examined optically by Prof. Rosenbusch, who writes as follows: "It was determined on more than 20 cleavage-flakes, that the axis of elasticity which makes an angle of only about 5° with c is a, not γ, as in the [other] amphiboles; its colour is dark blue; $b=\beta$, a rather less deep blue; γ, which is almost perpendicular to c,=green. Axial angle large. The characters are thus surprisingly like those of aegirine among the pyroxenes." That riebeckite holds chemically, as well as optically, the same place among the amphiboles as aegirine does among the pyroxenes, appears from Sauer's analysis. Compared with arfvedsonite, it shows more silica, much more ferric, and less ferrous oxide. Taking account of all its characters, there can be no reasonable doubt that the Mynydd Mawr mineral is riebeckite.

The blue tourmaline which I described, not without misgivings, as accompanying the blue hornblende, is, in all probability, the same mineral. Owing to the almost opaque nature of the sections, I was reduced to experimenting on the minute and impure crystals with a knife and a candle-flame; so perhaps the mistake was a pardonable one; the more so, as Professor Bonney, who has pointed it out to me, appears to have been himself deceived by the Socotra riebeckite, regarding it as a pseudomorph of tourmaline after hornblende.[1] His figure closely resembles the slides from Mynydd Mawr.

Besides the larger crystals of riebeckite, Sauer finds in the Socotra granite microlites of the same mineral, precisely similar to the colourless and pale-blue microlites already described in the rock of Mynydd Mawr. That these belong to riebeckite, rather than to tourmaline, is proved by the direction of maximum absorption being parallel, not perpendicular, to the long axis. Sauer regards them as due, at least in part, to the secondary alteration of the felspar. This last suggestion cannot be maintained in the case of the Welsh rock. Apart from chemical difficulties, the mode of occurrence of the microlites, and especially their fluxional disposition through the ground-mass, show them to be original constituents of the rock.

NOTICES OF MEMOIRS.

I.—British Association for the Advancement of Science.

Bath Meeting, September 5th to 12th, 1888.

List of Titles of Papers read before Section C. Geology.

Professor W. Boyd Dawkins, M.A., F.R.S., F.G.S., President.

The President's Address. (See infra p. 459.)

Horace B. Woodward.—Further Note on the Midford Sands. (p. 470.)

Horace B. Woodward.—The Relations of the Great Oolite to the Forest Marble and Fuller's Earth in the South-west of England. (See infra p. 467.)

Horace B. Woodward.—Note on the Portland Sands of Swindon, etc. (See infra p. 469.)

O. W. Jeffs.—On Geological Photography.

[1] Phil. Trans. vol. clxxiv. part i. p. 283, 1873.

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Dr. C. Callaway.—Further Notes on the Origin of the Crystalline Schists of Malvern and Anglesey.
Dr. C. Callaway.—Sketch of the Geology of the Crystalline Axis of the Malvern Hills.
Dr. Persifor Frazer.—Archæan Characters of the rocks of the Nucleal Ranges of the Antilles.
Dr. Persifor Frazer.—Oligoclase and Quartz with curious Optical Properties.
Dr. H. W. Crosskey.—Report on Erratic Blocks.
Dr. H. W. Crosskey—On a High Level Boulder-clay in the Midlands.
W. Whitaker.—On the Extension of the Bath Oolite under London, as shown by a deep boring at Streatham.
E. Wethered.—On the Lower Carboniferous Rocks of Gloucestershire.
Rev. H. H. Winwood.—On the Tytherington Section to be seen on Saturday's Excursion.
Handel Cossham, M.P.—The Northern Section of the Bristol Coal Field.
W. A. E. Ussher.—Some points of interest in the Geology of Somerset.
Prof. O. C. Marsh.—Comparison of the Principal Forms of Dinosauria of Europe and America.
H. F. Osborn.—The Evolution of the Mammalian Molar teeth to and from the tritubercular type.
Professor A. Gaudry.—On the great size of some Fossil Mammals.
Rev. Dr. A. Irving.—Note on the Relation of the Percentage of Carbonic Acid in the Atmosphere to the Life and Growth of Plants.
James Spencer.—On the Occurrence of a Boulder of Granitoid Gneiss or Gneissoid Granite in the Halifax Hard Bed Coal.
Chev. R. E. Reynolds.—The Caverns of Luray.
W. Topley.—Report on the rate of Erosion of the Sea Coasts of England and Wales.
Dr. Tempest Anderson.—The Volcanoes of the Two Sicilies. (p. 473.)
Dr. H. J. Johnston-Lavis.—Notes on the recent Volcanic Eruption in the Island of Vulcano.
Dr. H. J. Johnston-Lavis.—Report on the Volcanic Phenomena of Vesuvius.
Dr. H. J. Johnston-Lavis.—On the Conservation of Heat in Volcanic Chimneys.
Dr. H. J. Johnston-Lavis.—Note on a Mass containing Metallic Iron found on Vesuvius.
Dr. H. J. Johnston-Lavis.—Note on the Occurrence of Leucite at Etna.
Prof. E. W. Claypole.—Note on Some Recent Investigations into the Condition of the Interior of the Earth.
J. Logan Lobley.—On the Causes of Volcanic Action.
Professor John Milne.—Report on the Volcanic Phenomena of Japan.
O. H. Howarth.—On the recent Volcanic Structure of the Azorean Archipelago. (See infra p. 472.)
Professor G. A. Lebour.—Report of the Earth-Tremor Committee.
W. A. E. Ussher.—The Watcombe Terra-Cotta Clay.

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A. Bell.—Report on the "Manure Gravels" of Wexford.

T. W. Shore.—Beds exposed in the Southampton New Dock Excavation.

Clement Reid and H. N. Ridley.—Fossil Arctic Plants from the Lacustrine Deposit at Hoxne. (Printed in full, see supra p. 441.)

