impression,'[1] though shallow, is here well marked and about 13·5 mm. wide, but this may have been much narrower or even have entirely disappeared on the body-chamber, so that the transverse section of the body-chamber may have been more nearly digonal. Fortunately in the present specimen a few of the septa are visible, or at least partially visible; near the anterior end of the specimen they are about 6·0 mm. apart; they are, however, best displayed at about the commencement of the last third of the outer whorl, i.e. where the specimen is 69 mm. in diameter; here they are seen on a portion of the peripheral area and on a part also of the side of the whorl; on the lateral area they form a very slight backwardly-directed curve, and, crossing the umbilical rim, traverse the peripheral area in almost a straight line, or with only a very feeble backwardly-directed curve; on the periphery they are about 7·0 mm. apart. So far as can be seen, the form of the septation closely resembles that of *Vestinautilus pinguis* as figured by Dr. Foord,[2] but the chambers are a little shallower than shown in that figure. Notwithstanding the characters which differentiate this specimen from Foord's figured example, viz., the greater convexity of the peripheral area, the narrower and deeper hyponomic sinus, and the relatively greater height of the whorl in proportion to its width, there can be no doubt that the two forms are very closely allied and most probably specifically identical. In referring his species to the genus *Vestinautilus*, Dr. Foord seems, therefore, to be correct, the form of the septal sutures supporting that conclusion.

NOTICES OF MEMOIRS, ETC.

I.—Floras of the Past: their Composition and Distribution. By A. C. Seward, F.R.S., Fellow and Tutor of Emmanuel College, Lecturer on Botany in the University of Cambridge.

(*Continued from the November Number, p.* 512.)

THE geographical distribution of plants of approximately Rhætic age is shown in the following table on p. 557, which demonstrates an almost worldwide range of a vegetation of uniform character. The character of the plant-world is entirely different from that which we have described in speaking of the Palæozoic floras. Gymnosperms have ousted Vascular Cryptogams from their position of superiority; ferns, indeed, are still very abundant, but they have undergone many and striking changes, notably in the much smaller representation of the Marattiaceæ. The Palæozoic Lycopods and Calamites have gone, and in their place we have a wealth of Cycadean and Coniferous types. As we ascend to the Jurassic plant-beds the change in the vegetation is comparatively slight, and the same persistence of a well-marked type of vegetation

[1] The 'zone of impression' or 'impressed zone' is the zone which is in contact with, and impressed by, the peripheral area of the preceding whorl.

[2] *Op. jam cit.*, pl. xxv, fig. 3*a*.

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extends into the Wealden period. It is a remarkable fact that after the Palæozoic floras had been replaced by those of the Mesozoic era, the vegetation maintained a striking uniformity of character, from the close of the Triassic up to the dawn of the Cretaceous era.

Mesozoic Floras.—It may be of interest to glance at some of the leading types of Mesozoic floras with a view to comparing them with their modern representatives. We are so familiar with the present position of the flowering plants in the vegetation of the world, that it is difficult for us to form a conception of a state of things in the history of the plant-kingdom in which Angiosperms had no part.

A. *Conifers.*—How may we describe the characteristic features of Rhætic and Jurassic floras? Gymnosperms, so far as we know, marked the highest level of plant-evolution. Conifers were abundant, but the majority were not members of that group to which the best known and most widely distributed modern forms belong.

A comparison of fossil and recent conifers is rendered difficult by the lack of satisfactory evidence as to the systematic position of many of the commoner types met with in Mesozoic rocks. There are, however, certain broad generalisations which we are justified in making; such genera as the Pines, Firs, Larches, and other members of the Abietineæ appear to have occupied a subordinate position during the Triassic and Jurassic eras; it is among the relics of Wealden and Lower Cretaceous floras that cones and vegetative shoots like those of recent Pines occur for the first time in a position of importance. There are several Mesozoic Conifers, to which such artificial designations as *Pagiophyllum*, *Brachyphyllum*, and others have been assigned, which cannot be referred with certainty to a particular section of the Coniferæ; these forms, however, exhibit distinct indications of a close relationship with the Araucarieæ, represented in modern floras by *Araucaria* and *Agathis*. The abundance of cones in Jurassic strata showing the characteristic features of those of recent species of *Araucaria* affords trustworthy evidence as to the antiquity of the Araucarieæ, and demonstrates their wide geographical distribution during the Mesozoic era. Additional confirmation of the important status of this section of the Coniferæ is afforded by the abundance of petrified wood exhibiting Araucarian features, in both Jurassic and Wealden rocks. There is good reason to believe that the well-known Whitby jet was formed by the alteration of blocks of Araucarian wood drifted from forest-clad slopes overlooking a Jurassic estuary that occupied the site of the moors and headlands of North-East Yorkshire.

