NOTICES OF MEMOIRS.

I.—British Association for the Advancement of Science. Sixty-fifth Annual Meeting, held at Ipswich, Sept. 11–18, 1895.

List of Papers read in Section (C), Geology.

William Whitaker, B.A., F.R.S., F.G.S., President.

The President's Address. (See p. 461.)

F. W. Harmer.—The Southern Character of the Molluscan Fauna of the Coralline Crag tested by an Analysis of its Abundant and Characteristic Shells.

F. W. Harmer.—The Derivative Shells of the Red Crag.

H. W. Burrows.—Notes on the Stratigraphy of the Crag, with especial reference to the Distribution of the Foraminifera.

H. B. Woodward.—Note on a Section at the North Cliff, Southwold.

John Spiller.—Recent Coast-Erosion at Southwold and Covehithe.

Rev. E. Hill.—Observations on East Anglian Boulder-clay.

Rev. E. Hill.—Indications of Ice-raft Action through Glacial Times.

Rev. E. Hill.—On Traces of an Ancient Watercourse in West Suffolk.

Clement Reid and *H. N. Ridley.*—Further Notes on the Arctic and Palæolithic Deposits at Hoxne.

W. Whitaker.—Some Suffolk Well-sections.

Prof. W. J. Sollas.—Pitch Glaciers or Poissiers, and Illustrations of Glacier Movements.

Clement Reid.—Notes on the Cromer Excursion.

Prof. W. B. Scott.—On the Tertiary Lacustrine Formations of North America.

R. B. White—The Glacial Age in Tropical America.

Beeby Thompson.—Pre-Glacial Valleys in Northamptonshire.

W. W. Watts.—Notes on some Snowdonian Tarns.

Dugald Bell.—Report of the Committee on the High-level Shell-bearing Deposits of Clava, etc.

Rev. E. Jones.—Report of the Committee on the Calf-Hole Cave.

B. Harrison.—Report of the Committee on the High-level Flint-drift near Ightham.

C. E. de Rance.—Report of the Committee on the Rate of Erosion of Sea Coasts.

C. E. de Rance.—Report of the Committee on Underground Waters.

J. Lomas and *P. F. Kendall.*—Observations on Modern Glacial Striæ.

T. V. Holmes.—Notes on the Ancient Physiography of South Essex.

Prof. O. C. Marsh.—Restorations of some European Dinosaurs, with suggestions as to their place among the Reptilia.

J. Parker.—Report of the Committee on *Cetiosaurus*.

Prof. E. W. Claypole.—On the Cladodonts of the Upper Devonian of Ohio. (See p. 473.)

Prof. E. W. Claypole.—On the Great Devonian Placoderms of Ohio. (See p. 473.)

Montagu Browne.—Preliminary Notice of an Exposure of Rhætic Beds near East Leake, Notts.

G. F. Dollfus.—Probable Extension of the Seas during Upper Tertiary Times in Western Europe. (See p. 474.)

E. Van den Broeck.—On the present state of our knowledge of the Upper Tertiary Strata of Belgium.

Marcellin Boule.—Discovery of Fossil Elephant Remains at Tilloux (Charente).

Prof. J. Milne.—Earth Movements observed in Japan.

Prof. J. Milne.—Report of the Committee on the Volcanic and Seismological Phenomena of Japan.

Dr. H. J. Johnston-Lavis.—Report of the Committee on the Volcanic Phenomena of Vesuvius.

C. Davison.—Report of the Committee on Earth Tremors.

Prof. W. J. Sollas.—Report of the Committee on the Investigation of a Coral Reef.

O. W. Jeffs.—Report of the Committee on Geological Photographs.

Dr. F. H. Hatch.—The Auriferous Conglomerates of the Witwatersrand, Transvaal.

E. A. Walford.—Report of the Committee on the "Stonesfield Slate."

E. A. Walford.—Note on the Strata of the Shaft sunk at Stonesfield, Oxon, in 1895.

W. Whitaker.—The Trial-boring at Stutton.

Joseph Francis.—The Dip of the Underground Palæozoic Rocks at Ware and at Cheshunt.

F. W. Harmer.—The Importance of Extending the Work of the Geological Survey of Great Britain to the Investigation of the Deep-seated Rocks, by means of Boring. (See p. 476.)

Prof. H. A. Nicholson and *J. E. Marr.*—Notes on the Phylogeny of the Graptolites.

E. J. Garwood and *J. E. Marr.*—Zonal Divisions of the Carboniferous System. (See p. 474.)

Prof. T. R. Jones.—Report of the Committee on Palæozoic Phyllopoda.

M. Laurie.—Report of the Committee on the Eurypterid-bearing Deposits of the Pentland Hills.

Dr. H. Woodward.—On some Decapod Crustaceans from the Cretaceous Formation of Vancouver Island.

A. Smith Woodward.—Report of the Committee on the Registration of Type Specimens.

P. F. Kendall.—Report of the Committee on Erratic Blocks.

TITLES OF PAPERS BEARING ON GEOLOGY READ IN OTHER SECTIONS.

Report on Cosmic Dust.

Report on Underground Temperature.

A. Gobert.—The Gobert Freezing Process for Shaft-sinking and Tunnelling under Rivers.

J. Vivian.—East Anglian Coal Exploration, description of machinery.

W. J. Knowles.—On striated Flint Implements from North Ireland.

B. Harrison.—Report on Plateau Flints of North Kent.

H. Stopes.—Graving Tools from Terrace Gravels of Thames Valley.

H. Stopes.—Palæolithic Projectiles.

Graf Solms-Laubach.—On a new form of Fructification in *Sphenophyllum.*

C. W. Andrews.—On Stereornithes. (See p. 472.)

Dr. D. H. Scott, F.R.S.—Chief results of Williamson's work on the Carboniferous Plants.

A. C. Seward.—The Wealden Flora of England.

Wm. Barlow.—On the Relation between the Morphological Symmetry and the Optical Symmetry of Crystals.

Dr. F. H. Hatch.—Gold Production in the Witwatersrand Fields.