G. W. Lamplugh.—Report on an Ancient Sea Beach near Bridlington.

Professor H. G. Seeley.—On the Origin of Oolitic Structure in Limestone Rock.

Professor F. Bassani.—Notes of some Researches on the Fossil Fishes of Chiavòn, Vicentino.

Professor T. Rupert Jones.—Report upon the Fossil Phyllopoda of the Palæozoic Rocks.

Professor W. C. Williamson.—Report on the Flora of the Carboniferous Rocks of Lancashire and West Yorkshire.

Professor H. G. Seeley.—On an *Ichthyosaurus* from Mombasa; with observations on the Vertebral Characters of the Genus.

A. Smith Woodward.—A comparison of the Cretaceous Fish-fauna of Mount Lebanon with that of the English Chalk. (See infra p. 471.)

A. Smith Woodward.—On *Bucklandium diluvii*, König, a Siluroid Fish from the London Clay of Sheppey. (See infra p. 471.)

Rev. Dr. A. Irving.—On the Origin of Graphite in the Archæan Rocks, with a review of the alleged evidence of Life on the Earth in Archæan Time.

Rev. G. F. Whidborne.—On some Devonian Cephalopods and Gasteropods.

Rev. G. F. Whidborne.—On some Devonian Crustaceans.

Rev. G. F. Whidborne.—On some Fossils of the Limestones of South Devon.

T. Sterry Hunt.—Mineralogical Evolution.

Professor J. F. Blake.—Report upon the Microscopic Structure of the Older Rocks of Anglesey.

Dr. C. Ricketts.—On a Probable Cause of Contortions of Strata.

J. Joly.—On the Temperature at which Beryl is Decolorized.

J. Joly.—On the Occurrence of Iolite in the Granite of Co. Dublin.

W. W. Watts.—An Igneous Succession in Shropshire.

C. E. De Rance.—Report on the Circulation of Underground Waters in the Permeable Formations of England.

W. H. Dalton.—A List of Works referring to British Mineral and Thermal Waters.

Titles of Papers Read before Section D. (Biology) bearing upon Geology.

Professor O. C. Marsh.—Restoration of *Brontops robustus*, from the Miocene of America.

Dr. S. J. Hickson and G. C. Bourne.—Discussion on Coral-Reefs.

Dr. H. Gadow.—The Nature of the Geological terrain as an important factor in the Geographical Distribution of Animals.

C. A. Barber.—On *Pachytheca*, a Silurian Alga of doubtful affinities.

II.—Address to the Geological Section of the British Association, Bath, 1888. By W. Boyd Dawkins, M.A., F.R.S., F.G.S., F.S.A., Professor of Geology and Palæontology in Owens College, President of the Section.

IN taking the chair occupied twenty-four years ago in this place by my honoured master, Professor Phillips, I have been much perplexed as to the most fitting lines on which to mould my Address. It was open to me to deal with the contributions to our knowledge since our last meeting in Manchester in such a manner as to place before you an outline of our progress during the last twelve months. But this task, difficult in itself, is rendered still more so by the special circumstances of this meeting, attended, as it is, by so large a number of distinguished geologists, assembled from nearly every part of the world for the purposes of the Geological Congress. It would be presumptuous of me, in the presence of so many specialists, to attempt to summarize and co-ordinate their work. Indeed, we stand too near to it to be able to see the true proportions of the various parts. I will merely take this opportunity of offering to our visitors, in the name of this section and of English geologists in general, a hearty welcome to our shores, feeling that not only will our science be benefited enormously by the simplification of geological nomenclature, but that we ourselves shall derive great advantage by a closer personal contact with them than we have enjoyed hitherto.

Our science has made great strides during the last twenty-four years, and she has profited much from the great development of her sisters. The microscopic analysis of the rocks has opened out a new field of research, in which physics and chemistry are in friendly rivalry, and in which fascinating discoveries are being made almost day by day as to metamorphism, and the crushing and shearing forces brought to bear upon the cooling and contracting crust while the earth was young. The deep-sea explorations have revealed the structure and the deposits of the ocean abysses, and the depths supposed to be without life, like the fabled deserts in the interior of Africa, are now known to teem with varied forms glowing with the richest colours. From a comparison of these deposits with the stratified rocks, we may conclude that the latter are marginal, and deposited in depths not greater than 1000 fathoms, or the shore end of the Globigerina ooze, and most of them at a very much less depth, and that consequently there is no proof in the geological record of the ocean depths having ever been in any other than their present places.

In North America the geological survey of the Western States has brought to light an almost unbroken series of animal remains, ranging from the Eocene down to the Pleistocene age. In these we find the missing links in the pedigree of the Horse, and sufficient evidence of transitional forms to cause Professor Flower to restore to its place in classification the order Ungulata of Cuvier. These may be expected to occupy the energies of our kinsmen on the other side of the Atlantic for many years, and to yield further proof of the truth of the doctrine of Evolution. The use of this word reminds me how much we have grown since 1864, when evolution was under discussion, and when biological, physical, and geological laboratories could scarcely be said to have existed in this country. Truly may the scientific youth of to-day make the boast

Ἡμεῖς μὲν πατέρων μέγ' ἀμείνονες εὐχόμεθ' εἶναι—

"We are much better off than our fathers were," while we, the fathers, have the poor consolation of knowing that when they are fathers, their children will say the same of them. There is reason to suppose that our science will advance more swiftly in the future than it has in the past, because it has more delicate and precise methods of research than it ever had before, and because its votaries are more numerous than they ever were.

In 1864 the attention of geologists was mainly given to the investigations of the later stages of the Tertiary period. The bent of my pursuits inclines me to revert to this portion of geological inquiry, and to discuss certain points which have arisen during the last few years in connection with the classificatory value of fossils, and the mode in which they may be best used for the co-ordination of strata in various parts of the world.