B. *Cycads.*—One of the most striking features of the Mesozoic vegetation is the abundance and wide distribution of Cycadean plants. To-day the Cycads or Sago-Palms are represented by ten genera and about eighty species; they are plants which occupy a subordinate position in modern floras, and occur for the most part as solitary types in tropical latitudes, never growing together in sufficiently large numbers to constitute a dominant feature in the

I. Rhætic Floras.—Geographical Distribution of a few Characteristic Types.

Characteristic Types.	Arctic.						N. Temperate.			N. Sub-tropical.				Tropical.			S. Sub-tropical			S. Temperate.		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Equisetales																						
Equisetites Muensteri } *Equisetites arenaceus* }		x					x	x		x	x					x						
Schizoneura								x			x	x				x		x				
Phyllotheca											x								x		x	
Filicales																						
Clathropteris } *Dictyophyllum* }							x	x			x	x				x			x			
Laccopteris								x											x			
Todites		x					x	x			x	x				x			x		x	
Tæniopteris							x	x		x	x					x		x	x			
Thinnfeldia								x								x	x	x	x		x	
Sagenopteris							x	x											x		x	
Cycadophyta																						
Cycadites							x	x								x						
Podozamites		x					x	x			x					x						
Otozamites								x		x	x			x		x						
Anomozamites								x			x			x		x						
Pterophyllum		x					x	x			x			x		x			x		x	
Ginkgoales																						
Baiera } *Ginkgo* }		x					x	x			x							x	x		x	

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vegetation. Before the end of the Palæozoic era there existed plants bearing pinnate fronds similar to those of recent species of Cycadaceæ, and in succeeding ages the group rapidly increased in number and variety till, in the Jurassic and the early Cretaceous periods, the Cycads asserted their superiority as the leading type of vegetation. The majority of Mesozoic Cycadean fronds are assigned to artificial or form-genera as an indication of our ignorance of their reproductive organs, or of the anatomical structure of their stems. As Professor Nathorst has recently suggested, it is convenient to speak of these Cycadean remains as belonging to the group Cycadophyta. On the other hand, we find numerous petrified stems bearing well-preserved reproductive organs which enable us to compare the extinct with the existing species. We are in possession of enough facts to justify the statement that the majority of Mesozoic Cycads bore reproductive organs which differed in important morphological characters from those of existing forms. The Bennettiteæ, originally founded on a petrified stem discovered more than fifty years ago in the Isle of Wight, possessed a thick stem, clothed with an armour of persistent leaf-bases and bearing a crown of pinnate fronds, as in most modern Cycads; but their flowers, which were borne on lateral shoots, were more highly specialised than those of the true Cycads. While most of the Mesozoic Cycads were no doubt members of the Bennettiteæ, others appear to have possessed reproductive organs like those of recent species. The Bennettiteæ belong to that vast army of plants that succumbed in the struggle for existence æons before the dawn of the Recent period.

The wealth of Cycadean vegetation during the latter part of the Jurassic and the earlier stages of the Cretaceous periods is admirably illustrated by the discovery in the Black Hills of North America and in other districts of the United States of hundreds of silicified trunks of Cycadean plants. The investigations of Mr. Wieland, of Yale, who has been engaged for some time on the examination of this rich material, have already revealed the fact that in some of the Bennettiteæ the male and female organs were borne in a single flower, the female portion having a structure identical with that previously described from European stems, while the male flowers bear a close resemblance to the fertile fronds of a Marattiaceous fern.

C. *Ginkgoales.*—Before leaving the Gymnosperms a word must be said about another section—the Ginkgoales—represented by the Maidenhair-tree of China and Japan. *Ginkgo* (or *Salisburia*) *biloba* has almost, if not quite, ceased to exist in an absolutely wild state, but as a cultivated tree it has now become familiar both in America and Europe. The abundance of fossil leaves, like those of *Ginkgo biloba*, and of other slightly different forms referred to the genus *Baiera*, associated not infrequently with remains of male and female flowers, demonstrates the ubiquitous character of the Ginkgoales during the Rhætic, Jurassic, and Wealden periods. In the Jurassic shales of the Yorkshire coast, *Ginkgo* and *Baiera* leaves occur in plenty, some of them practically identical with those of the

II. Wealden Floras.—Geographical Distribution of Characteristic Types.

Characteristic Types.	Arctic.						N. Temperate.			N. Sub-tropical.				Tropical.			S. Sub-tropical			S. Temperate.		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Equisetales																						
Equisetites							x	x					x									
Filicales																						
Onychiopsis		x					x	x					x					x	x			
Matonidium							x	x														
Cladophlebis		x					x	x					x					x	x			
Sphenopteris							x	x										x				x
Weichselia							x	x					x									
Tæniopteris		x		x			x	x										x				
Laccopteris								x														
Gleichenites			x					x														
Ginkgoales																						
Baiera } *Ginkgo* }		x		x	x		x	x														
Coniferales																						
Sphenolepidium		x					x	x														
Araucarites							x	x														
Pinites			x					x														
Cycadophyta																						
Nilssonia								x					x					x				
Otozamites		x						x														
Zamites							x	x					x					x				
Bennettites							x	x														

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existing species. The abundance of fossil Ginkgoales in other parts of the world—in Australia, South Africa, South America, China, Japan, North America, Greenland, Franz Josef's Land, Siberia, and throughout Europe—demonstrates the former vigour of this class of plants, of which but one member survives. This type of Gymnosperm is distinctly foreshadowed in the Palæozoic vegetation, and as recently as the Eocene period a species of *Ginkgo*, indistinguishable in the form of its leaves from the living Maidenhair-tree, flourished in Western Scotland.

D. *Ferns.*—Although many of the Mesozoic ferns are preserved only in the form of sterile fronds and are of little botanical interest, several examples of fertile leaves are known which it is possible to compare with modern types. The Polypodiaceæ, representing the dominant family of recent ferns, are met with in nearly all parts of the world and possess the attributes of a group of plants at the zenith of its prosperity. We may confidently state that so far as the somewhat meagre evidence allows us to form an opinion, this family occupied a subordinate position in the composition of Mesozoic floras. Polypodiaceous sporangia have been met with in Palæozoic rocks, and their existence during the Mesozoic period is not merely a justifiable assumption, but is demonstrated by the occurrence of undoubted species of Polypodiaceæ. It seems clear, however, that this family did not attain to a position of importance until the Mesozoic vegetation gave place to that which characterises the present period. The Osmundaceæ are now represented by five species of *Todea* and four of *Osmunda*. They flourished over the greater part of Europe during the Rhætic and Jurassic periods; their remains have been recorded from England, Germany, Scandinavia, Russia, Poland, Siberia, and Greenland, also from North America, Persia, and China.

