destitute of long hairs, was pointed out to me at Failand by Mr. D. Williams, and subsequent observation shows it to be present in other localities. In this country but little notice has been taken of such variations, either in descriptive works or in those on local botany. Among the books to which I have been able to refer, the *Floras* of Berks and Middlesex alone mention them as being "not uncommon." It is stated by French and German authors that *subglabrum* occurs here and there throughout the more northern and mountainous regions, and doubtless it is the same at home, with intermediates connecting the extreme forms that have been named. It does not appear that soils can influence these plants. At Failand the shaggiest and the most glabrescent grow side by side on the same stream.

Several years ago I had an opportunity of examining a collection of plants made by a former resident in the Cheddar Valley, and noticed among them a specimen of the Great Spearwort (*Ranunculus Lingua*) labelled "Churchill, 1852." This was the only intimation that had ever reached us of the presence of this rare plant in that broad tract of North Somerset which lies between Clevedon and the peat moors, about 18 miles across. It was not even known that any suitable swamp or marsh existed in the vicinity of Churchill. Repeated visits to the parish were made in hope of a re-discovery, and on the third excursion, last July, I was pleased to find in some low-lying pasture to the N.W. of the village a large pool where the golden-yellow blossoms of the Spearwort shewed abundantly above a mass of *Menyanthes*. Such an incident serves to emphasize a fact which hardly needs support, *viz.*, that every portion of even the most unpromising ground in a district should be visited before the publication of a local *Flora* can be satisfactorily attempted. There are some plants which offer problems for enquiry in the broken or interrupted nature of their distribution. Among local species no more remarkable instances of this discontinuity could be selected than those of the Buckbean and Great Spearwort, whose localities in this district are separated by intervals extended often to a width of many miles. A number of connecting links must have been destroyed from time to time by enclosure and drainage of poor lands, resulting in a gradual disappearance of the swamps and morasses which alone form congenial homes for these paludal species.

It was not anticipated that the most important discovery of the year would be reserved for the last days of the season, but so it happened, and thus a large share of the interest of this sketch attaches to its closing paragraphs. At the end of September I learnt that Mr. Henry Corder, of Bridgwater, had rediscovered, near Catcott, *Cladium Mariscus*, which, although known to Sole upon the peat moors 120 years ago had eluded observation ever since. The news was a surprise, for it was not thought possible that the grand Fen Sedge could have survived the malign influence of a century's drainage and persistent turf-cutting. The moors as we now see them must have worn a very different aspect when the old Bath botanist rambled over the heaths of Catcott and

Shapwick and gathered *Parnassia* with other rarities no longer to be found. But once more the unexpected came about. Aided by directions kindly afforded by Mr. Corder, and by some good fortune, Mr. Bucknall and I made our way to the spot where a fine clump of Cladium, four or five feet across, grows in a wet swamp—possibly, in part, a primitive morass—of some acres in extent. Even after weeks of dry weather the plant is unapproachable without a little wading, and in a peat bog such a venture must be undertaken with caution and a good stick wherewith to probe for the deeper holes. The situation accounts in great measure for the Sedge having escaped notice for so long a period, and will, I think, secure it from molestation, at any rate until the drainage of the district becomes still more effective than it is at present.

On the bank of a rhine at no great distance we came upon some tufts of *Juncus diffusus*, as rare a rush in Somerset as it is in Gloucestershire. And a ditchful of *Apium inundatum*—another of Sole's old treasures from the peat that has seldom been noticed since his time—brought our successful foray to an end.

It will be evident, I think, that a fair proportion of the profit as well as the pleasure of recent botanical work has been derived from expeditions in North Somerset.

In conclusion I venture to appeal for information respecting a reported occurrence of the Giant Bell-flower (*Campanula latifolia*) in our Somerset division. Mr. G. H. Bryan, in *Science Gossip*, 1885, p. 194, said that it grew with *C. Trachelium* near Shepton Mallet; and lately a correspondent who knows a good deal about plants has expressed his belief that the statement was correct. But something more than that is necessary before the county list can be enriched by the addition of this fine species. Can anyone do us laudable service by producing a Somerset specimen?

Report of Meetings.