The principle of homotaxy, first clearly defined by Professor Huxley, has been fully accepted as a guiding principle in place of synchronism or contemporaneity, and the fact of certain groups of plants and animals succeeding one another in a definite order, in countries remote from each other, is no longer taken to imply that each was living in the various regions at the same time, but rather, unless there be evidence to the contrary, that they were not. While, however, there is a universal agreement on this point among geologists, the classificatory value of the various divisions of the vegetable and animal kingdoms is still under discussion, and, as has been very well put by my predecessor in this chair at Montreal, sometimes the evidence of one class of organic remains points in one direction, while the evidence of another class points in another and wholly different direction as to the geological horizon of the same rocks. The Flora, put into the witness-box by the botanist, says one thing, while the Mollusca or the Vertebrata say another thing in the hands of their respective counsel. There seems to be a tacit assumption that the various divisions of the organic world present the same amount of variation in the rocks, and that consequently the evidence of every part of it is of equal value.

It will not be unprofitable to devote a few minutes to this question, premising that each case must be decided on its own merits, without prejudice, and that the whole of the evidence of the flora and fauna must be considered. We will take the flora first.

The cryptogamic flora of the later Primary rocks shows but slight evidence of change. The forests of Britain and of Europe generally, and of North America, were composed practically of the same elements—Sigillaria, Calamites, and Conifers allied to the Ginkho—throughout the whole of the Carboniferous (16,336 feet in thickness in Lancashire and Yorkshire) and Devonian rocks, and do not present greater differences than those which are to be seen in the existing forests of France and Germany. They evidently were continuous both in space and time, from their beginning in the Upper Silurian to their decay and ultimate disappearance in the Permian age. This disappearance was probably due to geographical and climatic changes, following the altered relations of land to sea at the close of the Carboniferous age, by which Secondary plants, such as *Voltzia* and *Walchia*, were able to find their way by migration from an area hitherto isolated. The Devonian formation is mapped off from the Carboniferous, and this from the Permian, but to a slight degree by the flora, and nearly altogether by the fauna. While the fauna exhibits great and important changes, the flora remained on the whole the same.

The forests of the Secondary period, consisting of various Conifers and Cycads, also present slight differences as they are traced upwards through the Triassic and Jurassic rocks, while remarkable and striking changes took place in the fauna, which mark the division of the formations into smaller groups. As the evidence stands at present, the Cycads of the Lias do not differ in any important character from those of the Oolites or the Wealden, and the *Salisburia* in Yorkshire in the Liassic age is very similar to that of the Island of Mull in the Early Tertiary, and to that (*Salisburia adiantifolia*) now living in the open air in Kew Gardens.

Nor do we find evidence of greater variation in the dicotyledonous forests, from their first appearance in the Cenomanian stage of the Cretaceous rocks of Europe and America, through the whole of the Tertiary period down to the present time. In North America the flora of the Dakota series so closely resembles the Miocene of Switzerland that Dr. Heer has no hesitation in assigning it in the first instance to the Miocene age. It consists of more than one hundred species, of which about one-half are closely allied to those now living in the forests of North America—Sassafras, Tulip, Plane, Willow, Oak, Poplar, Maple, Beech, together with *Sequoia*, the ancestor of the giant Redwood of California. The first Palms also appear in both continents at this place in the Geological record.

In the Tertiary period there is an unbroken sequence in the floras, as Mr. Starkie Gardner has proved, when they are traced over many latitudes, and most of the types still survive at the present day, but slightly altered. If, however, Tertiary floras of different ages are met with in one area, considerable differences are to be seen, due to progressive alterations in the climate and altered distribution of the land. As the temperature of the Northern Hemisphere became lowered, the tropical forests were pushed nearer and nearer to the Equator, and were replaced by plants of colder habit from the northern regions, until ultimately, in the Pleistocene age, the Arctic plants were pushed far to the south of their present habitat. In consequence of this Mr. Gardner concludes that "it is useless to seek in the Arctic regions for Eocene floras as we know them in our latitudes, for during the Tertiary Period the climatic conditions of the earth did not permit their growth there. Arctic fossil floras of temperate and therefore Miocene aspect are in all probability

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of Eocene age, and what has been recognized in them as a newer or Miocene facies is due to their having been first studied in Europe in latitudes which only became fitted for them in Miocene times. When stratigraphical evidence is absent or inconclusive, this unexpected persistence of plant types or species throughout the Tertiaries should be remembered, and the degrees of latitude in which they are found should be well considered before conclusions are published respecting their relative age."

This view is consistent with that held by the leaders in botany, Hooker, Dyer, Saporta, Dawson, and Asa Gray—whose recent loss we so deeply deplore—that the North Pole region is the centre of dispersal, from which the Dicotyledons spread over the Northern Hemisphere. If it be true—and I, for one, am prepared to accept it—it will follow that for the co-ordination of the subdivisions of the Tertiary strata in various parts of the world, the plants are uncertain guides, as they have been shown to be in the case of the Primary and Secondary rocks. In all cases where there is a clash of evidence, such as in the Laramie lignites, in which a Tertiary flora is associated with a Cretaceous fauna, the verdict in my opinion must go to the fauna. They are probably of the same geological age as the deposit at Aix-la-Chapelle.

I would remark further, before we leave the floras behind us, that the migration of new forms of plants into Europe and America took place before the arrival of the higher types in the fauna, after the break-up of the land at the close of the Carboniferous period, after the great change in geography at the close of the Neocomian. The Secondary Plants preceded the Secondary Vertebrates by the length of time necessary for the deposit of the Permian rocks, and the Tertiary Plants preceded the Tertiary Vertebrates by the whole period of the Upper Cretaceous.

Let us now turn to the fauna.