Similarly, the Schizæaceæ were among the more abundant ferns in the Jurassic vegetation. The Cyatheaceæ, a family that is now for the most part confined to the tropics, constituted another vigorous and widely spread section in the Jurassic period; we find them in Jurassic rocks of Victoria, as well as in several regions in Europe, North America, and the Arctic regions.

The fertile fronds of many of the fossil Cyatheaceæ bear a striking resemblance to that isolated survivor of the family in Juan Fernandez—*Thyrsopteris elegans*. It is true that a considerable number of ferns of Jurassic and Wealden age have been described by the generic name *Thyrsopteris* without any adequate reason; but, neglecting all doubtful forms, there remain several types represented in the Jurassic flora of Siberia, England, and other parts of the world, which enable us to refer them with confidence to the Cyatheaceæ and to compare them more particularly with the sole existing species of *Thyrsopteris*. The Gleicheniaceæ, at present characteristic of tropical and southern countries, were undoubtedly abundant in the northern hemisphere in early Cretaceous days; abundant traces of this family are recorded from Greenland as well as from more southern European latitudes.

One of the most striking facts afforded by a study of the Mesozoic fern vegetation is the former extension and vigorous development of two families, the Dipteridinæ and Matonineæ, which are now confined to a few tropical regions and represented by six species. The fertile fragment of a frond of *Matonidium* exposed by a stroke of the hammer in a piece of iron-stained limestone picked up on the beach at Haiburn Wyke (a few miles north of Scarborough), is hardly distinguishable from a pinna of the Malayan *Matonia pectinata.* Rhætic and Jurassic ferns referred to the genus *Laccopteris* afford other examples of the abundance of the Matonineæ in the northern hemisphere during the earlier part of the Mesozoic era.

The modern genus *Dipteris*, with its four species occurring in India, the Malayan region, Formosa, Fiji, and New Caledonia, stands apart from the great majority of Polypodiaceous ferns, and is now placed in a separate family—the Dipteridinæ. Like *Matonia* it is essentially an ancient and moribund type with hosts of ancestors included in such Rhætic and Jurassic genera as *Dictyophyllum, Camptopteris*, and others which must have been among the most conspicuous and vigorous members of the Mesozoic vegetation.

E. *Flowering Plants.*—Our retrospect of the march of plant-life has so far extended to the dawn of the Cretaceous period, a chapter in geological history written in the rocks that constitute the Wealden series of Britain exposed in the Sussex cliffs and in the Weald district of south-east England. According to the geologist's reckoning, the Cretaceous period is of comparatively modern date; it occupies a position near the summit of a long succession of ages representing an amount of time beyond the power of imagination to conceive.

One interesting fact as regards the composition of the Jurassic flora is the absence of any plants that can reasonably be identified as Angiosperms. In the Wealden flora of England no vestige of an Angiosperm has been found; this statement holds good also as regards Wealden floras in most other regions of the world. On the other hand, as soon as we ascend to strata of slightly more recent age we are confronted with a new element in the vegetation, which with amazing rapidity assumes the leading rôle. It is impossible to say with confidence at what precise period of geological history the Angiosperms appeared. When the rocks that now form the undulating country of the Weald were being accumulated as river-borne sediments on the floor of an estuary, this crowning act in the drama of plant evolution was probably being enacted.

I have already pointed out that we have as yet recognised no Angiosperms in the Wealden floras of England, Spitzbergen, Germany, France, Austria, Belgium, Russia, and Japan; but from plant-bearing rocks of Portugal, regarded as homotaxial with those which British geologists speak of as Wealden, the late Marquis of Saporta named a fragment of a leaf *Alismacites primævus*, a determination that, while possibly correct, cannot be accepted as conclusive testimony. In Virginia and Maryland there occurs a thick series of strata known as the Potomac formation, from which a rich harvest of plant-remains has been obtained. Professor Lester Ward has recently shown that under this title are included several floras, some of which are undoubtedly homotaxial with the Wealden of Europe, while others represent the vegetation of a later phase of the Cretaceous era. From the older Potomac beds a few leaves have been assigned to Dicotyledons and referred to such genera as *Ficophyllum, Myrica, Proteæphyllum*, and others. Some of these may well be small fronds of ferns with venation characters like those of the Elk's Horn fern (*Platycerium*), while others, though presenting a close resemblance to Dicotyledonous leaves, afford insufficient data for accurate generic identification. In dealing with fossil leaves of the dicotyledonous type, we must not forget that the recent genus *Gnetum* —a gymnosperm of the section Gnetales—possesses leaves that may be said to be indistinguishable in form and venation from those of certain Dicotyledons. Before the close of the Potomac period these few fragmentary relics of possible Dicotyledons are replaced by a comparative abundance of specimens which must be accepted as undoubted Angiosperms. Previous to the discovery of the supposed Angiosperms in Wealden strata of Portugal and North America, the earliest record of an Angiosperm was represented by Heer's *Populus primæva* from Northern Greenland. This name was applied to a fragmentary specimen which may be a true dicotyledonous leaf. In 1897 Dr. White, of the Geological Survey of the United States, stated that additional examples of dicotyledonous leaves had been obtained during the visit of the Peary Arctic expedition to the well-known locality in Greenland where Heer's *Populus primæva* was discovered in the so-called Kome series. From strata known as the Atane beds, which rest on the Kome series, unmistakable Angiosperms have been collected in abundance.

