They have no alternations of hard and soft beds, and, so far as I have seen, no repetition of beds by folding. The evidences of movement on their flanks, if any, are not more than one would expect from the vertical pressure of a more or less plastic shale upon what is at least a less plastic limestone.

I admit fully that there are abundant evidences in the district of faulting, of great pressure, and quite likely of overthrusts; but to say that these have given to these rocks a change of character, or are responsible for the order of their succession, appears to me to be invoking an unnecessarily powerful but yet inadequate force. Such thrust-planes as are implied would meet the geologist in the field at every turn, and force themselves into recognition. They would admit of easy mapping, and no statement of their existence would be complete without some such systematic recognition.

NOTICES OF MEMOIRS.

I.—On some Recent Geological Discoveries in the Nile Valley and Libyan Desert.[1] By Hugh J. L. Beadnell, F.G.S., F.R.G.S.

In this paper the author draws attention to some interesting discoveries made by him during the last three or four years while attached to the Geological Survey of Egypt. When the latter Survey was established in 1896 the publications and maps, both geological and geographical, of the Rohlfs Expedition of 1873–74 still remained the only source of information on the greater part of Egypt.

In his geological reports Zittel, the geologist of the Rohlfs Expedition, calls special attention to the absence of any unconformity between the Cretaceous and Eocene deposits, in fact mentioning this as one of the most important results obtained. More extended researches have, however, enabled the author "to bring forward incontestable evidence from at least two areas in the Libyan Desert, namely, Abu-Roash, near Cairo, and Baharia Oasis, that instead of this perfectly gradual petrographical and palæontological passage, undisturbed by any unconformity, from the uppermost marine Chalk into the oldest Tertiary beds, there is as a matter of fact a strongly marked unconformity, representing a long lapse of time in the process of sedimentation. During this period the Cretaceous was elevated into land, often with intense folding and faulting, and underwent considerable denudation before subsidence led to the entire or partial submergence of the area below the sea, and allowed the deposition of successive beds of Eocene in a markedly overlapping manner."

The accompanying table is compiled chiefly from the work of Professor Zittel and the Geological Survey of Egypt.

[1] Abstract of a paper read (with the permission of Captain H. G. Lyons, R.E., F.G.S., the Director-General of the Egyptian Geological Survey) before the International Geological Congress at Paris, 1900.

TABLE OF THE EOCENE AND CRETACEOUS SERIES IN THE LIBYAN DESERT AND NILE VALLEY.

EOCENE.	Bartonian.	UPPER EOCENE of Siwa Oasis, with *Nummulites Fichteli*, *N. intermedia*, *N. Rutimeyeri*, and *Orbitoïdes papyracea*.			
	Parisian.	UPPER MOKATTAM. LOWER MOKATTAM, with *Nummulites Gizehensis* limestones.			
	Londinian. Suessonian. Flandrian.	UPPER LIBYAN. *Callianassa* beds, *Alveolina* limestones, etc. LOWER LIBYAN. { Limestones with *Operculina libyca*, *Lucina Thebaica*, *Nautilus Forbesii*, etc. { Esna Shales (of Qena, Farafra, Kharga, etc.).			
CRETACEOUS.		ABU-ROASH.	BAHARIA OASIS.	DAKHLA OASIS.	NILE VALLEY.
	Danian.	White Chalk with corals, *Ostrea*, *Spondylus*, *Rudistes*, etc.	White Chalk with corals, *Gryphæa vesicularis*, *Exogyra Overwegi*, *Pecten Farafrensis*, *Corax pristodontus*, etc.	White Chalk with corals. *Ventriculites*, *Ananchytes ovata*, *Gryphæa vesicularis*, *Pecten Farafrensis*, etc. Greenish and ash-grey leafy clays.	White chalky limestones.
	Senonian. { Campanian. Santonian.	Part of White Chalk? Marls and limestones with *Tissotia Tissoti*, *Ostrea Costei*, *O. dichotoma*, etc.; *Echinobrissus Waltheri*. Marls with *Plicatula Ferryi*. Flinty limestones.	Probably some of the intermediate beds are Senonian or Turonian.	Bone-beds. Nubian clays and sandstones.	Beds with *Trigonoarca multidentata*, *Ptychoceras*. Bone-beds. Nubian clays and sandstones.
	Turonian.	Limestones with *Nerinæa Requieniana*, *Acteonella* (*Trochacteon*) *Salamonis*, *Biradiolites cornu-pastoris*, *Millestroma Nicholsoni*.			
	Cenomanian.	Limestones with *Cyphosoma Abbatei*, *Hemiaster roachensis*, *Sphærulites*, *Radiolites*, etc. Clays and sandstones.	Limestones and variegated sandstones with *Hemiaster roachensis*, *Heterodiadema libycum*, *Neobolites Vibrayeanus*. Sandstones and clays with *N. Vybrayeanus*, *Exogyra flabellata*, *E. Mermeti*, and *E. olisoponensis*.		