February 4th.—Second General Meeting. A paper, entitled "Elephants, Living and Fossil," was read by Professor S. H. Reynolds, M.A. Commencing with a description of living elephants the lecturer pointed out that in a number of respects elephants were highly specialised, *e.g.*, the remarkable development of the nose. On the other hand, as regards the limbs, they were primitive, retaining the original five toes, whilst in the highly specialised limb of the horse the foot was practically reduced to one toe. Although an elephant's skull was extraordinarily large, the brain was relatively small, the size being due to the great development of air-cells in the bone. An elephant's grinding teeth were so large that there was only room for one and part of a second in the jaw at the same time, and the whole series gradually moved forward as the front part was worn out. The African elephant has larger ears, eyes, and tusks than the Indian, and its teeth are more coarsely ridged. Also, whilst in the African elephant the shoulder is the highest part, in the Indian elephant the middle of the back is highest. The extinct mammoth, which formerly roamed over Europe, Asia, and North America, and of which many remains have been found in the Bristol district, was closely allied to the modern Indian elephant. Until recently elephants stood absolutely isolated in the animal kingdom. Dr. Chas. Andrews' discoveries at Fayum (Egypt) have shown that elephants may be traced from certain small tapir-like animals found in the Eocene beds of that district. These animals show the commencement of the development of tusks, complicated grinding teeth and air-cells in the skull, all of which are eminently characteristic of modern elephants. In more recent beds other animals were found in which these characteristics were more marked, and the series led up to an animal very like our modern elephant.

March 4th.—Third General Meeting. A resolution, thanking Mr. G. A. Wills for his munificent gift of the Leigh Woods to the citizens of Bristol, was passed unanimously. Mr. E. C. Atkinson, M.A., F.R.A.S., read a paper on "The Theory and Practice of Colour Photography by the Autochrome Process." The lecturer commenced by throwing on the screen a spectrum, and showing that the colours of films were due to the absorption of some of the components of white light. He then, by means of an ingenious device, showed how a tint can be matched by proper mixtures of three colours only, and explained the Young-Helmholtz theory of vision on which the autochrome process is based. The lecturer very briefly described the autochrome process, which differs from the ordinary process in the fact that the light has to pass through a screen of coloured starch grains before reaching the sensitive film. A negative image is first developed ; this is subsequently changed to a positive by dissolving the silver salts acted on by the light, and then allowing daylight to act on the silver salt that is left. The picture is then seen as a transparency, the light passing through the colour screen before reaching the eye. The lecturer showed a spectrum of the light transmitted by the individual starch grains, and indicated that, in his opinion, there was too little overlapping in the different kinds of light ; and this was borne out by an autochrome photograph of the solar spectrum, which showed merely three uniform bands of colour separated by darker intervals. The colour effects of over—and under—exposure were described, and the lecturer suggested how this defect could be remedied by increasing the density of the starch screen, and consequently increasing the number of blue starch grains. Slides illustrating different types of failures were next shown, and remedies were suggested, amongst others the binding of the slides with compensating colour screens to correct defects of colour due to wrong exposures. After these some fine autochromes of various subjects were shown, some views in the Tyrol and autumn tints on Clifton Down being exceptionally good.

April 12th.—Fourth General Meeting. The Chairman raised the question, "Is the snowdrop indigenous to Britain?" No mention of this flower is made until the middle of the 17th century, but as it is only in the West Country that it has the appearance of being wild, it is quite possible that few people in those days knew of its existence. In North Somerset it grows in such abundance and so far from gardens that one is much inclined to conclude that there it must be indigenous. Professor Lloyd Morgan brought before the members a scheme for the preparation of a raised model of the Avon Gorge and the surrounding district. After saying a few words on the uses of such a model, and showing maps and photographs on the screen, Professor Lloyd Morgan described two methods that might be employed to build the model. The first was to paste 6-inch ordnance survey maps on cardboard, cut them out along the contour lines, and then superpose the cardboards, separating each higher level of 100 feet from the one below by an inch of plasticine. Another method was to take sections across the ordnance map at intervals of an inch, cut out these sections in cardboard, stand them in rows an inch apart, and fill up the spaces between with plasticine. Dr. Munro Smith showed a series of lantern slides made from magnificent photomicrographs to illustrate the structure of the cell and different types of cell.