Another indication of the sudden increase in the number of dicotyledons is furnished by the Dakota flora of the United States—in age somewhat more recent than the older Potomac beds. In these plant-beds it is stated that Angiosperms constitute two-thirds of the vegetation.

One of our most pressing needs is a thoroughly critical revision of the late Cretaceous and earlier Tertiary floras, with the object both of determining the systematic position of the older Angiosperms and of mapping out with greater accuracy the geographical distribution of the floras of the world in post-Wealden periods. This is a task which is sometimes said to be impossible or hardly worth the attempt; the available evidence is indeed meagre, and much of it has been treated with more respect than it deserves, but it is at least a praiseworthy aim, not to say a duty, to take stock of our material and to compile lists of plants that may bear the scrutiny of experienced systematists. We are profoundly ignorant of the means by which Nature produced this new creation; we can only emphasise the fact that in the early days of the Cretaceous era a new type was evolved which no sooner appeared than it swept all before it, and by its overmastering superiority converted the past into the present.

In conclusion, I would urge the importance of taking stock of our accumulated facts, and of so recording our observations that they may be safely laid under contribution as aids to broad generalisations. Detailed descriptions and the enumeration of small collections are a necessity, but there is danger of the student neglecting the application of his results to problems of far-reaching import.

There is no more fascinating task than to follow the onward march of the plant-world from one stage to another and to watch the fortunes of the advancing army. We see from time to time war-worn veterans dropping from the ranks and note the constant addition of recruits, some of whom march but a short distance and fall by the way; while others, better equipped, rise to a position of importance.

At long intervals the formation is altered and the constitution of the advancing and increasing host is suddenly changed; familiar leaders are superseded by newcomers, who mark their advent by drastic reorganisation. To change the metaphor, we may compare the stages of plant-evolution to the records of changing architectural styles represented in Gothic buildings. The simple Norman arch and massive pier are replaced, with apparent suddenness, by the pointed arch and detached shafts of the thirteenth century; the latter style, which marked an architectural phase characterised by local variations subordinated to a uniformity in essential features, was replaced by one in which simplicity was superseded by elaboration, and new elements were added leading to greater complexity and a modification of plan. Similarly, the Palæozoic facies of vegetation passes with almost startling suddenness into that which monopolised the world in the Mesozoic era, and was in turn superseded by the more highly elaborated and less homogeneous vegetation of the Cretaceous and Tertiary periods. In taking a superficial view of architectural styles we are apt to lose sight of the signs of gradual transition by which one period passes into the next; so, too, in our retrospect of the changing scenes which mark the progress of plant-evolution, we easily overlook the introduction of new types and the gradual substitution of new for old. The invention of a new principle in the construction of buildings is soon followed by its wide adoption; new conceptions become stereotyped, and in a comparatively few years the whole style is altered. As a new and successful type of plant-architecture is produced it rapidly comes into prominence and acts as the most potent factor in changing the facies of a flora. Making due allowances for the imperfection of the geological record, we cannot escape from the conclusion, which is by no means opposed to our ideas of the operation of the laws governing evolutionary forces, that the state of equilibrium in the vegetable kingdom was rudely shaken during two revolutionary periods. The earlier transitional period occurred when Conifers and Cycads became firmly established, while for the second revolution the introduction of the Angiospermous type was mainly responsible. As in the half-effaced documents accessible to the student of architecture "the pedigrees of English Gothic can still be recovered," so also we are able to trace in the registers imprinted on the rocks the genealogies of existing botanical types.

II.—A Theory of the Origin of Continents and Ocean Basins.

By William Mackie, M.A., M.D.[1]

Whatever the conditions at present obtaining in the interior of the earth, it is naturally supposed to have originally passed through a stage which would be represented by a solid, or potentially solid, nucleus, a slowly forming and slowly thickening acid crust, with a liquid and more or less basic interstratum. At first the crust would be sufficiently flexible to accommodate itself to the tidal movements of the subjacent liquid interstratum, but when it became too rigid to admit of this tidal movement it would be broken up, the fracture probably following certain fairly defined and assignable lines. It is argued that the fragments would not have 'gone under,' but would have remained with their surfaces at a considerably higher level than the surface of the magma, and have become so fixed by consolidation of the magma around them.

It is suggested that the first great breach in the crust followed the outline of the tidal protuberance, and was, in all probability, effected at some conjunction of the sun and moon with cataclysmal suddenness, the intervening crust being shivered into small fragments, these fragments being subsequently disposed of by fusion in and incorporation with the magma. The first oval breach thus caused is the prototype of the Pacific Ocean. Further fractures, it is suggested, gave rise to the other oceans, and caused the separation of the continents. Under the influence of tidal retardation the fragments as thus blocked out became separated and finally moored at their respective distances by the solidification of the magma around them.

With the resolidification of the crust, a series of stresses was set up between the ocean basins, which consisted of the more basic, consequently specifically heavier, more quickly conducting material, and the more acid, specifically lighter, more slowly conducting continental masses. The former are, in consequence of their character and composition, the more stable portions of the resolidified crust. Further cooling therefore leads to their sinking down on the cooling and shrinking nucleus, and their elbowing aside of the continental masses, which come to be elevated in lines parallel to and extending along their margins. With further cooling the superficial layers of the continents are thrown into folds and overfolds, which would tend to find relief along the ocean margins by thrusts directed from the continents towards the oceans. Central uplifts in the continental areas also may have resulted from such pressure.