The author then discusses separately several typical localities, which may be briefly alluded to.

Abu-Roash.—This peculiarly interesting Cretaceous complex, near Cairo, has been described by Walther and Schweinfurth as having been brought into position among the Eocene deposits by faults along its four sides. This view, however, is strongly opposed by the author, who maintains that the fault theory is absolutely untenable, "as a most casual examination of the boundary of the Cretaceous, at almost any point where its junction with the Eocene was visible, instead of suggesting the existence of faults, yielded indubitable evidence of their absence, and the presence instead of a well-marked unconformity." At some points "the upper surface of the white chalk of the Cretaceous shows a most irregularly eroded surface, which is covered by a bed of rolled pebbles, sometimes a metre thick, the latter being overlaid by a thick bed of Eocene shelly limestone, followed by a series full of characteristic Upper Mokattam fossils." The author further points out the existence in this area of Danian beds, the uppermost member (White Chalk) being apparently homotaxial with the White Chalk of Baharia and Farafra.

Baharia Oasis.—Of the remarkable sand belt which occurs between the Nile Valley and this oasis, the author says:—"This sand belt has a total breadth of five kilometres, and runs slightly west of north and east of south (parallel, in fact, to the normal direction of the wind). Its origin is much further north, probably in the neighbourhood of the oasis of Moghara, while to the south it runs, as far as known unbroken, into the depression of Kharga, whence, after a slight break, it continues southwards. Its length is thus certainly over 350 kilometres. The dunes are composed of light-yellow, siliceous, well-rounded sand-grains. The steepest sides are those facing west, which have an angle of 30°–31°. It is a remarkable sight, this narrow band of sand dunes extending across the open desert as far as the eye can reach, maintaining an almost exactly straight course, an even breadth, and with sides as well defined as if drawn with the edge of a ruler."

The author's work shows that, contrary to original ideas, there is in reality a remarkable development of Cretaceous rocks in the oasis of Baharia and the surrounding desert on the west and south sides.

The lowest beds, consisting of sandstones, clays, and marls, attain a thickness of 170 metres, and are of Cenomanian age. Above them come limestones and variegated sandstones (45 metres), followed by white chalk of Danian age, 40 metres thick. (See Table.)

As at Abu-Roash, the junction between the Cretaceous and Eocene is unconformable, the deposits of the latter overlapping successively the different beds of the former.

The author, in discussing the age and origin of the peculiar ferruginous quartzites which so constantly cap the numerous isolated hills within the depression, brings forward evidence which tends to show that these "were deposited in a lake which formed

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here when there existed only a slight depression in the Eocene and Cretaceous rocks, ages in fact before erosion had carved out the depression to its present form. The large amount of ferruginous material and general character of the beds point to freshwater lacustrine deposition and precipitation. Lithologically they are often exactly similar to the Oligocene beds of the Fayum and Jebel Ahmar, and to the deposits on the road between Feshn and the oasis, and it may be that they are of the same age."

The author states that the igneous rocks of Baharia are of Post-Cretaceous, probably Oligocene, age, contemporaneous with the basalt sheets of the Fayum, of Abu-Roash and the desert to the west, and of Abu-Zabel; and that the andesites of the Libyan desert at Bahnessa, Gara Soda, and Jebel Gebail were likewise erupted at the same time.

After describing the important folds which occur in Baharia the author continues:—"The Cretaceous beds as a whole evidently form a large anticline . . . . which has its axis more or less parallel to the syncline already described. It is continued into the north end of Farafra, where the dip is well marked . . . . Yet the Eocene beds forming the plateau are in general quite horizontal, even in close proximity to inclined Cretaceous beds . . . . it seems certain that the Cretaceous beds, after the deposition of the White Chalk of Danian age, underwent upheaval, denudation, and finally depression, before the deposition of the earliest Tertiary beds.

"In this part of Egypt it appears that the subsiding Cretaceous land had the form of a long, flat, irregular ridge of anticlinal structure, extending from Dakhla oasis through Farafra, Baharia, and Abu-Roash. The northern end of this ridge was the last to subside and receive Eocene deposits, which accounts for the fact that in Farafra the Cretaceous is overlaid, always unconformably, by the Esna Shales of the Lower Libyan, in Baharia by limestones of the Upper Libyan, and at Abu-Roash by still younger beds of Lower and Upper Mokattam age."

The author finds other evidence which "suggests the probability that there was another period of possibly even more important earth-movements in Post-Eocene times. In this case, it seems not unlikely that the folding was closely connected with the important series of earth-movements which took place in North-East Africa and South-West Asia in early Pliocene times, and which gave rise to the formation of the chief topographical features of the country, such as the Nile and Jordan valleys and their attendant series of lakes."