Professor Huxley, in one of his many addresses which have left their mark upon our science, has called attention to the persistence of types revealed by the study of Palæontology, or, to put it in other words, to the singularly little change which the ordinal groups of life have undergone since the appearance of life on the earth. The species, genera, and families present an almost endless series of changes, but the existing orders are for the most part sufficiently wide, and include the vast series of fossils without the necessity of framing new divisions for their reception. The number of these extinct orders is not equally distributed through the animal kingdom. Taking the total number of orders at 108, the number of extinct orders in the Invertebrata amounts only to 6 out of 88, or about seven per cent., while in the Vertebrates it is not less than 12 out of 40, or 30 per cent. These figures imply that the amount of ordinal change in the fossil Vertebrates stands to that in the Invertebrata in the ratio of 30 to 7. This disproportion becomes still more marked when we take into account that the former has less time for variation than the latter, which had the start by the Cambrian and Ordovician periods. It follows also that as a whole they have changed faster.

The distribution of the extinct orders in the animal kingdom, taken along with their distribution in the rocks, proves further that some types have varied more than others, and at various places in the geological record. In the Protozoa, Porifera, and Vermes there are no extinct orders; among the Cœlenterates one, the Rugosa; in the Echinodermata three, Cystideans, Edriasterida, and Blastoidea; in the Arthropoda two, the Trilobita and Eurypterida. All these, with the solitary exception of the obscure order Rugosa, are found only in the Primary rocks. Among the Pisces there are none; in the Amphibia one, the Labyrinthodonts ranging from the Carboniferous to the Triassic age. Among the Reptilia there are at least six of Secondary age, Plesiosauria, Ichthyosauria, Dicynodontia, Pterosauria, Theriodontia, Dinosauria; in the Aves two, the Saururæ and Odontornithes, also Secondary. In the Mammalia the Amblypoda, Tillodontia, Condylarthra, and Toxodontia represent the extinct orders—the first three Early Tertiary, and the last Pleistocene. It is clear, therefore, that while the maximum amount of ordinal variation is presented by the Secondary Reptilia and Aves, all the extinct orders in the Tertiary are Mammalian.

If we turn from the extinct orders to the extinct species, it will also be found that the maximum amount of variation is presented by the plants, and all the animals, excepting the Mammalia, in the Primary and Secondary periods.

The general impression left upon my mind by these facts is that, while all the rest of the animal kingdom had ceased to present important modifications at the close of the Secondary period, the Mammalia, which presented no great changes in the Secondary rocks, were, to quote a happy phrase of Professor Gaudry, "en pleine évolution" in the Tertiary age. And when, further, the singular perfection of the record allows us to trace the successive and gradual modifications of the Mammalian types from the Eocene to the close of the Pleistocene Age, it is obvious that they can be used to mark subdivisions of the Tertiary Period, in the same way as the reigns of kings are used to mark periods in human history. In my opinion they mark the geological horizon with greater precision than the remains of the lower members of the animal kingdom, and in cases such as that of Pikermi, where typical Miocene forms, such as Dinotheria, are found in a stratum above an assemblage of marine shells of Pliocene age, it seems to me that the Mammalia are of greater value in classification than the Mollusca, some of the species of which have been living from the Eocene down to the present day.

Yet another important principle must be noted. The fossils are to be viewed in relation to those forms now living in their respective geographical regions. The depths of the ocean have been where they are now since the earliest geological times, although continual geographical changes have been going on at their margins. In other words, geographical provinces must have existed even in the earlier geological periods, although there is reason to believe that they did not differ so much from each other as at the present day. It follows from this that the only just standard for comparison in dealing with the fossils, and especially of the later rocks, is that which is offered by the fauna and flora of the geographical province in which they are found. The non-recognition of this principle has led to serious confusion. The fauna, for example, of the Upper Sivalik Formation has been very generally viewed from the European standpoint, and placed in the Miocene, while, judged by the standpoint of India, it is really Pliocene. A similar confusion has followed from taking the Miocene flora of Switzerland as a standard for the Tertiary flora of the whole of the Northern Hemisphere.

It now remains for us to see how these principles may be applied to the co-ordination of Tertiary strata in various parts of the world. In 1880 I proposed a classification of the European Tertiaries, in which, apart from the special characteristic fossils of each group, stress was laid on the gradual approximation of various groups to the living Mammalia. The definitions are the following:—

Divisions.	Characteristics.
1. Eocene, or that in which the higher Mammals (Eutheria) now on the earth were represented by allied forms belonging to existing orders and families. Oligocene.	Extinct orders. Living orders and families. No living genera.
2. Miocene, in which the alliance between fossil and living Mammals is closer than before.	Living genera. No living species.
3. Pliocene, in which living species of Mammals appear.	Living species few. Extinct species predominant.
4. Pleistocene, in which living species of Mammals preponderate.	Living species abundant. Extinct species present. Man present.
5. Prehistoric, or that period outside history in which Man has multiplied exceedingly on the earth and introduced the domestic animals.	Man abundant. Domestic animals present. Wild Mammals in retreat. One extinct Mammal.
6. Historic, in which the events are recorded in history.	Records.

These definitions are of more than European significance. The researches of Leidy, Marsh and Cope prove that they apply equally to the Tertiary strata of North America. The Wasatch Bridger and Uinta strata contain representatives of the orders Cheiroptera and Insectivora, the suborders Artio- and Perissodactyla, and the families Vespertilionidæ and Tapiridæ; but no living genera.[1] The Mammalia are obviously in the same stage of evolution as in the Eocenes of Europe, although there are but few genera, and no species common to the two.

[1] The genus *Vesperugo* has not been satisfactorily determined. Cope, Report of Geological Survey of the Territories, Tertiary Vertebrata, vol. i. 1884.