The tendency of the ocean to become deeper and the continent to become more elevated as time goes on, leads more and more to the withdrawal of the waters of the ocean (which might at first almost or altogether have covered the continental areas) from these areas, and hence to greater and greater restriction in the limits of the areas of deposit as traced from earlier to later geological times.

[1] Abstract of paper read before the British Association, Southport, Section C (Geology), September, 1903.

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The origin of the Mediterranean is separately dealt with, and the cause of the unequal distribution of land and sea in the northern and southern hemispheres is discussed.

Though the contraction of the ocean basins has been the main cause of the deformation of the crust, the contraction of the continental areas has also had some share in the result. The central ridge of the Atlantic bottom may be an earth fold caused by pressure of the contiguous continental masses; but it may also be due to longitudinal fissures permitting volcanic action and consequent accumulation of volcanic products, the fissures in such case marking the relief of tension arising from the same cause.

The formation of secondary ridges parallel to the oceano-continental margins, but at some distance towards the continental side, seems to have played an important part in the evolution. Extending oceanwards in their operation they appear in some instances to have raised up portions of the ocean bottom into continuity with the land surface. In this way, with the aid of volcanic action, the ocean basins appear, in not a few instances, to have been successfully bridged. As the permanency of the master features of the globe in much their present form is a necessary corollary of the theory, such bridging of the ocean basins also becomes a necessary part of the theory, and is fairly met on the lines indicated.

Explaining as it does the general outlines of continents and ocean basins, as well as a large number of facts both in geography and geology, it is contended that the theory as sketched does represent in a general way the actual process by which the permanent features of the globe took origin.

III.—On the Lakes of the Upper Engadine. By André Delebecque.[1]

ONE of the most striking instances of a long depression forming a pass between two valleys, and occupied by a series of lakes, is to be seen in the strip of land which extends between St. Moriz and the Maloja. It is occupied by the four lakes of Sils, Silva Plana, Lampfer, and St. Moriz, with a depth of 71, 77, 34, and 44 metres respectively. The level of these lakes ranges between 1,771 and 1,800 metres. The lake of St. Moriz is obviously in a rock-basin.

As to the other three lakes, an opinion concurrently prevails which, though supported by the high authority of Professor Heim, is believed by the author to be unjustified. It is generally thought that the river Inn, weakened by the capture of some of its tributaries by the river Maira, has been unable to sweep away the deposits of the torrents descending from lateral valleys, and that consequently its waters have been dammed up into the three lakes in question.

An attentive survey of the region shows that, on the contrary, these lakes formerly constituted a single sheet of water in a rock-basin, which extended from the Maloja to the village of Lampfer, in both of which places ledges of gneiss are visible, and that the

[1] Abstract of paper read before the British Association, Southport, September, 1903, in Section C (Geology).

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lateral torrents, far from contributing to the formation of the lakes, have partly filled them up by their deposits, and have divided into three what was occasionally a single basin.

The length of the original lake was remarkable, as it measured no less than 12 kilometres (7½ miles), and it must be borne in mind that though mountain lakes are often very deep their horizontal dimensions are generally limited.

As to the origin of the lake, the author is of opinion that it cannot be attributed to tectonic movements cr to aqueous erosion, and that very probably glacial excavation has come into play.

IV.—Geology of the Country round Southport. By J. Lomas, A.R.C.S., F.G.S.[1]

LOOKING towards Southport from the sea, we notice three platforms rising in gigantic steps towards the east.

The first is low, varying in height from 9 to 20 feet above Ordnance datum, and is fringed on the seaward side by sandhills which rise to an elevation of from 50 to 90 feet. On the north the broad estuary of the Ribble separates this plain from a similar platform known as the Fylde district, and the Mersey on the south cuts off another fragment which forms the north end of the Wirral. Two less significant streams, the Douglas and the Alt, flow across the platform into the Ribble estuary and the Crosby Channel respectively.

The whole of this plain is the gift of the Irish Sea glacier, which formerly overrode the district, the solid rocks only reaching the surface in the case of a few islands, while the bulk is below sea-level.

In the immediate neighbourhood of Southport, Keuper marls occur. These are of great thickness, and contain bands of gypsum and pseudomorphs of rock-salt. To the north, in the Fylde district, where similar rocks occur, salt is obtained from the beds, and the boulders of gypsum which occur in great profusion in the local drift have evidently come from this formation.

The Bunter rocks of the Trias succeed to the east, and are in places capped by Keuper sandstones. Where these occur we reach the second platform.

At Ormskirk, distant about eight miles from Southport, several interesting sections show the Keuper resting on the Upper Bunter. At Scarth Hill, near the Water Tower, the relations between Keuper and Bunter are well displayed, and the quarries are worth visiting. Probably nowhere in the district do the Bunter sandstones display such clear evidence of their æolian origin. They consist of sand-grains perfectly rounded and polished, each bed containing grains of uniform size. So perfect is this sifting that it looks as if the layers had been passed through sieves of varying meshes. In some layers the grains are 2 mm. in diameter, and in others they are exceedingly fine. A comparison of these sands with others from the Sahara and

[1] Abstract of paper read before the British Association, Southport, Section C (Geology), September, 1903.

sand-dunes shows clearly the distinction between the deposition by wind agency and in water. Faults traversing the Triassic rocks conform to the general N. and S. direction so characteristic of Lancashire and Cheshire, and these are joined by E. and W. faults, which, as a rule, have little or no throw. It seems as if the N. and S. buckling which caused the main faults had cut up the rocks into blocks, and the E. and W. faults mark the units which dropped successively in the individual blocks.