Dr. Conwentz.—On English Amber, with Exhibition of Specimens.

Dr. J. G. Garson.—A Palæolithic Skeleton from the Thames Valley.

II.—British Association for the Advancement of Science, Ipswich, 1895.—Underground in Suffolk and its Borders: Address to the Geological Section. By W. Whitaker, B.A., F.R.S., F.G.S., President of the Section.

WHEN the British Association revisits a town it is not unusual for the Sectional Presidents to refer to the addresses of their local predecessors, and to allude to the advance of their science since the former meeting. I have at all events tried to follow this course, with the sad result of having to chronicle a falling back rather than an advance in our methods of procedure; for at the meeting of 1851 all the Sectional Presidents had the wisdom not to give an address, and of all the inventions of later years I look upon the presidential address as perhaps the worst.

Had I the courage of my opinion I should not now trouble you; but an official life of over thirty-eight years has led me to do what I am told to do, and to suppress my own ideas of what is right. After all it is the fault of the Sections themselves that they should suffer the evil of addresses. They could disestablish the institution without difficulty.

On these occasions it is not usual to allude to the personal losses our science has had in the past year; but there are times when the lack of a familiar presence can hardly be passed over, and since we last met we have lost one of our most constant friends, who had served us long and well, and had been our Secretary for a far longer time than any other holder of that office. When we were at Oxford last summer none of us could have thought that it was our last meeting with William Topley.

I do not now mean to say anything on the origin or on the classification of the various divisions of the Crag and of the Drift that occur so plentifully around us, and form the staple interest of East Anglian geology. These subjects, which are the more interesting from being controversial, I leave to my brother-hammerers, and without claiming the credit of magnanimity in so doing, having said what I had to say on them in sundry Geological Survey memoirs. The object of this address is to carry you below the surface, and to point out how much our knowledge of the geology of the county in which we meet has been advanced by workers in another field, by engineers and others in their search for water. As far as possible allusion will be made only to work in Suffolk; but we must occasionally invade the neighbouring counties.

This kind of evidence has chiefly accumulated since the meeting of the Association at Ipswich in 1851; for of the 476 Suffolk wells of which an account, with some geologic information, has been published, only 68 were noticed before that year, all but two of these being in a single paper. The notes on all these wells are now to be found in twelve Geological Survey memoirs that refer to the county. Number alone, however, is not the only point, and many of the later records are marked by a precision and a detail rarely approached in the older ones. It should be stated that in the above and in the following numbers strict accuracy is not professed, nor is it material. A slight error in the number of wells, one way or the other, would make practically no difference to the general conclusions.

Now let us see how these records affect our knowledge of the various geologic formations, beginning with the newest and working downward.

The Drift.—Under this head, as a matter of convenience for the present purpose, we will include everything above the Chillesford Clay. There is no need for refinement of classification, and the thin beds that come in between that clay and the Drift in some parts do not affect the evidence we have to deal with.

As a matter of fact, it is only from wells that we can tell the thickness of the Drift over most of the great plateau that this formation chiefly forms; open sections through a great thickness of Drift, to its base, are rare, except on the coast.

There is often some doubt in classifying the beds, the division between Drift and Crag being sometimes hard to make in sections of wells and borings; but from an examination of the records of these Suffolk sections that pass through any part of the Drift Series (as defined above) we find that no less than 173 show a thickness of 50 feet and upward, whilst of these 34 prove no less than 100 feet of Drift, many reaching to much more. Of the two that are said to show a thickness of over 200 feet and the one said to be more than 300 feet deep in Drift, we can hardly feel certain; but such amounts have been recorded with certainty as occurring in the neighbouring county of Essex.

These great thicknesses (chiefly consisting of Boulder-clay) show the importance of the Drift, and the impossibility of mapping the formations beneath with any approach to accuracy, on the supposition that the Drift is stripped off, as is the case in the ordinary geologic map. The records also show the varying thickness of the Drift, and how difficult it often is therefore to estimate the thickness at a given spot. Sometimes the sections seem to point to the existence of channels filled with Drift, such as are found also in Essex and in Norfolk; and it may be noted that in the northern inland part of the former county, one of these channels has been traced, though of course not continuously, for some eleven miles along the valley of the Cam, and at one place to the depth of 340 feet (or nearly 140 below sea-level), the bottom of the Drift moreover not having been reached even then. A channel of this

sort seems to occur close to us, in the midst of the town of Ipswich, where, by St. Peter's, one boring has pierced 70 feet of Drift, and another 127, in ground but little above the sea-level.

As the Drift sands and gravels, that in many places occur below the Boulder-clay, often yield a fair amount of water, the proof of their occurrence and of the thickness of the overlying clay is of some practical good.

The Crag.—On this geologic division we have a less amount of information, as would be expected from the fact that it is not nearly so widespread as the Drift, and this information is confined to the Upper or Red Crag, the Lower or Coralline Crag occurring only over a very small area, and no evidence of its underground extension being given by wells.

What we learn of the Red Crag, however, is of interest, several wells having proved that it is far thicker underground than would have been supposed from what is seen where its base crops out. One characteristic, indeed, of this sandy deposit, in the many parts where it can be seen from top to bottom, is its thinness, as in such places it rarely reaches a thickness of 40 feet. But, on the other hand, wells at Hoxne seem to prove more than 60 feet of Crag, whilst at Saxmundham the formation is 100 feet thick, and at Leiston and Southwold over 140. Further north, just within the border of Suffolk, there is, at Beccles, a thickness of 80 feet of sand, or, with the overlying Chillesford Clay, a total of 95. Our underground information has, then, trebled the known thickness of the Upper Crag of Suffolk.

It has also shown that at some depth underground the colour-name is a misnomer, the shelly sands being light-coloured and not red. This is the case, too, with some other deposits, which owe their reddish-brown colour at the surface to peroxide of iron. Presumably the iron-salt is in a lower state of oxidation until it comes within reach of surface actions. This seems to point to the risk of taking colour as the mark of a geologic formation.