The White River and Loup Fork Groups present us with the living genera *Sciurus*, *Castor*, *Hystrix*, *Rhinoceros*, *Dicotyles*, and others; but no living species, as is the case with the Miocenes of Europe. In the Pliocenes of Oregon the first living species appear, such as the Beaver, the Prairie Wolf, and two Rodents (*Thomomys clusius* and *T. talpoides*), while in the Pleistocene river deposits and caves, from Eschscholtz Bay in the north to the Gulf of Mexico in the south, there is the same grouping of living with extinct species as in Europe, and the same evidence in the glaciated regions that the Mammalia occupied the land after the retreat of the ice.

If we analyze the rich and abundant fauna yielded by the caves and river deposits both of South America and of Australia, it will be seen that the Pleistocene group in each is marked by the presence of numerous living species in each, the first being remarkable for their gigantic extinct Edentata, and the second for their equally gigantic extinct Marsupials.

The admirable work of Mr. Lydekker allows us also to see how these definitions apply to the fossil Mammalia of India. The Miocene fauna of the Lower Sivaliks has yielded the living genera *Rhinoceros* and *Manis*, and no living species.

The fauna of the Upper Sivaliks, although it has only been shown, and that with some doubt, to contain one living Mammal, the Nilghai (*Boselaphus tragocamelus*), stands in the same relation to that of the Oriental region, as that of the Pliocenes of Europe to that of the Palæarctic region, and is therefore Pliocene. And lastly, the Narbada formation presents us with the first traces of Palæolithic Man in India in association with the living one-horned Rhinoceros, the Nilghai, the Indian Buffalo, two extinct Hippopotami, Elephants, and others, and is Pleistocene.

It may be objected to the Prehistoric and Historic divisions of the Tertiary Period that neither the one nor the other properly fall within the domain of Geology. It will, however, be found that in tracing the fauna and flora from the Eocene downwards to the present day there is no break which renders it possible to stop short at the close of the Pleistocene. The living plants and animals were in existence in the Pleistocene age in every part of the world which has been investigated. The European Mollusca were in Europe in the Pliocene age. The only difference between the Pleistocene fauna, on the one hand, and the Prehistoric, on the other, consists in the extinction of certain of the Mammalia at the close of the Pleistocene age in the Old and New Worlds, and in Australia. The Prehistoric fauna in Europe is also characterized by the introduction of the ancestors of the present domestic animals, some of which, such as the Celtic shorthorn (*Bos longifrons*), Sheep, Goat, and domestic Hog, reverted to a feral condition, and have left their remains in caves, alluvia, and peat-bogs over the whole of the British Isles and the Continent. These remains, along with those of Man in the Neolithic, Bronze, and Iron stages of culture, mark off the Prehistoric from the Pleistocene strata. There is surely no reason why a cave used by Palæolithic Man should be handed over to the geologist,

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while that used by men in the Prehistoric age should be taken out of his province, or why he should be asked to study the lower strata only in a given section, and leave the upper to be dealt with by the archæologist. In these cases the ground is common to geology and archæology, and the same things, if they are looked at from the standpoint of the History of the Earth, belong to the first, and, if from the standpoint of the history of Man, to the second.

If, however, there be no break of continuity in the series of events from the Pleistocene to the Prehistoric ages, still less is there in those which connect the Prehistoric with the period embraced by history. The Historic date of a cave or of a bed of alluvium is as clearly indicated by the occurrence of a coin as the geological position of a stratum is defined by an appeal to a characteristic fossil. The gradual unfolding of the present order of things from what went before compels me to recognize the fact that the Tertiary Period extends down to the present day. The Historic period is being recorded in the strata now being formed, exactly in the same way as the other divisions of the Tertiary have left their mark in the crust of the earth, and history is incomplete without an appeal to the geological record. In the masterly outline of the description of Roman civilization in Britain the historian of the English Conquest was obliged to use the evidence, obtained from the upper strata, in caves which had been used by refugees from the cities and villas; and among the materials for the future history of this city there are, to my mind, none more striking than the proof, offered by the silt in the great Roman bath, that the resort of crowds had become so utterly desolate and lonely in the ages following the English Conquest as to allow of the nesting of the Wild Duck.

I turn now to the place of Man in the geological record, a question which has advanced but little since the year 1864. Then, as now, his relation to the Glacial strata in Britain was in dispute. It must be confessed that the question is still without a satisfactory answer, and that it may well be put to "a suspense account." We may, however, console ourselves with the reflection that the River-drift Man appears in the Pleistocene strata of England, France, Spain, Italy, Greece, Algiers, Egypt, Palestine, and India along with Pleistocene animals, some of which were pre-Glacial in Britain. He is also proved to have been post-Glacial in Britain, and was probably living in happy, sunny, southern regions, where there was no ice, and therefore no Glacial period, throughout the Pleistocene age.

It may further be remarked that Man appears in the geological record where he might be expected to appear. In the Eocene the Primates were represented by various Lemuroids (*Adapis*, *Necrolemur*, and others) in the Old and New Worlds. In the Miocene the Simiadæ (*Dryopithecus*, *Pliopithecus*, *Oreopithecus*) appear in Europe, while Man himself appears, along with the living species of Mammalia, in the Pleistocene age, both in Europe and in India.

The question of the antiquity of Man is inseparably connected with the further question: "Is it possible to measure the lapse of geological time in years?" Various attempts have been made, and

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all, as it seems to me, have ended in failure. Till we know the rate of causation in the past, and until we can be sure that it has been invariable and uninterrupted, I cannot see anything but failure in the future. Neither the rate of the erosion of the land by subaërial agencies, nor its destruction by oceanic currents, nor the rate of the deposit of stalagmite or of the movement of glaciers, have as yet given us anything at all approaching a satisfactory date. We only have a sequence of events recorded in the rocks, with intervals the length of which we cannot measure. We do not know the exact duration of any one geological event. Till we know both, it is surely impossible to fix a date, in terms of years, either for the first appearance of Man or for any event outside the written record. We may draw cheques upon "The Bank of Force" as well as on "The Bank of Time."