Further to the east the Bunter rocks give place to Coal-measures, but at one or two places in the area, as at Skillaw Clough and Bentley Brook, thin beds of Permian age intervene.

Succeeding the Coal-measures, Millstone Grit appears in the next platform, which forms the hills above Chorley and Horwich. An outlier of Millstone Grit also occurs at Parbold, further to the west.

The disposition of the rocks already given indicate an approach towards the arch of the great Pennine anticline, and on crossing the Pennine chain a similar succession, in the reverse order, is met with in Yorkshire.

The matter is complicated, however, by the occurrence of another line of folding which shows itself in the Rosendale anticline, running E.N.E. to W.S.W.; and it is owing to this cross folding that the Millstone Grit is brought to the surface on Anglezark Moor and at Parbold.

As a result of this folding the main faults in the Carboniferous area run parallel with the anticline, and the cross faults at right angles to the faulted blocks are characterised by having only a slight throw.

Returning now to the first platform, we find the chief interest lies in the glacial and post-glacial deposits which cover the area. The surface of the Boulder-clay is very uneven, and in the hollows meres have been found. Many of these have since been filled with peat, and tree trunks, both prone and erect, are found enclosed in it. A great number of these meres, or mosses, are seen, not only about Southport, but in the Fylde, in South Lancashire, and the northern part of Cheshire.

In all cases they either drain eastwards or formerly did so. Borings in the peat show that they often extend below sea-level, and there must have existed barriers which prevented the waters from reaching the Irish Sea. It has been estimated that the coasts in the neighbourhood are being eroded, in some places at the rate of five yards a year; so that 400 years ago the land would extend more than a mile seawards; and if the same rate of waste has obtained since the Glacial period there would be a land of meres and mosses extending as far as the Isle of Man. It is possible that the Irish elk found in the Isle of Man crossed by this lost land.

Along the coast meres can be seen in all stages of decay. Immediately to the east of Southport lies Martin Mere, which is only separated from the sea by a narrow bank at Crossens. At the Alt mouth, at Leasowe, in Cheshire, and in other places, the ancient meres have been cut in two by the sea, and we have peat and tree trunks on the coast below high-water level. These are usually spoken of as 'submerged forests,' and their occurrence in the places mentioned may indicate a lowering of the surface of the land since the trees grew.

The present mouths of the Mersey, Alt, Douglas, and Ribble have all been cut through ancient meres, and as there is evidence that these formerly drained to the east it is probable that the breaching of the meres has resulted in a reversal of flow since Glacial times, and the present mouths are of comparatively recent date.

The sandhills on the coast only occur in districts adjacent to rivers. It is probable that they owe their origin to the material brought down by the rivers, forming a bank of sand in the slack water at each side of their channels. These banks drying at low water, the sand has then been blown inland by the prevailing south-west winds. No dunes existed in this district 400 years ago, and they are probably subsequent to and result from the reversal of the drainage of the Mersey and Ribble.

V.—Diatomaceous Earth at Lake Gnangara, Western Australia.

THE Government Geologist of Western Australia reports the discovery of an extensive deposit of Diatomaceous earth at Lake Gnangara, in the Wanneroo district. It is composed almost entirely of the skeletons of Diatoms, and of the spicules of fresh-water sponges (Spongilla). The main deposit forms a quaking bog, with a smooth surface, starting immediately at the foot of the sandy banks on the northern shore of the lake at a height of a few inches above water-level, and sloping gradually towards the lake, beneath the surface of which it passes. The whole deposit is covered with a scanty growth of reeds, and, from all appearances, is still in process of formation. The deposit occupies the northern and western edges of Lake Gnangara, a permanent fresh-water lake eleven miles due north from Perth, and about four miles north-east of Wanneroo. Under the microscope, the earth is seen to be composed of a felted mass of siliceous spicules, in which are embedded numerous diatom frustules, of perfect form. They belong mainly to the groups of *Naviculeæ* and *Eunotieæ*, a very large species of *Pinnularia* being especially noticeable. The genus *Bacillaria*, which is said to yield the best dynamite, is apparently entirely absent. The Wanneroo earth would not appear to be well suited for the manufacture of dynamite, owing to the high percentage of alumina in it, and also owing to the forms of the diatoms present in it. It is, however, eminently suited for the manufacture of disinfectants by the absorption of phenol, etc., as well as for lining cold-storage rooms, and railway wagons, and as an ingredient for refrigerating paint. Owing to the extremely small percentage of iron and other mineral impurity present, it would be an excellent source of silica for the manufacture of soluble and other glass. It could also be used as an ingredient of metalpolishing powders and soaps. For all these purposes it would require to be calcined and crushed.

VI.—A Method of Facilitating Photography of Fossils, by Gilbert van Ingen.