Eocene Tertiaries.—Below the Crag there is a great gap in the geologic series, and we come to some of the lower of the Tertiary formations, about which little had been published, as regards Suffolk, before the work of the Geological Survey in the county. It seems as if the special interest in the more local Crag had led observers to neglect these beds, which had been amply noticed in other parts.

We have records of more than forty wells in Suffolk that are partly in these deposits, and of these thirty-six reach down to the Chalk, twenty giving good sections from the London Clay to the Chalk. The thickness of the Lower London Tertiaries (between those formations) thus proved varies from 30 to 79½ feet, the higher figure being much greater than anything shown at the outcrop. The greatest recorded thickness is at Leiston, where, moreover, the top 26 feet of the 79½ may belong to the uppermost and most local of the three divisions of the series, the Oldhaven Beds, of very rare occurrence in the county. The next greatest thickness is at Southwold, where the whole has been classed as Reading Beds (the

persistent division), though here and elsewhere it is possible that the underlying Thanet Beds are thinly represented. It is noteworthy that at both these places, where the Lower London Tertiaries are thick, they are also at a great depth, beginning at 252½ and 218 feet respectively, which looks as if, like the Crag, they thickened in their underground course away from the outcrop.

The important evidence given by these wells, however, is not as regards thickness; it is to show the underground extent of the older Tertiary beds, beneath the great sheet of Crag and Drift that prevents them from coming to the surface north-eastward from the neighbourhood of Woodbridge. It is clear that over this large tract we can know nothing of the beds beneath the Crag otherwise than from wells and borings; and, until these were made, our older geologic maps cut off the older Tertiary beds far south of the parts to which we now know that they reach, though hidden from our sight. No one, for instance, would have imagined many years ago that at Southwold the Chalk would not be touched till a boring had reached the depth of 323 feet, or some 280 below sea-level, nor that at Leiston those figures would have been about 297 and 240.

It is from calculations based on the levels of the junction of the Chalk and the Tertiary beds in many wells that the line engraved on the Geological Survey map as the probable boundary of the latter beds under the Crag and Drift has been drawn. From what has gone before, however, as to the great irregularity in the thickness of the Drift, it is clear that this line must be taken only as approximate, and open to correction as further evidence is got; albeit the junction of the Chalk and the Tertiary beds is found to be here, as elsewhere, fairly even, along an inclined plane that sinks towards the coast.

Cretaceous Beds.—Though the *Chalk* is reached by very many wells, yet we get less information about it, by reason of its great thickness. Moreover, the great amount of overlying beds in many cases is a bar to deep exploration.

Of our Suffolk wells there are forty which go through 100 feet or more of Chalk. Of these twenty go through 200 feet or more, half of these to 300 or more, and again half of the ten to 400 or more, a very exact piece of geometric progression, or more strictly, retrogression. Although two wells pass through the great thickness of more than 800 feet of Chalk, yet neither of them gives us the full thickness of the formation; for the 816 feet at Landguard Fort do not reach to the base, whilst the 843 (or 817) feet at Combs, near Stowmarket, do not begin at the top.

As in no case yet recorded has the Chalk been pierced from top to bottom in Suffolk (a defect that will be supplied during this meeting by the description of the Stutton boring), that is to say, no boring has gone from the overlying older Tertiary beds to the underlying Gault, we must now, therefore, cross the border of the county to get full information as to the thickness of the Chalk; and we have not far to go, for the well-known Harwich boring passes through the whole of the Chalk, proving a thickness of 890 feet. It is almost

certain, indeed, that this should be given as a few feet more, for the 22 feet next beneath, which have been described as Gault mixed with Greensand, is probably in part the green clayey glauconitic base of the Chalk Marl. We may fairly add for this another 5 feet (as also in the case of the Combs boring), and may say that, in round numbers, the Chalk reaches a thickness of about 900 feet in the south-eastern part of Suffolk. Toward the northern border of the county it is probably more, as the deep boring at Norwich passes through nearly 1,160 feet of Chalk, and that without beginning at the top of the formation.

Of our recorded Suffolk wells only three reach the base of the Chalk, at Mildenhall, Culford, and Combs; consequently we have little knowledge of the divisions of the Chalk. These divisions, indeed, are of comparatively late invention, having been evolved since the publication of many of the deep sections that have been referred to.

If the Upper Chalk at Harwich goes as far down as the flints, then we must allow it to be 690 feet thick, leaving little more than 200 for the Middle and Lower Chalk together. At Landguard Fort, from the same point of view, the Upper Chalk would certainly be 500 feet thick, and one cannot say how much more.

At Combs, on the other hand, flints have been recorded as present only in the top 27 feet of the Chalk; but whilst this may have been owing in part to the boring having passed between fairly scattered nodules, and in part perhaps to insufficient care in observation, at Harwich it is possible that some flints may have been carried down in the process of boring.

What evidence we have tends to show, however, that the Upper Chalk forms a good deal more than half, and perhaps about two-thirds, of the formation, the Middle and Lower Chalk being rather thin. This agrees with what is found in other parts where the Chalk is thick, extra thickness being chiefly due to the highest division. The glauconitic marly bed at the base seems to be well developed and to be underlain by the Gault clay; so that we have no good evidence of the occurrence of the Upper Greensand. This division may be thinly represented at Mildenhall, but it is difficult to classify some of the beds passed through in the old boring there.

As far as the *Gault* is concerned little of course is known; but that little points to this formation being unusually thin, presumably only 73 feet from top to bottom at Culford, and probably not more than between 50 and 60 at and near Harwich. In the north-western part of the neighbouring county of Norfolk it is well known to be still less, the clay thinning out northward along the outcrop, until at last there is nothing but a few feet of Red Chalk between the carstone of the Lower Greensand and the Chalk. The Gault being of much greater thickness around and under other parts of the London Basin, this thinning in Norfolk and Suffolk is noteworthy. The absence of the more inconstant Upper Greensand is to be expected in most places, and calls for no remark; it may, however, be noted that geologists are coming to the conclusion that these two

divisions are really parts of one formation, and one result of this geologic wedding is for the inconstancy of one partner to be greatly compensated by the constancy of the other.