The author's theory as to the origin of these wonderful depressions in the Libyan desert is interesting, and may be quoted in full. He writes:—"Baharia is a self-contained depression without drainage outlet, so that the ordinary methods of removal of disintegrated material do not here apply. Next, we have a large, flat, anticlinal ridge of Cretaceous beds, with at least one subsidiary, sharp, parallel, synclinal fold, overlaid by more or less horizontal beds of Eocene limestone. Since the elevation of this part of North Africa into dry land in late Tertiary times, denudation must have gone on continuously over the whole surface of the country.

"The most important denuding agent at the present day in the Libyan desert is wind-borne sand, the erosive action of which is very powerful and at once apparent to every traveller in these regions; but in the past there may have been, and probably were, other eroding agencies as well at work on the surface of this part of North Africa. Imagine, then, the general planing down of the country little by little through a long interval of time, until the anticlinal ridge of Cretaceous beds was reached, with its attendant soft sandstones and clays. As soon as the latter were exposed the action of denudation would have rapidly quickened, chiefly by the breaking up of the constituents of these beds by changes of temperature, rains and frosts, and the removal of the resulting sand and dust by wind. In this way must these wonderful depressions have been formed.

"Generalizing, then, we may say that where there have been extensive deposits of soft beds, and these have become exposed by the action of denudation, there large depressions have been cut out. The existence of soft Cenomanian sandstones and clays is thus the primary cause of the existence of the depression of Baharia, the soft Esna shales have played a similar role in that of Farafra, while, again, Dakhla is cut out in a thick series of soft beds of Danian age. The other oases and depressions probably owe their existence largely to the same cause."

Farafra and Dakhla Oasis.—In Farafra the author's chief additions to our knowledge were rather geographical than geological, although some evidence is brought forward to show that the very fossiliferous clays on the road between Farafra and Dakhla are somewhat younger than the age assigned to them by Zittel.

In Dakhla oasis thick and extensive highly phosphatic bone-beds of considerable commercial value were discovered.

Fayum.—It was in this province that there existed, some 2,000 years before Herodotus, the celebrated Lake Moeris, the exact site of which has led to so much discussion. The author shows that the geological evidence, in the shape of clays with numerous freshwater shells and fish-remains, of the same species as those at present inhabiting the existing lake, proves that the ancient lake occupied the lowest part of the depression, i.e. that now occupied by the Birket el Qurun and a considerable area of the low surrounding country. His position, in fact, closely agrees with that assigned to the lake by Major Brown, who bases his conclusions chiefly on considerations of level.

An extensive series of fluvio-marine beds, with intercalated sheets of basalt near the top, is shown to overlie the Upper Mokattam formation throughout the north part of the Fayum. This series is provisionally regarded as Oligocene. At the top come the silicified, wood-bearing sandstones, which stretch northwards across the desert to beyond the latitude of Cairo.

Within the Fayum depression, high up on the slopes or summits of the surrounding ridges, are found extensive raised beaches, probably of marine Pliocene age, at which time the sea stretched far up the Nile Valley.

Nile Valley.—In conclusion, some highly interesting facts are brought forward with regard to the Nile Valley itself, which the author summarizes as follows:—"The general north and south direction of the Nile Valley in Egypt, the remarkable high, lofty, wall-like cliffs by which it is hemmed in, the absence of any true river deposits at any considerable height above the river, the almost entire absence of hills or outliers of the plateau within the valley, the proved existence of bounding faults throughout a long stretch of the valley, lead us to infer that the formation of this gorge was brought about by faulting, rifting, and folding, and not cut out in the usual way by river action."

Between Cairo and Assuan the Nile Valley floor is covered for the most part with deposits of comparatively recent geological age, which may be divided into (1) Marine, Pliocene; (2) Lacustrine, Pleistocene; and (3) Fluviatile, Recent.

The marine Pliocene deposits, discovered near Esna by Mr. Barron and the author in 1897, consist of a thick series of limestones and interbedded conglomerates. In the limestones numerous foraminifera were found, and have been described by Mr. F. Chapman.

The lacustrine series consist of fresh-water deposits of the most variable nature, including gravels, conglomerates, clays, marls, limestones, and tufas. They have been mapped and examined by the author throughout a large length of the Nile Valley from Qena to Cairo. Calcareous tufas, crowded with the most beautiful impressions of leaves and twigs, abound in places. At Isawia the limestones of the series are of considerable commercial importance, supplying the material for the construction of the great dam at Assiut. Finally, the fluviatile deposits include the Nile mud and other recent accumulations.

In conclusion, the author shows the probable date of the formation of the Nile Valley gorge to be Lower Pliocene, and refers it to the same great series of earth-movements which determined and formed the main physical feature of North-East Africa and part of Asia. After the deposition of the Pliocene beds a gradual elevation led to the final retreat of the sea, the valley then becoming the site of a series of fresh-water lakes in which were deposited large quantities of calcareous tufa, which enclosed the numerous leaves carried into the lakes from the surrounding forests.