May 6th.—Fifth General Meeting. Mr. A. M. Tyndall, B.Sc., read a paper on "Electric Discharges in the Atmosphere." The lecturer remarked that whatever view was at present taken of the nature of electricity, it was still very convenient to regard it as of two kinds, positive and negative, always tending to neutralise one another. When the tendency becomes great enough to overcome the insulating properties of the intervening air a spark passes between the two charged bodies. The lecturer then illustrated by experiments the production of spark and brush discharges, and showed some effective lantern slides of their counterpart in nature, forked lightning. The insulation of the air can be broken down by other methods of a silent nature ; by the use, for instance, of a flame, a radio-active substance, or a sharply-pointed metal rod. The last method is important in practical life, the lightning conductor being essential for the safety of large buildings. Although air may be generally regarded as an insulator, it is not a perfect one, and free charges are always present, produced at any rate to some extent, by the radium in the earth's surface In fine weather it is found that there is always an excess of positive electricity in the air, and this travels as a current downwards to the surface of the earth. In wet weather the amount is much less, and may even be negative in kind. This prevalent stream of electricity probably has an influence on plant life, and the very striking results obtained by Lemstrong and by local agriculturists have chiefly been obtained by increasing the downward current. In explanation of the phenomena of atmospheric electricity, Mr. Tyndall mentioned the Wilson-Gerdien theory, which is that the water vapour in the air condenses on the negative charges and when falling as rain leaves behind the positive charges. It is doubtful whether this can be regarded as a complete explanation of the more violent effects of a thunderstorm. Finally, the lecturer contrasted the Aurora Borealis with the glow discharge in a vacuum tube, and mentioned the theory which attributes the appearance of the Aurora to the entrance of charged particles from the sun into the upper regions of the atmosphere, and their attraction by the magnetic poles of the earth.

October 7th.—Sixth General Meeting. Dr. A. B. Prowse exhibited the fruits of the flowering currant, the Siberian crab apple, and the American Blackberry. Mr. R. Priestley, one of the members of the Shackleton Antarctic Expedition, kindly sent for exhibition specimens of Antarctic lichens, including the one known as Tripe de Roche, which was used as an article of food by the explorers. Miss Ida M. Roper, F.L.S., read a short paper on the "Nonesuch," or "Flower of Bristowe." Mr. J. H. Priestley, B.Sc., F.L.S., University lecturer in botany, read a short paper on "Antarctic Rotifers and Low Temperatures." Some material gathered on Mount Erebus was sent to the Bristol University, and the rotifers found in it were subjected, for periods of time varying from 24 to 72 hours, to a temperature of 108 degrees Faht. They were found to resist this temperature when in a dry state, but were killed by it when in a wet state.

Mr. B. T. P. Barker, M.A., director of the National Fruit and Cider Institute, Long Ashton, said a few words about the "Future of the Orchard," and illustrated his remarks with a number of excellent lantern slides. He began by pointing out how the present conditions of orchards were unsatisfactory owing to neglect, prevalence of pests, wrong methods of cultivation, and choice of unsuitable varieties. He then described the various types of trees obtained by pruning and the advantages and suitability of each type as deduced from experimental trees. When planting an orchard, varieties should be chosen which are suited to the soil, are not very susceptible to disease, yield good crops, and yield the best cider or the finest table fruits. It is well to mix the varieties to ensure cross-fertilisation. Light pruning is better than hard pruning, and root pruning should be resorted to when the tree is of vigorous growth but yields no fruit. When planting the roots should be set deep and the soil well rammed around them. Where possible no grass should be allowed to grow close to the trunk.

January 21st.—Annual Meeting. The Forty-sixth Annual Meeting of the above Society was held at University College. Mr. H. J. Charbonnier, one of the oldest members, who is leaving Bristol, was elected Hon. Member in recognition of past services.