The *Lower Greensand* has been found in one deep boring only, at Culford, in the western part of the county, where it is represented by 32½ feet of somewhat exceptional beds. This slight thickness prepares us for underground thinning, and in the far east of the county the formation is presumably absent, there being no trace of it at Harwich or at Stutton.

With the Cretaceous beds we pass from the regular orderly succession of geologic formations; indeed, it may be said that when we reach the base of the Gault we pass out of the region of facts into the realm of speculation.

We have come then to perhaps the most interesting problem in the geology of the Eastern Counties, to the consideration of the question, What rocks underlie the Cretaceous beds at great depths? In dealing with this I must ask your patience for frequent excursions outside our special district, and sometimes indeed far away from it.

Beyond the outcrop of the lower beds of the Cretaceous Series in Cambridgeshire and Norfolk, we find of course a powerful development of the great Jurassic Series; but the only two recorded deep borings in and near Suffolk that have pierced through the Cretaceous base, at Culford on the north-west and at Harwich on the south-east, show not a trace of anything Jurassic: they pass suddenly from Cretaceous into far older rocks. And here a paper that is to be brought before you must be anticipated, to a slight extent, by adding that the trial-boring at Stutton shows just the same thing—the Gault resting directly on a much older rock, which cannot be classed as of Secondary age.

There is no need now to discuss the literature of the old rocks underground in South-eastern England: that has often been done. We may take the knowledge of what has been shown by the various deep borings as common property, and may use it freely, without troubling to state the source of each piece of information, and I will not therefore burden this address with references. I had indeed thought of supplementing a former account by noticing the later literature of the subject; but decided to spare you from the infliction, and myself from the trouble of inflicting; though it may be convenient to add, in the form of an appendix, a list of the chief papers on the subject that have been published since the question was discussed at length in 1889, in an official memoir on the geology of London, and to supply some omissions in that work. Nor do I propose to make any special criticism of papers on the subject that have appeared of late years; this is hardly the occasion for controversy, which may well be put off to a more convenient season. Some general remarks, however, I shall have to make after putting the facts before you.

There are 10 deep borings reaching to old rocks in the London Basin, of which accounts have been published. We find that in

4 of these (Meux's, Streatham, Richmond, and Dover) Jurassic beds separate those rocks from the Cretaceous beds; so that there are 6 in which these last rest direct on old rocks (Ware, Cheshunt, Kentish Town, Crossness, Culford, and Harwich). Stutton, of course, make a seventh. The Jurassic rocks occur only in the southern borings, either in London or still further southward, and in one case only (Dover) is there any considerable thickness of these: in the other 3 they are from 38½ to 87½ feet thick. As far as regards Suffolk and its borders we may therefore disregard them, except in the far west, near their outcrop, and we may pass on to consider the older rocks that have been found.

So far the occurrence, next beneath the Cretaceous or Jurassic beds, of Silurian, Devonian, and Carboniferous rocks has been proved, whilst in some cases we are still doubtful as to the age of the old rocks found. In 5 cases distinctive fossils have been found (Ware, Cheshunt, Meux's, Dover, and Harwich), but in 5 others they have not (Kentish Town, Crossness, Richmond, Streatham, and Culford), and it is in the latter group, too, that the character of the beds leaves their age in doubt. So far another must be added to these, as no fossil has yet been found in the old rocks at Stutton.

Of the above 10 deep borings in the London Basin (using that term in the widest sense, as including the Chalk tract that everywhere surrounds the Tertiary beds) we owe 9 to endeavours to get water from deep-seated rocks, and in addition to these 9 we have several other deep borings, which, though not carried through to the base of the Secondary rocks, yet give us much information concerning those beds (at Holkham, Norwich, Combs, Winkfield, London, Loughton, Chatham, and Dover). In one case only, that of Dover, has the work been done for the purpose of exploration, but now, after a few years' interval, a second trial has been made at Stutton.

Now both of these borings were started for a much more definite object than merely to prove the depth to older rocks, or the thickness of the Cretaceous and Jurassic Series. There is one particular division of those older rocks that has a distinct fascination for others than geologists. We, happily, are content to find anything and to increase our knowledge in any direction, but naturally those who are not geologists, as well as many who are, like to find something of immediate practical value. As already shown, we owe much knowledge of the underground extension of formations to explorations for water; it has now become the turn of geologists to help those who would like to find that much less general, though nearly as needful and certainly more valuable thing, *coal*.

The first place to suggest itself to those geologists who had worked at this question, as a good site for trial, was the neighbourhood of Dover, and for various good reasons. The trial has been made, and successfully, several hundred feet of Coal-measures having been found, without reaching their base, but with several beds of workable coal.

Beyond that neighbourhood, however, geologists are not in such accord, and generally speaking, fairly good reasons can be given both for and against the selection of many tracts for trial, except in and near London, where no geologists would recommend it, from the evidence in our hands.

Let us then shortly review the evidence that we have on the underground extension of the older rocks in South-eastern England, with a view of considering the question of the possibility of finding Coal-measures in any of the folds into which those rocks have probably, nay almost certainly, been thrown.

The area within which the borings that reach older rocks in the London Basin is enclosed is an irregular pentagon, from near Dover, on the south-east, to Richmond on the west, thence to Ware, thence to Culford on the north, thence to Harwich, and thence southward to Dover, the greatest distance between any borings being from Dover to Culford, about eighty-six miles. It is therefore over a large tract, extending, of course, beyond the boundaries sketched above, that we have good reason to infer that older rocks are within reasonable distance of the surface, nowhere probably as much as 1,600 feet, and mostly a good deal less.

We must now consider some evidence outside the tract hitherto dealt with. Southward of the central and eastern parts of the London Basin we have evidence that the Lower Cretaceous beds thicken greatly, from what is seen over their broad outcrop between the North and South Downs. We know also, from the Dover and Chatham borings, that the Upper and Middle Jurassic beds come in to the south-east, whilst the Sub-Wealden Exploration, near Battle, proves that those divisions thicken greatly southward, the latter not having been bottomed at the depth of over 1,900 feet at that trial-boring.