Finally, "in later Pleistocene times drainage must have become well established down the Nile Valley, and a river, the youthful Father Nile, commenced its career by carving out a channel through the valley deposits, before, owing to changed conditions, it finally took to depositing layer upon layer of 'Nile mud,' thus forming the strip of cultivable and inhabitable country without which the Land of Egypt, as we know it, would be non-existent."

II.—British Association for the Advancement of Science. Bradford, 1900. Joint Discussion, Sections C and K. On the Conditions under which the Plants of the Coal Period grew.

1. Flora of the Coal-measures. By R. Kidston, F.R.S.E., F.G.S.

LEAVING out of consideration a few genera of which we possess little or no definite knowledge, the flora of the Coal-measures consists of Ferns, Calamites, Lycopods, Sphenophylleæ, Cordaites, and Coniferæ.

In genera and species the Ferns are probably more numerous than the whole of the other groups, and contain representatives of the Eusporangiate and Leptosporangiate members of the class. The Eusporangiate, or those ferns whose sporangia are unprovided with an annulus, were more numerous in the Carboniferous period than at present, though in the Coal-measures they do not appear to have been more numerous than the genera with annulate sporangia. Tree ferns, though not very common, are more frequent in the Upper than in the Lower Coal-measures, in the lowest beds of which they seem to be very rare.

The Calamites are largely represented throughout the whole of the Coal-measures, *Asterophyllites* (*Calamocladus*) and *Annularia* probably being their foliage.

Lycopods are also very numerous, and are represented by many important genera — *Lycopodites, Lepidodendron, Lepidophloios, Bothrodendron,* and *Sigillaria,* with their rhizomes *Stigmaria* and *Stigmariopsis.* These genera contributed largely to the formation of Coal.

The genus *Sphenophyllum* was also frequent during Coal-measure times, and forms a type of vegetation essentially distinct from any existing group.

The Gymnosperms are represented by Cordaites, Coniferæ, and Cycads.

The Cordaites had tree-like trunks and long yucca-like leaves. They are plentiful in the Coal-measures, and, like the arborescent lycopods, must have been a prominent feature in a Carboniferous forest scene.

The Coniferæ, so far as I have seen, are only represented by a single specimen of *Walchia* from the Upper Coal-measures; and though Cycads have been discovered in the Upper Coal-measures on the Continent, I am not aware of any British species which can be referred with certainty to this group.

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2. The Origin of Coal. By A. Strahan, M.A., F.G.S.

The deposition of the Coal-measures was due to the subsidence of large portions of the earth's crust to a depth often amounting to several thousand feet. The subsidence, being unequal, led to the formation of coal-basins, parts of the margins of which are still recognizable. That the intervening areas rose no less rapidly than the basins sank is proved by the vast denudation suffered by the earlier Palæozoic rocks during the Carboniferous period.

The subsidence was counterbalanced during Coal-measure times by sedimentation, for the occurrence of marine beds among deposits of a generally estuarine aspect proves that the surface was maintained at or near sea-level. The Carboniferous sediments consist, in the majority of coalfields, of marine limestones in the lower part, of marine grits and conglomerates in the middle part, and of estuaro-marine sandstones and shales in the upper part. The sequence is due, firstly, to the admission of the sea to the subsiding areas; and lastly, to the restoration of level brought about by sedimentation and denudation. But there is evidence also of the sedimentation having been more or less spasmodic. Thus the Limestone Series generally consists of repetitions of small groups of strata, each group being composed of sandstone, followed by shale, shale followed by limestone. Similarly the Coal-measures present repetitions of sandstone followed by shale, shale by coal. Limestone in the one case and coal in the other are therefore comparable in this respect, that each represents an episode when sedimentation had come to a pause. Early views as to the origin of coal, namely, that it was formed of vegetable matter drifted beyond the region to which the finest mineral sediment could reach, were in accordance with these facts.

More minute examination of the strata, however, revealed proofs of land-surfaces in the Coal-measures, and it was generally accepted that the coal-seams represent forests in the place of their growth. The evidence may be summarized as follows:—

(1) Rain-pittings, sun-cracks, and footprints prove that the surfaces of some of the beds were exposed to the air.

(2) Erect tree-trunks of large size, in some cases attached to large spreading roots, are not uncommon. Land-shells, millipedes, and the skeletons of air-breathing reptiles have occasionally been found within the hollow trunks.[1]

(3) The underclays of coal-seams are traversed in all directions by branching rootlets, unlike the drifted fragments in the bedding planes of the other strata. They were described as an invariable accompaniment of coals, and as being the soils in which the coal-forest was rooted.

(4) Coal-seams, with thin minute partings, persist over vast areas, and it was thought impossible that so wide and regular a distribution of vegetable matter could have been accomplished by drifting.