Two of my predecessors in this chair, Dr. Woodward and Professor Judd, have dealt with the position of our science in relation to Biology and Mineralogy. Professor Phillips in 1864 pointed out that the later ages in Geology and the earlier ages of mankind were fairly united together in one large field of inquiry. In these remarks I have set myself the task of examining that side of our science which looks towards History. My conception of the aim and results of Geology is, that it should present a universal history of the various phases through which the earth and its inhabitants have passed in the various periods, until ultimately the story of the earth, and how it came to be what it is, is merged in the story of Man and his works in the written records. Whatever the future of Geology may be, it certainly does not seem likely to suffer in the struggle for existence in the scientific renascence of the nineteenth century.

III.—The Relations of the Great Oolite to the Forest Marble and Fuller's-earth in the South-west of England. By Horace B. Woodward, F.G.S., of the Geological Survey of England and Wales.

[Communicated by permission of the Director-General of the Geological Survey.]

THE southerly attenuation of the Great Oolite, and its absence in Dorsetshire, have been generally attributed to lateral changes in the strata—it being considered that the Great Oolite is mainly replaced by Forest Marble (which has been stated to increase in thickness southwards), and perhaps in part by the Fuller's-earth.

In Gloucestershire the Great Oolite and Forest Marble are so interblended that there is no real line of demarcation. At Bradford-on-Avon this is not the case: the surface of the Great Oolite, with its clusters of *Apiocrinus*, indicates a pause in deposition, and we have locally a good line of division between this formation and the Bradford Clay, which is a subordinate portion of the Forest Marble. Southwards the Bradford Clay horizon extends to the Dorsetshire coast, but the Great Oolite is no longer found, and we see no evidence of the Crinoid growth *in situ*. The estimated thickness of the Forest Marble in Dorsetshire has been much exaggerated, and the evidence

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furnished by the persistence of the Bradford Clay is opposed to the view that the Great Oolite is replaced in any way by the Forest Marble.

In Oxfordshire and Gloucestershire the Great Oolite and the Stonesfield Slate merge downwards into the Fuller's-earth with no marked stratigraphical division, and this is the case as far as Lansdown, near Bath. Northwards the Fuller's-earth is much attenuated, and near Chipping Norton it rests on a higher stage of the Inferior Oolite than we find in the Cotteswold Hills, as if in the former area the conditions attending the deposition of Inferior Oolite lingered longer. Rarely do we find any interblending of Inferior Oolite and Fuller's-earth; indeed, we sometimes find indications of local pauses in deposition, marked by annelide burrows, etc. So that on stratigraphical grounds the Fuller's-earth is more intimately connected with the Great Oolite than with the Inferior Oolite.

In Dorsetshire the Fuller's-earth series attains its greatest development in this country, and is separable into Upper and Lower clayey divisions, with an intermediate bed of Fuller's-earth Rock. These divisions may be traced northwards to Lansdown and Slaughterford, near Bath, where the Fuller's-earth Rock is present in an attenuated form, and where the Upper Fuller's-earth merges into the base of the Great Oolite.

It is therefore clear that the mass of the Great Oolite is not represented in the Fuller's-earth series of Dorsetshire, although its lower beds may be partially replaced by the Upper Fuller's-earth. The mass of the Great Oolite, therefore, either wedges out abruptly south of Bradford-on-Avon, or has been to some extent denuded. On the whole, it appears probable that the Great Oolite has been denuded—the erosion being local and contemporaneous so far as the Great Oolite series is concerned. The structure of the Forest Marble, with its clay-galls, its current-bedded limestones made up of broken shells and oolitic grains (the latter sometimes in a sandy matrix), favours the notion that it may have been largely derived from previous accumulations; and this opinion was suggested by Dr. Sorby from a microscopical study of some of the beds.

The organic remains of the Fuller's-earth include many species common to the Inferior Oolite and many common to the Great Oolite. Of seventy-two species, obtained during the course of the Geological Survey, fifty-eight are known also in the Great Oolite and forty-two in the Inferior Oolite, a number being common to the two formations. The palæontological evidence therefore coincides with the stratigraphical, that the Fuller's-earth on the whole is more intimately connected with the Great Oolite than with the Inferior Oolite. For convenience of classification it should therefore be placed with the Great Oolite series.

IV.—Note on the Portland Sands of Swindon and Elsewhere.

By Horace B. Woodward, F.G.S., of the Geological Survey of England and Wales.

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ATTENTION was drawn to some fresh sections at Swindon, and these confirmed the sequence made out by Prof. J. F. Blake from somewhat scattered data. The sandy beds that yield the Swindon Stone were originally grouped as "Portland Sands," but they clearly belong to the Portland Stone division, as pointed out by Mr. Blake. The basement-bed here and at Aylesbury consists of a conglomeratic band containing lydites, a few quartz pebbles, and some derived fossils. The true Portland Sands occur below, and are about 60 feet thick. The sequence is as follows:—

		Feet.
Portland Stone, with lydite bed at base and in upper part of clay beneath.		
Portland Sands.	3. Blue and brown clay	19
	2. Sandy calcareous rock. Oyster-bed with small acuminate oyster	8
	1. Greenish and yellowish sands with huge concretionary masses of calcareous sandstone. The sands merge downwards into	30 to 40
Kimeridge Clay.		