Westward, however, near Burford in Oxfordshire, and some miles northward of the nearest part of the London Basin, Carboniferous rocks have been found at the depth of about 1,180 feet, these being separated from the thick Jurassic beds (including therein the Liassic and Rhætic) by perhaps 420 of Trias. They consist of Coal-measures, which were pierced to the depth of about 230 feet.

In and near Northampton, north-eastward of the last site, and still further from the northern edge of the London Basin, the like occurs; but the beds found are older than the Coal-measures, and the Trias is thin, not reaching indeed to 90 feet in thickness, and being absent in one case. At one place, too, the Carboniferous beds have been pierced through, with a thickness of only 222 feet, when Old Red Sandstone was found, and in another place still older rock seems to have been found next beneath the Trias. The depth to the rocks older than the Trias, where they were reached, was 677, 738, and 790 feet, or respectively 395, 460, and 316 below sea-level. Some of these figures must be taken as somewhat approximate, though they are near enough to the truth for practical purposes.

A boring at Bletchley, to the south, reached granitic rocks at the

depths of 378½ and 401 feet; but these rocks seem to be only boulders in a Jurassic clay: their occurrence, however, is suggestive of the presence of older rocks at the surface no great way off, in Middle Jurassic times.

Much further northward, at Scarle, south-west of Lincoln, the older rocks have been reached at the depth of about 1,500 feet, all but 141 of which are Trias, and they begin with the Permian (which crops out some eighteen miles westward), the Carboniferous occurring after another 400 feet, and having been pierced to 130.

We have then evidence that over a large part of South-eastern England, reaching northward and westward of the London Basin, though the older rocks are hidden by a thick mantle of Jurassic, Cretaceous, and Tertiary beds, yet they seem to be rarely at a depth that would be called very great by the coal-miner. They are distinctly within workable depths wherever they have been reached.

There is no area of old rocks at the surface in our island, south of the Forth, in which Coal-measures are not a constituent formation. Truly, further north, in the great tract of Central and Northern Scotland there are no Carboniferous rocks; but we can hardly say that none ever occurred, at all events in the more southern parts. We know, though, that on the west and north Jurassic and Triassic beds rest on formations older than the Carboniferous.

It is not, however, to this more northern and distant tract that we should look for analogy to our underground plain of old rocks; rather should we look to more southern parts, to Wales and to Central and Northern England, where Coal-measures are of frequent occurrence. On the principle of reasoning from the known to the unknown, I cannot see why we should expect anything but a like occurrence of Coal-measures, in detached basins, in our vast underground tract of old rocks.

What, then, is the evident conclusion from what we know and from what we may reasonably infer? Surely that trials should be made to see if such hidden coal-basins can be found.

One trial has been made, and it has succeeded: the Dover boring has proved the presence of coal underground in Eastern Kent, along the line between the coal-fields of South Wales and of Bristol on the west, and those of Northern France and of Belgium on the east.

The long gap between the distant outcrops of the Coal-measures near Bristol and Calais has been lessened very slightly by the working of coal under the Triassic and Jurassic beds near the former place, but much more by our brethren across the narrow sea, the extent of the Coal-measures beneath the Jurassic and Cretaceous beds, having not only been proved by the French and the Belgians along their borders, but the coal having been largely worked. At last, we too have still further decreased the gap, by the Dover boring, a work that I trust is to be followed by other work along the same line.

But is this the only line along which we are to search? Are we to conclude that the only coal-fields under our great tract of

Cretaceous beds (where these are either at the surface or covered by Tertiary beds) are in Kent, Surrey, and other counties to the west? Have we no coal-fields but those of Bristol and of South Wales? The bounds of our midland and northern coal-fields have been extended by exploration beneath the New Red Series: are we to stop here and to assume that there can be no further underground extension of the Coal-measures south-eastward? This seems hardly a wise course, and is certainly a very unenterprising one. It seems to me rather that the right thing to be done is to try to find out the real state of things, by means of borings.

There are, of course, objectors in this as in other matters. Some may say that it is silly to try in Suffolk, and that Essex gives a better chance of success. Others, again, may prefer Norfolk. And yet others may argue that there is no chance of finding Coal-measures in any of those three counties. But I must confess my inability to understand this line of reasoning; the fact is, that the data we have are few and far between, and that we want more. It is really of little use to bandy words, and I do not now mean to take up the matter in detail. We cannot get at the truth except by actual work; justification by faith will not hold in this case, still less justification by unfaith.

Let us hark back a little and call to mind what has happened in the past. I remember the time when certain geologists disbelieved in the possibility of the occurrence of Coal-measures anywhere in South-eastern England, it being argued that the formation thinned out before it could get so far eastward. Then this view was somewhat varied, and it was inferred, from certain observed facts, that even if Coal-measures did reach underground into these benighted parts, they would be without workable coal, and so practically useless.

Now for some years nothing occurred to upset the prophets of evil, that is to say, no fact came to light. There were not wanting inferences to the contrary, but it remained practically a matter of opinion. One day, however, the needful fact came, and the first boring made specially to test the question (at Dover) disproved both the above negative theories by finding Coal-measures with workable coal. Let us hope that a like result may happen in East Anglia, and that the pessimists may again be in the wrong.

We should not, however, fall into the opposite error, that of optimism. We must not expect an immediate success like that at Dover. We are here much further from any known coal-field. Advertisements of various wares sometimes tell us that "one trial will suffice," but it is not so in this case. We should not be content until many borings have been made, and we should not be despondent if, after sites have been selected to the best of our judgment, we begin with a set of borings that are unsuccessful in finding coal.

At the time of writing I cannot say that the Stutton boring is a success or a failure as far as coal is concerned, but I am quite ready to accept the latter without being discouraged. Whatever it is you

may know during our meeting; it is certainly a success in the matter of reaching the old rocks at a depth of less than 1,000 feet. We should remember that every boring is almost certain to give us some knowledge that may help in future work.