A SIMPLE apparatus has been devised by which a fossil of any size can be coated with a thin, opaque, white film which effectually illuminates under the influence of both colour and reflected light. The necessary articles for construction of the apparatus are: a foot-blower, large wide-mouthed bottle of gallon capacity, with three-holed rubber stopper, two bottles of quart capacity, each with two-holed rubber stopper, glass tubing of one-eighth-inch bore and rubber tubing to fit same (three feet of each), two U-shaped calcium chloride tubes filled with chloride, strong ammonia water, strong HCl. To use: Air from the foot-blower is forced into the large bottle, which equalises the pressure, and thence through the ammonia water and HCl into the smaller bottles. The air, mixed with the gases taken up, is passed through the calcium chloride tubes, where the moisture is extracted, and escapes through the two glass tubes held in the hands at a short distance from the object to be coated. The union of the two gases escaping from the tubes forms ammonium chloride, which settles as an exceedingly fine powder upon the surface of the specimens. The coating thus obtained, when deposited slowly, is of a dead white, which effectually hides all coloration of the surface, and, instead of obliterating the finer modelling, renders the details of the topography with the utmost distinctness. Some surfaces take the coating more readily than others. Fine-grained black limestones and all other rocks that present a velvety surface take the coating well. Porous rocks are difficult to cover. Specimens which have been handled must be washed with benzene. The coating of the salt is perfectly harmless, and may readily be removed by water, gentle heating, or the use of a soft brush. Photographs of such coated specimens fulfil more nearly the requirements of the work than do those taken by the ordinary methods. The coating is also of great assistance in the elucidation of the details of small species, as was found to advantage while studying the lobation of the heads of small trilobites.—*Annals N.Y. Acad. Sci.*, xiv, pp. 115, 116; March, 1902.

REVIEWS.

I.—Annual Reports of the Geological Commission of the Cape of Good Hope for the Years 1901 and 1902.

THESE two volumes, issued by the Department of Agriculture of the Cape of Good Hope, reach the same standard of excellence as previous publications, both with respect to the style in which they are presented and the important and interesting matter they contain.

Since the last Report the Scientific staff has undergone some change. Dr. G. S. Corstorphine retired from the Directorship in 1901, and was succeeded by Mr. A. W. Rogers under the title of

Acting Geologist, with a field staff consisting of Messrs. E. H. L. Schwarz and Alex. L. du Toit; while Miss M. Wilman acts as Museum Assistant.

The field work for the two years embraced by the Reports chiefly lay among rocks ranging in age from the Karroo formation upwards, the older rocks forming in proportion only a small amount of the area examined. The account of the Karroo beds, with their numerous and peculiar reptilian remains, and the great extent of the volcanic and igneous activity displayed, affords interesting reading. Very suggestive, too, are the remarks by Mr. Schwarz on the lavas of the Drakensberg and on the line of volcanoes trending parallel with the eastern coast, implying a line of weakness and an axis of folding in this direction. He naturally concludes that the shelving sea-shores at present existing off the southern coast may be explained by the gradual sinking of the sea-bottom without rupture, and that there is no necessity to invoke the aid of great faults.

The Cretaceous rocks and Superficial Deposits are carefully and fully described, while questions of economic importance receive due attention. A petrological account of the Rocks of Matatiele, by Mr. Schwarz, accompanies the Report for 1902, and the geological maps of parts of the Division of Matatiele and of the Igneous Rocks of Kentani, though somewhat roughly reproduced, will be found a distinct addition to the Reports.

It is a matter for congratulation that the fossils collected since the commencement of the Survey are in the hands of specialists, and that the descriptions are to be published in a special volume of the Annals of the South African Museum. We hope that good figures will accompany the descriptions.

The Report for 1901 contains an account of a journey from Swellendam to Mount Bay; a general survey of the rocks in the southern part of the Transkei and Pondoland, including a description of the Cretaceous rocks of Eastern Pondoland; and a Geological Survey of the Division of Kentani. The work, owing to the war. had to be carried on in the native reservation, instead of being continued in the Western Provinces, and this somewhat breaks the thread of previous Reports. The results obtained are, however, of considerable interest. The account of the igneous intrusions in Pondoland deserves especial attention, more particularly the following passage:—"Along the banks of the Great Kei River, north of the Bridge, there are some very fine examples of the laccolitic form of intrusion of the dolerite, but what strikes one at once is that the sedimentary rocks do not seem to have been arched up over the dome-shaped masses of igneous rocks; the contacts are not well shown, but it certainly looks as if the strata had disappeared in the space occupied by the igneous rocks, and the ends of the beds seem to abut against the rounded contours of the dolerite, a fact which we again and again noticed throughout the Territories, and which was beautifully shown in the sections of actual contacts along the Kentani coast."

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Among other points of interest we may notice the description of the richly fossiliferous Cretaceous rocks (Umtamvuna Beds of Mr. Dunn's map, Izinhluzabalungu deposits of Griesbach); and the field evidence obtained as to the correlation of the Enon Conglomerate and Uitenhage Series.

The Report for 1902 contains an excellent summary of the year's work by Mr. Rogers, which consisted of an examination of the Matatiele Division by Mr. Schwarz, and parts of the Divisions of Beaufort West, Prince Albert, and Sutherland, by Messrs. Rogers and Schwarz. The account of the volcanic rocks of Matatiele by Mr. Schwarz contains much interesting matter, not the least important being the discovery of a whole series of volcanic necks in such positions as indicate that large parts of the Drakensberg and Maluti Ranges were formerly chains of volcanoes, and that they owe their elevation to these causes.

The higher parts of East Griqualand, Mr. Schwarz considers, offer a good field for the search for workable seams of coal, which would probably lie on about the same horizon as those of Indwe.

In the Western Province a nearly complete skeleton of *Pareiasaurus serridens*, weighing 700 lbs., was obtained and sent to Cape Town, where it is to be set up in the Cape Museum. Many other reptilian remains of great interest were also obtained, and the belief is expressed that the Karroo System will be satisfactorily subdivided by their means when they are sufficiently collected and described.