(5) The chemical composition of the coals was believed to prove that the vegetable matter underwent partial decomposition in the open air before being submerged or buried.

This evidence, however, though it proves the existence of land surfaces, is not conclusive of the coal-seams being forests in place of growth. The rain-pittings, sun-cracks, and footprints occur, not in the coals, but in the intervening strata. Of the erect tree-trunks a large proportion occur in sandstones devoid of coal, a few only having been found to stand upon an underclay, or to be associated

[1] C. Brongniart and others have shown that air-breathing insects of the orders Neuroptera, Orthoptera, Thysanura, and Homoptera, were *very numerous* in the Coal-period in Europe and America.—Edit. Geol. Mag.

with seams of coal. Vast areas of coal have been worked without any such trunks having been encountered. The majority of the trunks, moreover, are destitute of spreading roots, and are believed to have been floated to their present positions. The land-shells, insect and reptilian remains, are of extremely rare occurrence.

The underclays do not resemble soils, inasmuch as they are perfectly homogeneous, and lie with absolute parallelism to the other members of a stratified series. They are not always present beneath coal-seams, but, on the other hand, often occur in them or above them. Frequently they have no coal associated with them. The rootlets in them have no connection with the coal, which is a well-stratified deposit with a sharply defined base.

The persistence of the partings and characters of the coal over wide areas is in favour of their being subaqueous deposits, for on so large an expanse of land there must have been river-systems and variations in the vegetation. The stream-beds, known to miners as 'wash-outs,' are not proportioned in size to the supposed land-surfaces.

Subaërial decomposition of part of a mass of vegetable matter would take place whether it were floating or resting on dry land. Spores, which enter largely into the composition of many coals, would travel long distances either by wind or water.

Some coal-seams show clear proof of a drifted origin, as, for example, those which are made up of a mass of small water-worn chips of wood or bark. Other seams pass horizontally into bands of ironstone, and one case has been observed of a coal changing gradually into a dolomitic tufa, doubtless formed in a stagnant lagoon. Putting aside exceptional cases, the sequence of events which preceded the deposition of a normal coal-seam seems to have been—firstly, the outspreading of sand or gravel with drifted plant-remains, followed by shale as the currents lost velocity. The water was extremely shallow, and even retreated at times, so as to leave the surface open to the air. The last sediments were extremely fine, homogeneous, and almost wholly siliceous, and in them a mass of presumably aquatic vegetation rooted itself. This further impediment to movement in the water cut off all sediment, and the material brought into the area then consisted only of wind-borne vegetable dust or floating vegetable matter carrying an occasional boulder. Lastly, the formation of the coal-seam was brought to a close by a sudden invasion of the area by moving water. The mass of vegetable matter, often after suffering some little erosion, was buried by sandstone or shale rich in large drifted remains of plants or trees, and the whole process was recommenced.

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3. Botanical Evidence bearing on the Climatic and other Physical Conditions under which Coal was formed. By A. C. Seward, F.R.S.

Botanical investigations into the nature and composition of the vegetation which has left abundant traces in the sediments of the Coal-measures may be expected to throw some light on the natural

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conditions which prevailed during that period in the earth's history that was *par excellence* the age of coal production. The minute examination of petrified tissues has rendered possible a restoration of the internal framework of several extinct types of plant-life, and has carried us a step further towards the solution of evolutionary problems. It is possible, even with our present knowledge, to make a limited use of anatomical structure as an index of life-conditions, and to restore in some degree from structural records the physiological and physical conditions of plant-life characteristic of the close of the Carboniferous epoch.

(1) *Evidence furnished by the Coal-period Floras as to Climatic and other Physical Conditions.*

The uniformity in the character of the vegetation has no doubt been somewhat exaggerated; e.g., the *Glossopteris* flora of Australia, South Africa, and South America. The existence of botanical provinces in Upper Palæozoic times.

A comparison of the Coal-period vegetation with that of the present day as regards (i) the relative abundance of certain classes of plants, (ii) the geographical distribution of certain families of plants during the Carboniferous epoch and at the present day. The importance of bearing in mind the progress of plant-evolution as a factor affecting the consideration of such comparisons. The possible existence of a Palæozoic Mountain flora of which no records have been preserved.

(2) *The Form, Habit, and Manner of Occurrence of Individual Plants as Indices of Conditions of Growth.*

Comparison of Calamites and horse-tails. Fossil forests of Calamites. *Psaronius* stems *in situ* and bearing roots at different levels, suggesting growth in a region of rapid sedimentation. Vertical stems either *in loco natali* or drifted. Climbing plants possibly represented by *Sphenophyllum*, some species of ferns and Medulloseæ. Function of the so-called *Aphlebia* leaves of ferns.

(3) *Anatomical Evidence.*

The value of evidence afforded by anatomical features. Risks of comparison between structural character of extinct and recent plants. Structure considered from the point of view of evolution, as the result of adaptation to external conditions, and to mechanical and physiological requirements.