Comparing the sequence with that at Aylesbury, worked out by Mr. Hudleston, we find the Portland Stone with lydite bed at base, resting on the Hartwell Clay. This clay, like the Blue and Brown clay (No. 3) at Swindon, was originally taken to be Kimeridge Clay, but the former has been shown to be on the horizon of the Middle Portlandian of French geologists, and there is no doubt, on stratigraphical and palæontological grounds, that the clays of Swindon and Hartwell are on the same approximate horizon, and that both belong to the Portland Sands. We have not clear evidence of the sequence beneath the Hartwell Clay at Aylesbury; but a deep well at Stone, in that neighbourhood, showed the presence beneath the Portland Stone of Blue clay, Limestone, Dark sand, and then Blue clay again—this last-named bed being, no doubt, the true Kimeridge Clay, although detailed measurements are wanting.

Doubtless there is some inconvenience in a term like Portland Sands, when it includes prominent beds of clay like those of Swindon and Hartwell, and when the Portland Stone of Swindon is so largely represented by sand. We might employ the terms Upper and Lower Portlandian, were it not that on the Continent a threefold division has been adopted, and the Lower Portlandian embraces beds that in this country cannot be separated from the Kimeridge Clay. The Middle Portlandian, as before mentioned, represents our Portland Sands and Hartwell Clay; and Professor Blake has applied the term Bolonian to these Middle and Lower Portlandian beds. On stratigraphical grounds it does not appear possible for us to adopt this term, and on the whole the following grouping appears best adapted for the English strata:—

Upper Portland Beds—Portland, Tisbury and Swindon Stone.
Lower Portland Beds—Portland Sands and Hartwell Clay.

It is true that at Swindon and Hartwell the Lower Portland Beds are more intimately connected, on stratigraphical grounds, with the Kimeridge Clay than with the Upper Portland Beds; but this is not the case on the Dorsetshire coast, where no conglomeratic band has been met with at the base of the Portland Stone.

V.—Further Note on the Midford Sands.[1] By Horace B. Woodward, F.G.S., of the Geological Survey of England and Wales.

[Communicated by permission of the Director-General of the Geological Survey.]

THE term Midford Sands, introduced in 1871 by Professor Phillips, has been accepted by many geologists because it avoided the confusion that had arisen from the use by some authorities of the term Inferior Oolite Sands, and by others of Upper Lias Sands.

At Midford the upper portion of the Inferior Oolite (zone of *Ammonites Parkinsoni*) rests directly on the Sands, whereas in other parts of Somersetshire, in Dorsetshire and Gloucestershire, the lower portion of the Inferior Oolite (comprising the zones of *A. Humphriesianus and A. Murchisonæ*) is present above the Sands. In the absence of palæontological evidence, it has been questioned whether the Midford Sands are really equivalent to the Sands in other parts of the south-west of England. Hence other local names, *e.g.* the Yeovil and Bridport Sands, and the Cotteswold Sands, have been introduced.

Regarding the zone of *Ammonites opalinus* and the Gloucestershire Cephalopoda-bed as a portion of the Cotteswold Sands, there is no doubt about their correlation with the Sands of Bridport and Yeovil. Two species of *Ammonites* (*A. striatulus* and *A. aalensis*) have been obtained by the Rev. H. H. Winwood from the Midford Sands. The latter of these species was recorded by myself, on the authority of Mr. Etheridge, in 1876, but its occurrence has been overlooked. More recently I have seen in the William-Smith Collection in the British Museum, an *Ammonite* from the Coal-canal at Midford; and this has been identified by Mr. Etheridge and Mr. R. B. Newton, as very near to, if not identical with *A. Levesquei*, a species recorded by Dr. Lycett from the Gloucestershire Cephalopoda Bed. These species show that the Midford Sands belong to the same general horizon as the Sands of Gloucestershire and Dorsetshire, so that there is no adequate reason for discarding the name Midford Sands. If the beds near Bath have not proved so fossiliferous as those in other localities, there is no reason why they should remain so; for in Dorsetshire there are many sections where the beds appear barren, in close proximity with other exposures that yield an abundant fauna.

[1] A previous Note on the Midford Sands was published in the Geological Magazine, 1872, p. 513.

VI.—On *Bucklandium diluvii*, König, a Siluroid Fish from the London Clay of Sheppey. By A. Smith Woodward, F.G.S.

In his well-known 'Icones Fossilium Sectiles,' pl. viii. No. 91, König figures a remarkable fossil from the London Clay of Sheppey, which is mentioned in the text as not certainly determinable, but generally regarded, by the anatomists who have examined it, as pertaining to some type of Lizard. This specimen is preserved in the British Museum, and the author has determined that it is truly the imperfect head and pectoral arch of a Siluroid. The roof of the skull is preserved almost as far forwards as the middle of the frontals; the pectoral arch is in position, though slightly bent backwards; and the mass of anchylosed anterior vertebræ, with the basioccipital, is displaced downwards and thrown beneath the clavicles. All the bones are remarkably strong, and the exposed surfaces are ornamented with large tubercles. The head must have been originally somewhat deeper than broad, and the roof exhibits no flattening, but is strongly arched from side to side. Posteriorly, the supraoccipital projects in the usual manner, probably to meet a dermal plate upon the nape; and the post-temporal element seems to be merged with the bones of the postero-lateral angles of the cranium. It is impossible to determine the family-position of the genus in the usual manner, but the skulls of the West African *Auchenoglanis* and *Synodontis* appear to approach the fossil most closely. The provisional name of *Bucklandium diluvii* may be retained; and the fish is interesting as being the earliest undoubted Siluroid hitherto discovered.

VII.—A Comparison of the Cretaceous Fish-fauna of Mount Lebanon with that of the English Chalk. By A. Smith Woodward, F.G.S., F.Z.S.