There is a further point, however, to be taken into account. A boring that may at first seem to be a failure, from striking beds older than the Coal-measures, may some day turn out otherwise. The coal-field along the borders of France and Belgium is sometimes affected by powerful and peculiar disturbances, by faults of comparatively gentle inclination (far removed from the usual more or less vertical displacements) which have thrown Coal-measures beneath older beds in large tracts. This is no mere theory, though advanced as such at first by some Continental geologists, who have had the great satisfaction of seeing their theory adopted by practical men, and proved to be true, much coal being worked below the older beds that have been pushed above the Coal-measures by overthrust faults.

Our trial work, of course, does not yet lead us to consider such disturbances as those alluded to. We have at first to assume a normal succession of formations, and not to carry on explorations in beds that can be proved to be older than the Coal-measures; but the time may come when it will be otherwise.

Another matter to which attention has been drawn by our foreign friends is an apparent general persistence of disturbances along certain lines, or, in other words, the recurrence of disturbances in newer beds in those parts where earlier movements had affected older beds; so that, reasoning backward, where we see marked signs of disturbance for long distances in beds at or near the surface, there we may expect to find pre-existing disturbances of the older beds beneath. This, however, is a somewhat controversial question, and much remains to be done on it; but should it be proved as a general rule it may have much effect on our underground coal.

Finally, the question of the possibility of finding and of working coal in various parts of South-eastern England is not merely of local interest; it is of national importance. The time must come when the coal-fields that we have worked for years will be more or less exhausted, and we ought certainly to look out ahead for others, so as to be ready for the lessening yield of those that have served us so well. It is on our coal that our national prosperity largely, one may say chiefly, depends, and, as far as we can see, will depend. Let us not neglect any of the bounteous gifts of nature, but let us show rather that we are ready to search for the treasures that may be hidden under our feet, and the finding of which will result in the continued welfare of our native land.

ABSTRACTS OF PAPERS READ AT THE BRITISH ASSOCIATION MEETING, IPSWICH, SEPTEMBER 1895.

III.—SOME REMARKS ON THE STEREORNITHES, A GROUP OF EXTINCT BIRDS OF PATAGONIA. By C. W. ANDREWS, B.A., B.Sc., F.G.S., Assistant in the British Museum.

THE history of the discovery of the extinct birds of Patagonia is briefly given, and the more important of the opinions that have been expressed as to their affinities are noticed.

The age of the deposits in which the remains occur is probably much later than the Eocene, to which they are usually referred, and may perhaps be taken as Miocene.

The structure of the skull and skeleton of *Phororhacos*, as described by Ameghino in his recent valuable and interesting paper, is discussed and compared with that of some other birds. In the absence of actual specimens it is impossible to arrive at any very definite results, but it may be suggested that some, at least, of the Stereornithes may be related to the Geniformes, particularly to the Dicholophi. Others of the group are imperfectly known, but some of them appear to differ considerably from *Phororhacos*. It therefore seems probable that the "Stereornithes" may include a somewhat heterogeneous collection of birds which have lost their power of flight in consequence of some local conditions affecting their mode of life, and in correlation with the reduction of their wings attained a greatly increased size. A similar instance is to be found in the extinct birds of New Zealand, where the Dinornithid *Apteryx*, *Cnemiornis*, *Aptornis*, etc., all flightless, and for the most part of great size, formerly coexisted. In most cases, as soon as the peculiar conditions to which they are adapted pass away, such specialized forms become extinct, and this appears to have happened to the Stereornithes.

There seems no reason why such groups of flightless birds should not arise at any period and in any region, providing the conditions of life are favourable; indeed, the Gastornithidæ, in the Eocene of Europe, and the Stereornithes, in somewhat later deposits in South America, may be taken as instances of this.

In the Stereornithes the keel of the sternum was no doubt reduced or absent, so that they were "Ratites" in the narrowest sense of the word; but on the other hand, they can hardly be referred to the sub-class Ratitæ as usually understood, the members of which possess numerous primitive characters which point to the conclusion that they are the survivors of a group, or perhaps several groups, not necessarily contemporaneous, of ancient and generalized birds in which the power of flight had been lost, perhaps even in the Secondary period. Unfortunately, the want of any means of distinguishing truly primitive characters from those which Fürbringer calls "pseudo-primitive," which are acquired in the course of retrogression (*rückbildung*), makes it impossible to determine the exact relation of the "Ratitæ" to other flightless birds, and until a long series of remains from different horizons is available, this uncertainty must remain. It seems very doubtful whether *Gastornis* is at all related to the South American forms.