(*a*) *Spores and leaves.*—Abundance of spores provided with filamentous or hooked appendages; adaptation of spores to floating or to wind-dispersal. The leaf structure of Calamites, ferns, etc.; presence of stomata, palissade tissue, and water-glands; the 'parichnos' or aërating tissue in the leaves of Lepidodendreæ and Sigillarieæ.

(*β*) *Stems and roots.*—Absence of annual rings of growth. The large size of water-conducting elements connected with rapid transport (e.g. *Sphenophyllum*) or with storage of water (e.g. *Megaloxylon*). The chambered pith of Cordaites, quoted as evidence of rapid elongation, of little or no physiological significance. Abundance of secretory tissue. Anatomical characteristics of a Lepidodendroid type of stem; great development of secondary tissue in the outer cortex, little or no true cork, lax inner cortex. Lacunar tissue in the roots of Calamites; hollow appendages of *Stigmaria*. Indications of xerophytic characters may be the result of growth in salt marshes.

(4) *Evidence as to the Manner of Formation of Coal.*

(*a*) The structure of *calcareous nodules* found in coal-seams; the preservation of delicate tissues, the occurrence of fungal hyphæ, and the petrification of Stigmarian appendages as evidence in favour of the subaqueous accumulation of the plant-débris found in the calcareous nodules.

(*b*) *Ordinary coal* microscopically examined. Spores, fragments of tissues, bacteria, and the ground substance of coal. Coal found in the cavities of cells in carbonized tissues. Suggested non-vegetable origin of the matrix of coal. 'Boulders' and coal-balls included in coal-seams.

(*c*) *Boghead, Cannel coal, and Oil-shales.* Recent investigations of Bertrand, Renault, and others. The structure and mode of origin of torbanite, kerosene, shale, etc. Suggested origin of Boghead from the minute bodies of algæ (*fleurs d'eau*), spores, etc., embedded in a brown ulmic substance found on the floor of a lake. Absence of clastic material. Cannel coal characterized by abundance of spores.

(*d*) *Paper-coal of Russia.*—The paper-coal of Culm age in the Moscow basin consists largely of the cuticles of a Lepidodendroid plant. Bacterial action as an agent in the destruction of plants and as a factor in the production of coal.

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4. By J. E. Marr, F.R.S.

(1) *What is coal?*—A non-scientific term introduced into scientific nomenclature for substances of divers character, and, therefore, probably of different modes of origin.

(2) *Was the Carboniferous period one where conditions suitable to formation of coal were unusually widespread?*

Coincidence at this period of dominant giant cryptogams, extensive plains of sedimentation, and suitable climatic conditions. Such coincidence never occurred before or after the Carboniferous period.

(3) *What work should be done in order to advance our knowledge of origin of coal?*

In the past light has been thrown on coal-formation by chemical, petrological, palæontological, and stratigraphical studies, and these should be continued.

(*a*) *Chemical.*—Importance of study of chemical composition of fire-clays and other accompaniments of coal in addition to coal itself.

(*b*) *Petrological.*—Dr. Sorby's work on origin of grains of mechanically formed rocks (sandstones, etc.) should be continued.

(*c*) *Palæontological.*—Studies of faunas and floras throwing light on physical and also on climatic conditions.

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(*d*) *Stratigraphical.*—Much detailed work is required in many parts of the world to discover over what periods coal-formation occurred in exceptional amount. Tendency at outset to refer all Upper Palæozoic coal-formations to the Coal-measures.

III.—On the Construction and Uses of Strike-Maps.[1] By J. Lomas, A.R.C.S., F.G.S.

In studying the deformations which a series of rocks have undergone, we are apt to regard the vertical movements as all-important, and neglect the horizontal movements to which they have been subjected. This is largely owing to the difficulties experienced in picturing such horizontal movements and representing them on a plan. Lines dependent on surface inequalities confuse the worker when he seeks to use the ordinary geological maps for this purpose. It is easy to get rid of these lines by projecting the strikes of the beds on to a horizontal plane. We then have the appearance that would be produced if the country were planed down to a horizontal surface. The outcrops would coincide with the strikes, and any deviation from straight lines would indicate horizontal movements. Vertical movements would also be shown on such a plan by the closing up of outcrops of beds of equal thickness. All the data necessary to represent these features on a strike-map are given in the ordinary Geological Survey sheets. To construct such a map, first trace the dips given on the geological map and draw short lines at the points of the arrows, at right angles to the direction of dip. We thus have represented the strikes of the beds at a number of points. Now it is necessary to connect these up by lines to show the strike at intermediate places. It would not be safe to connect one line with another, as the strikes may refer to different beds. In order to overcome this difficulty, draw a series of lines parallel to the strike line on both sides of it. On doing this for all the positions it will be found that the lines either connect themselves in linear series, or we have represented a series of tangents to curves which become evident when the lines are prolonged in the direction of the strike. Care should be taken not to connect in the same line strikes with dips in contrary directions, and it is well to represent the dip side of the strike lines by a short mark ——ı——. When the amount of dip is known, as well as the direction, we can represent the steepness of the folds by suitable shading, either by hachures or closeness of strike lines. As an illustration I exhibit strike maps of the district about Clitheroe, including the well-known knolls at Worsa and Gerna. The anticlinal ridge just north of Chatburn is clearly shown, and the strata dipping with wavy folds towards the Ribble on the north and Clitheroe on the south. The Salt Hill quarries are excavated in this southern slope at a place where the fold becomes acute. The knolls at Worsa and Gerna appear like whirls or eddies, such as may be seen in a stream when the flow is obstructed by boulders in the stream bed.