Mr. J. W. White, F.L.S., then gave his presidential address on "The History of Bristol Botany, Part II." This second part begins with John Ray (1627-1705), who wrote the first Flora of British Plants. He came to Bristol in 1662 and 1667, and he describes many rarities which he found. Dillenius (1687-1747), Sherardian Professor at Oxford, visited Bristol in 1726 and discovered some new plants. Among these was one he found on Brean Down, which he carefully described and preserved. This specimen was mislaid, but in 1904 it was found in the Oxford Museum. The finder visited Brean Down and found this plant growing there in fair abundance. It seems incredible that no one since the days of Dillenius had recorded this plant for the district. Hudson, in his "Flora Anglica" (1762), was the first botanist to recognise *Geranium rotundifolium* of our district as a British plant. Withering, who published the first English Flora, written in English (1776), had many correspondents in our district, among whom may be mentioned Dr. Stokes, the Rev. G. Swayne, and Dr. Arthur Broughton, who was the first to print a list of our local flora. Sir Joseph Banks visited Bristol in 1767, and again in 1773 in the company of the Rev. John Lightfoot. W. Curtis, who wrote the "Flora Londiniensis," and W. Sole, of Bath, who wrote a treatise on "Mints," both added new records to our local flora. Several of the plates in Sowerby's English Botany are drawn from specimens sent to Sowerby from Bristol. Samuel Rootsey (1788-1855), the first lecturer on Botany in the Bristol Medical School, was a prominent local botanist. In the early part of the nineteenth century Dr. Stevens made an herbarium, which is now the property of the Bristol Naturalists' Society. J. H. Cundall (1807—1883) gave in his "Everyday Book of Natural History" charming descriptions of local plants. He also left a herbarium, which contains, among many rarities, unique specimens of two plants never since recorded for this district.

November 4th.—Seventh General Meeting. Owing to a slight indisposition Dr. A. Vaughan was unable to read the paper he had promised. Prof. S. H. Reynolds very kindly consented to take his place, and made some very interesting remarks on certain aspects of British physical geography. He spoke mainly about the position of the British Isles on a submerged plateau, the geological conditions to which the indented coast line is due, and the geological formation of the mountain ranges.

December 13th.—At the invitation of the Museum and Art Gallery Committee the members of the Bristol Naturalists' Society, to the number of about a hundred, met at the Museum.

Alderman J. Fuller Eberle, on behalf of the chairman of the committee (Alderman Barker), extended a hearty welcome to the visitors. He said he trusted their visit to the Museum would be as useful as he was sure it would be pleasant. During the last few years, and more especially during the last few months, a great deal had been done to improve the Museum. After the lecture, which had been specially arranged, they would have an opportunity of seeing the Greville Smyth collection, which had been fitted up through the kindness and generosity of Lady Smyth. In the arrangement of many of the valuable and interesting objects it contained, the Curator (Mr Herbert Bolton) had had the assistance of members of their Society. The thanks of the Committee were due to those gentlemen for the kind help they had given in the work, and he was glad of the opportunity of tendering it to them.

Mr. James W. White, President of the Society, said the members of the Society esteemed it a high privilege to be invited to the Museum in the way they had been, and he expressed his thanks on their behalf. It was fitting, perhaps, that those who were so deeply interested in the study of natural history should be accorded such an opportunity of meeting within the walls of the municipal building which was set apart for the housing of natural history objects.

Mr. Harold W. Atkinson then delivered a lecture on "Shellfish of Land and Sea." By the aid of 90 slides, 60 of which represented his original work, he dealt in an exhaustive manner with the life of shellfish. Starting with the egg state, he traced the birth and development of various forms, describing how they were able to move, eat, and protect themselves. He showed many of their organs, and told of their functions—information which had been gleaned as the result of long and patient observation. A new and interesting feature of the lecture were the radiograph and chromatic slides.

At the close the lecturer was thanked by Mr. White. After refreshments had been partaken of, Mr. Herbert Bolton graphically explained some of the principal contents of the Greville Smyth room.

BOTANICAL SECTION.

SINCE my last report five meetings of the Section have been held. I regret to say that they have been poorly attended.

At the meeting held on the 15th of December last Mr. J. H. Priestley explained at some length a number of very interesting facts from research he had made on the presence of chlorides in the soil on different parts of the Portishead shore. He showed how the different amounts were responsible in a large measure for the various kinds of vegetation found on the different zones of the shore.