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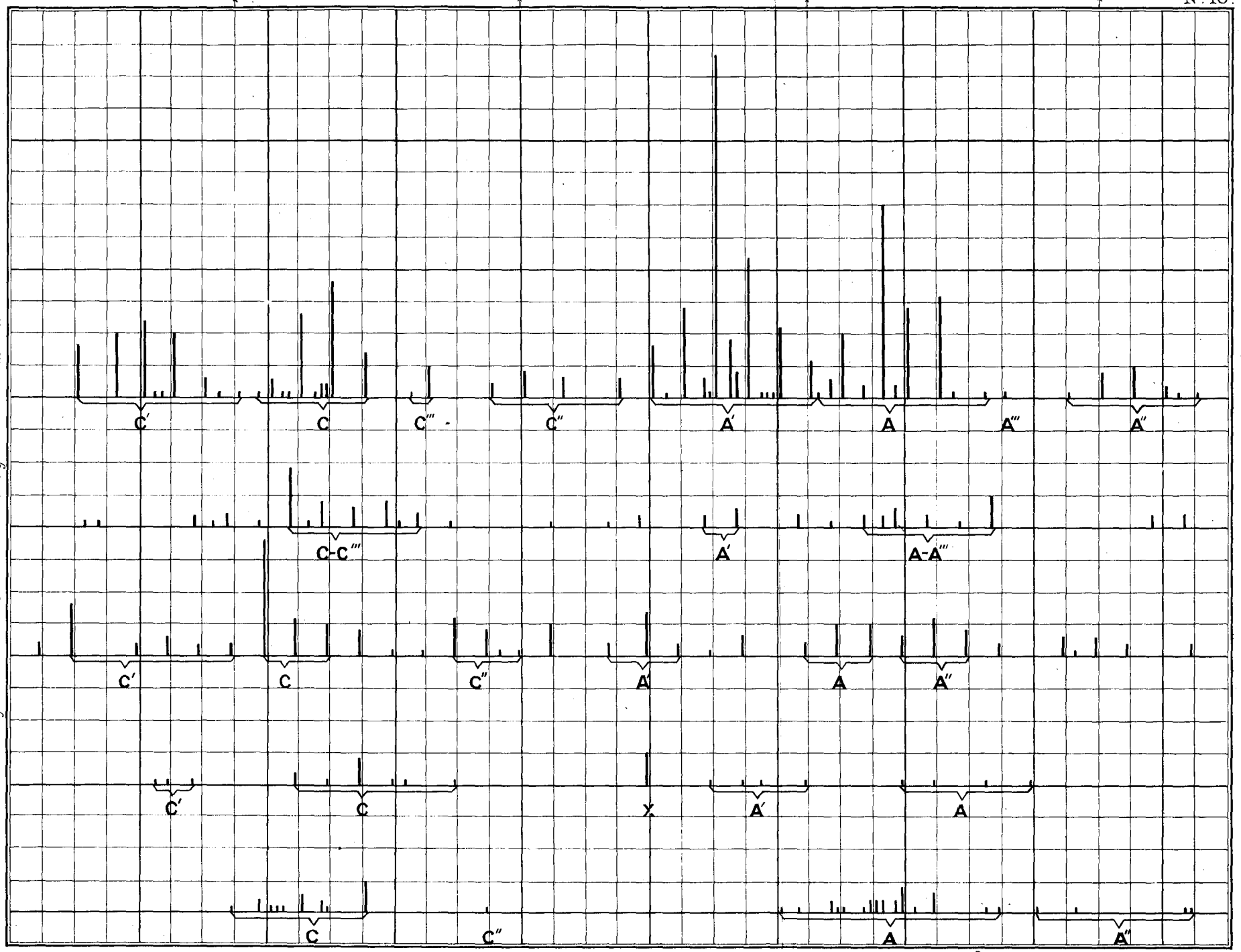

To illustrate Mr. Moddicott's paper on Faults in strata.

Lith. Whitman & Bass, London.

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IV.—The Cladodonts of the Upper Devonian of Ohio. By Professor E. W. Claypole, D.Sc. (Lond.).

NUMEROUS specimens of the Cladodonts of the Cleveland Shale in Ohio have been found by Dr. William Clark. They for the first time reveal to us the general form of the fishes to which belonged the teeth that have alone so long represented the genus *Cladodus*. The fossils are in very fair preservation, but their state of pyritization has obscured many of the details of their structure. So far as regards their form, however, we now know that they were long, slender fishes, resembling in their character the sharks of the present day; that they possessed well-developed and powerful pectoral and caudal, with weak ventral fins, the dorsals being unknown; that they were for the most part, or altogether, spineless; that at least one species possessed cladodont teeth of more than one pattern; and that they had near the hind end of the body a peculiar flat expansion or membrane of rudely semicircular form, which gave to the caudal extremity when seen from above the outline of a sharp-pointed shovel.

The largest whole specimen yet found shows a fish of about 6 feet in length, but detached teeth and other fragments indicate others of double this size, and supply abundant proof that in late Devonian times, and in the North American area, the elasmobranch fishes had attained very great proportions and a high stage of development.

Hitherto the Cladodonts have been regarded as, in the main, characterizing the Lower Carboniferous rocks, but we now find them abounding in the earlier Devonian strata, and, as shown by the contents of their stomachs, preying—in some cases at least—on the smaller placoderms of the same area.

From the evidence of the new specimens it appears most likely that the species already defined from single and isolated teeth can no longer be maintained.

For details see the papers in the "American Geologist" for 1893–4–5.

V.—The Great Devonian Placoderms of Ohio, with Specimens. By Professor E. W. Claypole, D.Sc. (Lond.).

THE Upper Devonian Shales of Ohio have recently afforded a remarkable series of fossil fishes rivalling in size and interest those found many years ago in the Old Red Sandstones of similar age in Scotland, and described by Agassiz and Hugh Miller. The earliest of these, *Dinichthys*, was closely studied, and its structure was well explained by the late Dr. Newberry. It was an immense armour-clad fish, whose head measured from 2 to 3 feet in length. *Titanichthys*, the second of the group, though less massive, was of yet larger size. *Gorgonichthys*, the third, was described by the present writer in 1893, and, so far as is yet known, was the most formidable of all, possessing jaws of enormous size and thickness, above 24 inches long, ending in teeth or points from 6 to 9 inches in length. The fourth and last, *Brontichthys*, of which a description was also published by the writer in the "American Geologist" for 1894, is equally heavy and of equal size, but differs from all the rest

in possessing very massive symphysial portions in the mandibles with sockets apparently for the reception of teeth, as in *Titanichthys*.

Of the two last-named genera only the jaws are yet known with exactness. Other portions have been found of *Gorgonichthys*, but are still embedded in the matrix. So far as can at present be determined, all the four are closely allied to *Coccosteus*, and belong to the same family.

The set of casts exhibited in illustration of the fossils has been prepared by their discoverer, Dr. William Clark, and faithfully represents the originals, of many of which only single specimens are yet known. The labour of extricating them from the pyritous shale has proved very heavy, and much yet remains to be done in this direction.

VI.—Zonal Division of the Carboniferous System. By E. J. Garwood, M.A., F.G.S., and J. E. Marr, M.A., F.R.S.

THE authors call attention to previous attempts which have been made to divide the Carboniferous rocks into zones, noting the zonal divisions of the Lower Carboniferous rocks of North England established by De Koninck and Lohest, and the view expressed by Waagen that fuller work will enable geologists to define a series of zones in the Carboniferous as in older and newer strata.