[1] Read before the British Association, Section C (Geology), Bradford, Sept., 1900.

IV.—The Concretionary Types in the Cellular Magnesian Limestone of Durham.[1] By G. Abbott, M.R.C.S.

ASSOCIATED with the Cannon-ball bed near Sunderland is a cellular limestone which is much more extensive, and exhibits still more remarkable physical features. Although described by Professor Sedgwick more than sixty years ago with other magnesian beds in the North of England, it is still comparatively unknown. He divided the concretions in these strata into four classes, but I have been unable to find any classified collection except the one in the Newcastle Museum, and even in this series it is only partially done.

My own studies at Fulwell and Hendon lead me to suggest a new classification, with *five primary forms*, viz.: (1) rods, (2) bands, (3) rings, (4) balls and modified spheres, (5) eggs. *Combinations* of these forms constitute the major part of these massive beds, and frequently a bed of less than a foot thick shows examples of several different combinations. These I place in ten classes, though they may have to be added to. The chief types are (1) tubes, (2) 'cauliflowers,' (3) basaltiform, (4) irregular, (5 and 6) troughs and bands (two kinds), (7) 'floral,' (8 and 9) 'honeycomb' or coralloid (two kinds), (10) pseudo-organic.

I exhibit photographs on the screen showing both the primary forms and the combinations as seen (wherever possible) in the undisturbed rock sections.

My own conclusions are as follows:—

1. That the rod structure is *secondary* to the formation of the conspicuous bands which run across the beds at various angles. (These bands need to be distinguished from the bands mentioned among the 'primary forms.') The conspicuous bands act as planes of origin for the 'rods,' and do not cross through the long axes of the rods themselves. They appear never to cross the bedding planes, though occasionally they follow them and also the outline of the joints. The question therefore arises, whether this does not give us a clue to the age and sequence of the changes which have occurred in these beds, and whether the previous existence of joints does not mean that the beds were already above the sea-level when the changes commenced.

2. The rods invariably start from the last-mentioned bands, and may be seen at every possible angle. As they have grown upwards and obliquely as well as downwards the term 'stalactitic' is a very misleading one to use. As Mr. Garwood stated long ago, these beds "present many points which appear irreconcilable with the theory of their stalactitic origin."

3. The first step in the series of changes which have taken place was probably an orderly but unsymmetrical arrangement of amorphous molecules of calcium carbonate which separated themselves from those of the carbonate of magnesia.

4. The internal architecture is due to such arrangement of amorphous particles of lime which has since been coated with an

[1] Read before the British Association, Section C (Geology), Bradford, Sept., 1900.

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outer crystalline layer. In some cases, however, the entire mass has undergone a complete subsequent change into a crystalline structure.

5. Pearl-spar (crystals of the combined carbonates) is seldom met with. I failed to find any.

6. In the Fulwell beds there are very few fossils, and where met with, as at Marsden, concretionary action is seldom traceable near them.

7. The specimens at Fulwell which arouse the most interest are coralloid masses ('honeycomb' of the quarrymen). They are confined, so far as I could discover, to a stratum, about 1½ foot thick, above the marl bed, and lie in close juxtaposition to each other, which accounts for their peculiar external shape.

In conclusion I would point out the close resemblance which exists between the 'lines' and 'planes' in these concretionary beds, and the 'lines' which shoot across congealing water. In some respects the architecture of the magnesian beds compares with the ice decorations seen on our window-panes in frosty weather.

V.—The Jurassic Flora of East Yorkshire.[1] By A. C. Seward, F.R.S.