No detailed comparison having hitherto been instituted between the Cretaceous fish-fauna of Mount Lebanon and that of the English Chalk, which belongs to a well-determined horizon, the author has undertaken a general survey of the genera, with the result that the two faunas are proved to have more forms in common than hitherto supposed. The Selachian fishes are scarcely comparable, *Notidanus* and *Squatina* being the only genera as yet recognized in the two formations; and, on the whole, those of Mount Lebanon exhibit the most modern facies, all traces of Hybodont Sharks and of *Ptychodus* being wanting. Chimæroids are unknown at Mount Lebanon, but abundantly met with in the English Chalk. Among Ganoids there are representatives of the Pycnodonts both in the Lebanon (*Palæobalistum*, *Coccodus*, *Xenopholis*) and in England (*Cœlodus*), but no identical genera can yet be recognized. Rhombic-scaled Ganoids are rare in the English Chalk (*Lophiostomus*, *Neorhombolepis*), and unknown in Mount Lebanon; traces of Acipenseroids also occur in the former, but have not been discovered in the latter; and at least one Crossopterygian genus occurs plentifully in England (*Macropoma*), while no uncertain remains have been

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detected in the Syrian beds. *Belonostomus*, however, is common to the two formations, one species having been described from Mount Lebanon under the name of *Rhinellus laniatus*.

Of Physostomous Teleosteans, the great early families represented in the Chalk of England and the Upper Cretaceous of North America by *Portheus*, *Ichthyodectes*, *Protosphyræna* and *Pachyrhizodus*, are quite unknown in the deposits of Mount Lebanon; but in the latter locality *Enchodus* is abundant, having been described under the synonym of *Eurygnathus*, and this is accompanied by a closely-allied genus, *Eurypholis*, only differing in the possession of a few dermal scutes. The English *Pomognathus* may also be regarded as represented at Mount Lebanon, for the so-called *Phylactocephalus* merely differs in the presence of extremely delicate minute scales, which would not be preserved in a matrix of the nature of the Chalk; and *Aspidopleurus* (Mount Lebanon) possesses scutes indistinguishable from the detached examples long known in the English Chalk under the name of *Prionolepis*. *Dercetis*, also, is met with abundantly in the Syrian beds, being described under the synonym of *Leptotrachelus*. Among Elopine Clupeoids, some undescribed forms occur in the English Chalk, and one from Mount Lebanon has been erroneously assigned to the genus *Clupea* (*C. Lewisii*); and the supposed Salmonoid, *Osmeroides*, is common to the two formations, though inferior in size at the last-named locality. In the Syrian deposits, however, there are many more specialized Physostomi, such as *Cheirothrix*, *Spaniodon*, *Opistopteryx*, *Rhinellus*, *Scombroclupea*, *Diplomystus*, and *Clupea*, not represented among English Chalk fossils. Among Physoclystous Teleosteans but few genera are common to the two formations under comparison. *Hoplopteryx*, with perhaps *Beryx*, represents the Berycidæ in both localities; but only a single imperfect specimen from the English Chalk can yet be assigned to any higher type, namely, *Platax* (?) *nuchalis*. At Mount Lebanon more specialized Physoclysti are numerous, as *Platax*, *Imogaster* and *Pycnosterinx*; although to the latter have been erroneously assigned certain extraneous forms, including at least one well-marked Berycoid, the so-called *Pycnosterinx Lewisii*.

The conclusion is thus arrived at, that in those respects in which the Lebanon fish-fauna differs from that of the English Chalk, it exhibits greater specialization. Considered alone, therefore, it is distinctly of a more modern type than the latter, although the beds in which it occurs are regarded, from other evidence, as being of Senonian or even Turonian age.

VIII.—On the Recent Volcanic Structure of the Azorean Archipelago. By Osbert H. Howarth.

THE object of the author's notes upon the relation of the Azorean group to the other islands of the West Atlantic is to indicate a line of inquiry by which some approximation may be made to the intervals separating the great eruptive changes; and determining any modifications in the type of flora during that important succession of volcanic products, which has been evolved since the Upper Miocene period assigned to the islands generally. A field for such inquiry seems to be offered by the present phase of action in the Furnas district, in the eastern centre of St. Michael's, where existing activity is associated with some of the oldest formations in the series. The author has traced in that valley a series of beds of vegetable origin dating back from the most recent changes, immediately connected with the present boiling-spring area, to a period antecedent to the formation of the Furnas Valley itself. The intermediate intervals of repose are now represented by peaty beds and subaqueous vegetable deposits, interstratified with the successive lava streams, tuffs, and pumice beds of various dates, within and prior to the historical period. From the more recent of these, buried trunks and branches have been obtained which represent the intervals of recent eruptions; while in one of the older tuffs, underlying nearly the whole series at that portion of the islands, a tree (probably an *Erica*) has been found, presumably *in situ*, and offering possibilities of a subjacent soil for examination, which would be contemporaneous with the earliest vegetation of the island.

IX.—The Volcanoes of the Two Sicilies. By Tempest Anderson, M.D., B.Sc.

THE author has recently visited the volcanoes of Naples, the Lipari Islands and Sicily, including Vesuvius, Stromboli, Vulcano and Ætna, and taken photographs of their craters and some of their lava streams, and other most important parts, in order to obtain a record of their present condition which may be available for comparison in case of future eruptions. Some of these photographs were shown as projections on a screen by means of a lime-light lantern.

REVIEWS.

The Building of the British Isles: A Study in Geographical Evolution. By A. J. Jukes-Browne, B.A., F.G.S. Sm. 8vo. pp. 335, with Maps and Woodcuts. (George Bell & Sons, 1888.)

ONLY a few years have elapsed since the late John Richard Green, combining physical geography, archæology, and history in the most happy manner, presented his fellow-countrymen with that admirable story in the development of their race, entitled "The Making of England." We are now presented with an equally interesting volume of physical history, and somewhat wider geographical scope, in which is told the story, how and during what geological periods the British Isles were built. Just as the modern English are a remarkable mixture of many races, so are the British Isles, as every geologist knows, a most remarkable epitome of the physical history of the Earth's crust, our limited territory being in fact like Jacob's coat in respect of the variety of the pieces which go to make it up.

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