The detailed work of one of the authors (Mr. Garwood) leads them to suppose that the following zones occur in the Lower Carboniferous beds of the northern part of the Pennine Chain and adjoining regions :—

Zone of Productus *cf.* Edelburgensis.
„ P. latissimus.
„ P. giganteus.
„ Chonetes papilionacea.
„ Spirifera octoplicata.

Mr. Garwood has traced the zone of *Productus latissimus* occupying the same relative position to that of *P. giganteus*, from Settle, in Yorkshire, to the Northumbrian coast, near Howick Burn.

The authors believe that brachiopods and goniatites will furnish good results, if a detailed study of their distribution be made; and they suggest that a committee be appointed to inquire into the possibility of dividing the Carboniferous rocks into zones, to call the attention of local observers to the desirability of collecting fossils with this view, and, if possible, to retain the services of eminent specialists, to whom these fossils may be submitted.

VII.—Probable Extension of the Seas during Upper Tertiary Times in Western Europe. By G. F. Dollfus.

TAKING into consideration the position and nature of all the outliers of Upper Tertiary age, the author is led to the following conclusions as to the extension of the Neogenic seas in Western Europe. During Miocene times England was united to France, and we have proof of the existence of two seas in the western part of Europe: one on the east extended over part of Belgium (Bolderian system), Holland, and north of Germany—probably

this sea was not very far off the eastern coast of England; the other sea, the Western, or old Atlantic Sea, was off Ireland, penetrating in various gulfs into France, as in some part of Contentin, Brittany, in the Loire valley, in the gulf of the Gironde, but there was no way of communication with the Mediterranean basin crossing France. In North Spain there are no Miocene deposits, in Portugal Miocene beds are purely littoral.

The communication with the Mediterranean Sea was certainly by the valley of the Guadalquivir. The Gibraltar Strait had not exactly its present place. The fauna of these Miocene coasts was warm and very similar to the existing fauna of Senegal and Guinea.

We can divide Pliocene time into three periods, but the situations of the seas were not very different. England was always in direct continental communication with France; the English Channel was not open at all. All the Pliocene deposits of Belgium, North France, or England, even the Lenham beds, are on the side of the North-eastern Sea; we find all these patches on the northern side of the great anticlinal line of the Artois, Boulonnais, and Weald. The fauna is different from the Miocene, and colder—it even turns more and more cold during the progress of Pliocene time. On the western or Atlantic side we have little gulfs leading the sea into the land, but not so frequently and not so far as during Miocene times. The Cornwall deposits, Contentin beds, and the Brittany patches are very limited; the basin of the Gironde contains no trace of Pliocene beds, and we have no trace of recent marine beds at the foot of the Pyrenees. In the north of Spain there is also no trace of Pliocene beds. The continent seems to have been higher, and the Atlantic tolerably distant. All the Portuguese sands recently discovered are littoral, and only on the Algarve coast and south of Spain do we find proof of the probable communication with the Mediterranean. The Gibraltar Strait was not always in the same place during Pliocene time; in the beginning probably the Guadalquivir valley to Murcia continued to be the strait, but later the rock of Gibraltar was separated from Africa and a new road was open; this way was certainly deeper than the former one, and as deep as the existing strait. By this depression the cold fauna of the depths of the Atlantic penetrated into the Mediterranean Sea as far as Sicily and Italy with *Cyprina islandica*.

The geology of Morocco is unknown, but we have plenty of information on Algeria. We have there great Miocene deposits raised along the Atlas Chain up to a great altitude, and a little lower a good and very long band of Pliocene beds of marine and continental origin. Quaternary deposits, similarly continental and littoral, occur lying along the actual coast, pointing out the south side of the Mediterranean connection.

In a few words, the English Channel has been opened very recently, and no sea occupied its place before. No sea has crossed France or Central Spain, and we are obliged to seek for an outlet for the Eastern Sea during Miocene time by way of Germany, Galicia, and South Russia, or by the north of Scotland.

During the existence of the Pliocene seas there was no other

communication for the Crag seas than the northern one, for the western, the southern, and eastern sides were undoubtedly shut in by land.

VIII.—On the Importance of Extending the Work of the Geological Survey of Great Britain to the Deep-seated Rocks, by Means of Boring. By F. W. Harmer, F.G.S.

THE systematic exploration of the subterranean geology of these islands is equally important from a scientific and a practical point of view. At present our knowledge of the structure of the rocks which form the foundation of our island home is due either to isolated and occasional borings, such as that of the Ipswich Syndicate in search of coal, or to deep wells sunk by mercantile firms; but the latter do not reach further than is necessary to obtain a supply of water, and the work is generally suspended just where it becomes geologically most interesting. But such a Survey is important practically, because unsuspected sources of wealth may be hidden under our very feet.

It is a mistake to suppose that a discovery such as that of a new coal-field would enrich only the landowners of the district, because whenever any appreciation of real property takes place, the State at once claims its share of the increased value, both for imperial and local purposes. The average for the whole country of the rates raised by local taxation alone was, for 1891, 3*s.* 8*d.* in the pound, to which must be added imperial taxes and the tithe. It may be stated roughly, that for every £100 of yearly 'unearned increment' the State is benefited in one way or another by £25, or one-fourth of the amount. The discovery of a new coal-field would cause increased prosperity in the district in which it occurred, and from this the State, through taxation, would derive great though indirect advantage.

The growing difficulty of finding employment for the ever-increasing population of these islands is a strong reason why this Survey should be undertaken.

Part of the cost might be borne by the landowners under whose property any minerals were discovered. Certain districts should be selected with the consent of the Local Authorities, and Parliamentary power taken to charge a royalty on any minerals obtained below a certain depth. Landowners would probably welcome proposals to make borings on their estates on such conditions. In the first instance, however, the Survey should map out accurately the subterranean limits of existing coal-fields, or mineral-bearing rocks, but trial borings should be put down in different localities, and each new boring would help to show more plainly the direction in which further investigations should be made. Much light would be thrown by such a Survey on the circulation of underground waters, a matter of great practical importance.

The expense of boring would be much reduced if undertaken on a large scale, as machinery and apparatus would be available again and again. The Survey would employ its own workmen, who would become increasingly efficient and economical.