Not the least welcome feature of the Report for 1902 will be the following table of the classification of the Sedimentary Rocks of the Colony, of which we hope Mr. Rogers' anticipation that it will not require any considerable alteration in the near future will be realized :—

SUPERFICIAL DEPOSITS.	Dune sands, and limestone derived from them. Alluvial muds, sands, and gravels near the present levels of the rivers. Laterite. Estuarine deposits containing foraminifera and *Cryptodon globosus*. Quartzitic rocks and ironstone gravels, representing older river deposits and laterites.		
	Pondoland Cretaceous Series.		
	Uitenhage Series.		
			In the Transkei.
KARROO SYSTEM.	STORMBERG SERIES.	Volcanic Beds. Cave Sandstone. Red Beds. Molteno Beds.	
	BEAUFORT SERIES.	Zone of Specialized Theriodonts.	Kentani Beds.
		Dicynodon Beds. *Pareiasaurus* Beds.	Idutywa Beds.
	ECCA SERIES.	Shales and thin sandstones. Laingsburg Beds. Shales.	Umsikaba Beds.
	DWYKA SERIES.	Upper Shales. Conglomerate. Lower Shales.	

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CAPE SYSTEM. { Witteberg Series.
Bokkeveld Series.
Table Mountain Series.

PRE-CAPE ROCKS:—
In the south and west of the Colony—
Ibiquas Series.
Cango Series.
Malmesbury Series.
In the north and north-west of the Colony—
Matsap Series.
Griqua Town Series.
Campbell Rand Series.
'Keis Series.
Namaqualand Schists (?).

The age of the pre-Cape Rocks (Primary of Schenck), among the different members of which two, and probably three, unconformities have been detected, is left an open question; it being only suggested that some of them may eventually prove to be of Lower Palæozoic age. We ourselves have been struck with their many resemblances to the pre-Cambrian rocks of India. The overlying, unconformable Cape System is considered to be probably the equivalent of the Lower Devonian of other countries. The classification of Schenck is adopted for the Karroo System, excepting in the separation of the Dwyka Series from the Ecca Beds. Whether the Uitenhage Series and the Cretaceous Series of Pondoland may be placed together in a Cretaceous System depends upon the results obtained by the palæontologists, who have not definitely settled the age of the Uitenhage fauna and flora. WALCOT GIBSON.

II.—PETROGRAPHISCHES PRAKTIKUM: ZWEITER TEIL: GESTEINE. By Dr. REINHOLD REINISCH. Large 8vo; pp. vii, 180. Berlin, 1904.

THIS is a practical guide to the study of rocks, written by one familiar with teaching. The characters of the several rock-forming minerals having been dealt with in the former part of the work, dated 1901, the author is able to plunge directly into the systematic description of the rocks themselves. About three-fifths of the book is devoted to the eruptive rocks, which are treated under comprehensive heads which we may call families. For each family the author gives a brief notice of the chief component minerals, the structural peculiarities, the more important types included in the family, and a selection of chemical analyses. The rather conventional arrangement is based on that of Zirkel, the principal divisions being characterized by the preponderance of alkali-felspars, of lime-soda-felspars, or of felspathoids, or by the absence of all these minerals. The discarding of the 'dyke-rocks' leads to confusion in some places, as e.g. when minette and vogesite are grouped with the orthophyres, etc. On the other hand, the distinction made in most of the families between the 'Alkali' and the 'Alkalikalk' groups is one which may profitably be impressed on the student. The practical point of view is constantly maintained in the treatment of the rocks; but there are at the end of this section a few pages dealing with petrogenesis and chemical classification, too condensed to be of much service.

The second section, on the sedimentary rocks, is concerned with precipitates (rock-salt, etc.), tuffs, sandstones, sinters, limestones, clays, etc.; while the third is devoted to the crystalline schists, a term used in a rather wide sense to include gneisses, granulites, mica-schists, eclogites, etc.

The work, though not professing to offer original information, will be found a useful handbook of descriptive petrography. It is clearly written; and the illustrations of the micro-structures of rocks, simply designed, are well adapted to their object. The only statement which we have to quarrel with occurs on the title-page, where the publication is post-dated by some two months.

A. H.

REPORTS AND PROCEEDINGS.

Geological Society of London.

November 4th, 1903.—Sir Archibald Geikie, D.Sc., F.R.S., Vice-President, in the Chair.

The Secretary announced the presentation, by Sir John Evans, K.C.B., D.C.L., F.R.S., For. Sec. G.S., of a platinotype portrait of himself.

The following communications were read:—

1. "Metamorphism in the Loch Lomond District." By E. Hubert Cunningham-Craig, Esq., M.A., F.G.S.[1]

The area dealt with includes all the Highland rocks on either side of the Loch, as well as the area lying to the eastward, including the Trossachs. Each stage of the progressive metamorphism can be accurately determined, and each process can be studied, as a rule, without confusing its effects with those of another process. The rocks from the Leny Grit Group and the Aberfoil Slate Group show dynamic metamorphism, which increases on a higher stratigraphical horizon—the Beinn-Ledi Group; and at Rudha Mor the beginning of the thermal type is seen. This is quickly superseded by a constructive metamorphism, probably of hydrothermal type, under which, combined with, or preceded by, the increasing dynamic metamorphism, the rocks become more highly crystalline, until all clastic structures are obliterated. The segregation of like minerals into folia, the total recrystallization, and the genesis of new mineral groupings, result finally in the production of coarsely crystalline albite-gneisses from a series of fine and coarse siliceous and felspathic grits. Contact with plutonic igneous masses obliterates many of the results produced by hydrothermal, constructive, metamorphism.

[1] Communicated by permission of the Director of H.M. Geological Survey.

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