THE plant-beds exposed in the cliff sections of the Yorkshire coast have afforded unusually rich data towards a restoration of the characteristics and composition of a certain facies of Mesozoic vegetation. Rich collections of plants from Gristhorpe Bay and other well-known localities are found in the British Museum (Natural History), also in the Museums of Scarborough, Whitby, Cambridge, Oxford, Manchester, York, Newcastle, Leeds, and elsewhere. The Natural History Museum, Paris, contains several important Yorkshire plants, some of which have been described by Brongniart and Saporta. The following species have been recognized from the East Yorkshire area:—

Marchantites erectus (Leck., ex Bean MS.); *Equisetites columnaris*, Brongn.; *Equisetites Beani* (Bunb.); *Lycopodites falcatus*, L. & H.; *Cladophlebis denticulata* (Brongn.); *C. haiburnensis* (L. & H.); *C. lobifolia* (Phill.); *Coniopteris arguta* (L. & H.); *C. hymenophylloides* (Brongn.); *C. quinqueloba* (Phill.); *Dictyophyllum rugosum*, L. & H.; *Klukia exilis* (Phill.); *Laccopteris polypodioides* (Brongn.); *L. Woodwardi* (Leck.); *Matonidium Goepperti* (Ett.); *Pachypteris lanceolata*, Brongn.; *Ruffordia Goepperti* (Dunk.); *Sagenopteris Phillipsi* (Brongn.); *Sphenopteris Murrayana* (Brongn.); *S. Williamsoni*, Brongn.; *Tæniopteris major*, L. & H.; *T. vittata*, Brongn.; *Todites Williamsoni* (Brongn.); *Anomozamites Nilssoni* (Phill.); *Araucarites Phillipsi*, Carr; *Baiera gracilis*, Bunb.; *B. Lindleyana* (Schimp.); *B. Phillipsi*, Nath.; *Beania gracilis*, Carr; *Brachyphyllum mammillare*, Brongn.; *Cheirolepis setosus* (Phill.); *Cryptomerites divaricatus*, Bunb.; *Ctenis falcata*, L. & H.; *Czekanowskia Murrayana* (L. & H.); *Dioonites Nathorsti*, sp. nov.; *Ginkgo digitata* (Brongn.); *G. whitbiensis*, Nath.; *Nageiopsis anglica*, sp. nov.; *Nilssonia compta* (Phill.);

[1] Read before the British Association, Section C (Geology), Bradford, Sept., 1900.

N. mediana (Leck., ex Bean MS.); *N. tenuinervis*, Nath.; *Otozamites acuminatus* (L. & H.); *O. Beani* (L. & H.); *O. Bunburyanus*, Zign.; *O. Feistmanteli*, Zign.; *O. graphicus* (Leck., ex Bean MS.); *O. obtusus* (L. & H.), var. *ooliticus*; *O. parallelus* (Phill.); *Pagiophyllum Williamsoni* (Brongn.); *Podozamites lanceolatus* (L. & H.); *Ptilozamites* (Leck., ex Bean MS.); *Taxites zamioides* (Leck.); *Williamsonia gigas* (L. & H.); *W. pecten* (Phill.).

The English flora is compared by the author with Rhætic, Jurassic, and Wealden floras of other regions; a comparison is made also between the fossil flora and the vegetation of the present day.

VI.—On the Fish Fauna of the Yorkshire Coalfields.[1] By Edgar D. Wellburn, F.G.S.

ONLY the Lower and Middle Coal-measures are present. The author described the Lower Measures, their extent and general characters, with their beds of marine and fresh-water origin. The Middle Measures and their general character; formed in a series of fresh-water lake basins. The author described the fish-remains, where found and in what state of preservation. Elasmobranchs, Teleosteans (and in some cases Dipnoans), commingled, i.e. marine and fresh-water types in the same beds; Elasmobranchs found in marine and fresh-water beds; Dipnoi only found under fresh-water conditions. Teleostean orders, Crossopterygii and Actinopterygii found in both fresh-water and marine beds. The conditions under which coal was deposited was shown to have a bearing on the occurrence and habits of the fishes. The swim-bladder of Cœlacanths, and its peculiar use to them under certain conditions. The Elasmobranchii were represented by eleven genera and twenty-three species; Ichthyodorulites by seven genera and eight species; Dipnoi by two genera and two species; and the Teleostomi by twelve genera and thirty-three species. A tabular list of fish-remains was given showing their stratigraphical distribution; several new fish-bearing coal shales were recorded, the distribution and vertical range of the Yorkshire coal-fishes being thus greatly extended; several genera and species new to Yorkshire, and others new to science, were referred to by the author.

REVIEWS.

I.—Catalogue of the Bateman Collection of Antiquities in the Sheffield Public Museum. Prepared by E. Howarth, F.R.A.S., F.Z.S., Curator of the Public Museum and Mappin Art Gallery. 8vo; pp. xxiv and 254, with 262 illustrations in the text. Published by order of the Committee. (London: Dulau & Co., 1899. Price 3*s*. 6*d*.)

THE very valuable and interesting collection which forms the subject of this excellent Catalogue is not only entirely British, but is confined to Derbyshire, Staffordshire, and Yorkshire, and is the work of three generations of Batemans of Middleton Hall,

[1] Read before the British Association, Section C (Geology), Bradford, Sept., 1900.