At the other meetings some interesting specimens of plants have been exhibited followed by discussions.

There has been no increase of membership.

J. W. EVES, *Hon. Sec.*

GEOLOGICAL SECTION.

THE year commenced with 42 members, which shows a great falling off from the previous year.

There have been seven meetings, at which the following papers were read.

Jan. 29th.—The geology of the Tourmakeady District, Co. Mayo, by the President (illustrated by Lantern Slides).

Feb. 25th.—The geology of the Tenby District (illustrated by Maps lent by Mr. Dickson, and Photographs by Mr. Leach), by Dr. A. Vaughan, F.G.S.

Mar. 25th.—The Dyke of Bartestrye, by the President (illustrated by Maps, Sections, and Lantern Slides). Paper by W. H. Wickes on an old book, "Museum Regalis Societaties, or Catalogues and description of the natural and artificial rarities belonging to the Royal Society," by Nehemiah Grew, M.D.

May 20th.—Paper on "Glaciers," by Miss Helen Drew (illustrated by Lantern Slides).

A Paper on "Celestine, and the new deposits," by B. A. Baker, F.G.S.

Oct. 21st.—An exhibition of Mineral Specimens, Fossils, and Photographs of geological subjects, in which thirteen members took part.

Nov. 25th.—"Graphtolites," by the President. Exhibitions of Flint implements from Chili, by J. T. Kemp, M.A.

Dec. 16th.—"The Scuir of Eigg, and some ancient rivers and valleys of the West Coast of Scotland," by G. W. Palmer, M.A. (illustrated by Photographs and Lantern Slides).

The average attendance was only about 8 members at each meeting, not including the Exhibition Meeting, when there were about 30 members and friends present.

The financial statement is as follows :—

	£	s.	d.
Balance brought forward from 1908 ...	2	7	11
Subscriptions, 1909	3	11	11
	5	19	10
Expenses	3	12	2
	£2	7	8

This shows a loss on the year's working, and only allows a balance of £2 7s. 8d. to be carried forward to next year.

B. A. BAKER, F.G.S., *Hon. Sec.*

ENTOMOLOGICAL SECTION.

JANUARY 26th.—Mr. H. J. Charbonnier was elected an Honorary Member of the Section. Exhibits included the following— Dr. Rudge, several boxes of striking forms of exotic coleoptera, also some British hemiptera. Mr. Griffiths, specimens of *Nonagria neurica v. dissolula, Leucania vittelina, Dicycla Oo. v. renago* and *Aplecta nebulosa v. Thomsonii* (Delamere). Mr. Bartlett, Hymenoptera, from Looe and Trevose. *Mononychus pseudacori*, from Niton, I. of W. *Platycis minutis*, Leigh Woods. A series of *Agrotis ripæ* bred from larvæ taken at Braunton and Tregarnon. *Cucullia gnaphalii*, Tolgate, and *Laphygina exigua*, Torbay.

March 16th.—A paper by Mr. Charbonnier on "Diptera, in January, at Shepton Mallett," was read, twenty species being reported. Mr. Griffiths exhibited a box of lepidoptera from New Guinea, including *Delias Kumeri*, *D. Niepolti*, *D. Dives*, *D. Clathrata*, *D. Bomemani*, *D. Ittis,* and *Papilio Weistei*. Hon. Sec. showed a pair of *Polia Nigroceucta*, N. Cornwall, *Noctua Ashworthii,* N. Wales, and others.

November 12th.—Mr. Griffiths exhibited a large number of South American *Papilionidæ*, also *Papilio Blumei* from Celebes. Dr. Rudge, a specimen of *Ploiaria culiciformis*, which mimics and feeds on gnats.

December 14th.—Mr. Griffiths gave details of the Vegetable Caterpillar of New Zealand, species of which remain in doubt, and exhibited varieties of the Currant moth, *Abraxas grossulariata*, viz., v. *lacticola*, v. *nigro leucata*, v. *nigro leutea*, v. *axantha*. Hon. Sec. showed some black varieties of *Xylophasia polyodon*, from I. of Lewes.

CHAS. BARTLETT, *Hon. Sec.*