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GEOLOGY AT THE BRITISH ASSOCIATION, 1895.

THE British Association for the Advancement of Science held its sixty-fifth meeting this year at Ipswich, the chief town in Suffolk, in the east of England, the district in which the Pliocene rocks of the country are best developed. The Section of Geology was presided over by Mr. W. Whitaker, who was engaged for many years in mapping these rocks for the Geological Survey. The address delivered by this gentleman on the opening day, September 12th, naturally dealt with local problems, and especially those raised by the numerous deep borings for coal and water which have been put down through the rocks of eastern England.

Neglecting deposits newer than the Gault, the variations of which are slight and of but little consequence, he notes that the Lower Greensand has only been met with in one boring, that of Culford, where it is 32 feet thick and of anomalous character, preparing us for the thinning out which occurs elsewhere. Jurassic rocks are only present in the southern borings and do not occur in Suffolk. Under the Jurassic or Cretaceous rocks the Trias is supposed to occur in one case and in the others strata belonging to the Carboniferous, Devonian and Silurian Systems. In five bores out of ten put down under the London Basin the determination of the age of the rocks is aided by fossil evidence, but in the rest this support is wanting. The general result is to prove that over an area not less than 86 miles from northwest to southeast older rocks almost certainly occur everywhere at a distance of not more than 1600 feet from the surface.

The only boring in eastern England which has struck productive Coal Measures is that at Dover, where evidence from the Continent was at hand to aid in fixing the exact position for the trial locality, but two or three others have struck Carboniferous rocks at a horizon below that at which workable coals are usually found, thus proving that there are Carboniferous rocks in the eastern counties, and showing that there is every likelihood of eventually meeting with productive measures if exploration is persisted in. The Stutton experimental boring, on which the President read another paper in the course of the meeting, after passing through 1000 feet of Neozoic rock had struck on Palæozoic rock and was being continued through it in the hope that some satisfactory evidence of the age of the latter rock would be forthcoming. It had then reached the depth of 1350 feet and the lithological character of the rock resembled Carboniferous or Ordovician shale. The section of the bore hole is given below:

	Feet.
Drift (River Gravel)	16
London Clay and Reading Beds	54
Upper and Middle Chalk	720
Lower Chalk, with very glauconitic marl at the base (almost a green sandstone)	154½
Gault	49½
Palæozoic Rock' with a high dip.	

In conclusion Mr. Whitaker stated that, even if it was necessary to abandon the present experiment, it was intended to make one or possibly two more trials, so as to have a fair chance of really settling the question of the occurrence of coal in East Anglia. Taking up the question thus prominently brought forward by the President, Mr. Harmer advocated that the systematic survey of deep-seated rocks by means of borings should become one of the duties of the Geological Survey. Anticipating that valuable economic discoveries of coal, water, iron and other products were only a question of time, he stated that the starting of new industries in agricultural districts, the appreciation in the value of land, and if necessary the imposition of a royalty on minerals worked beyond a certain depth, would far more than pay the expenses of such systematic work, whilst, under the present state of the law, no private individual cared to undertake deep exploration, because his very success would only bring him into competition with those who would profit by his discoveries without sharing his risks.

Mr. Whitaker likewise contributed to the Section a paper on deep wells in Suffolk; six of these penetrate the Tertiary rocks and reach the chalk.

A paper of very great importance was that by Mr. Joseph Francis on methods for determining the direction of dip in strata at the bottom of deep borings, methods which have proved quite successful at depths of 1,000 feet and might be applied to almost any depth. The author had carried out his experiments at the borings at Ware and Turnford, and, after abandoning plans dependent on fastening a compass needle on the top of the core, he fell back on the method of lowering the rods with the utmost care to prevent twisting, and checking the result by equally careful raising and the lifting of wax moulds of the top of the core. The crown of the boring-tool was furnished interiorly with three sharp steel points so arranged as to give a line in a known direction; these points on descending ruled three lines on the side of the core which was then broken off, lifted, and the angle of the diametral line with the direction of dip measured. A test experiment was also arranged by grinding the surface of the next piece of core and impressing a line of points on it by lowering a steel bar armed with punches on to the smooth surface; on raising this core it yielded a measurement within a degree of the preceding observation. The Palæozoic rocks at Ware aud Turnford gave dips a little west of south.

Owing to the presence of many observers who had worked in East Anglia, local papers were numerous. First came two by Mr. Harmer, a gentleman who was for many years the colleague of Mr. Searles Wood, Jun. One dealt with the commonly occurring species of Mollusca of the Coralline Crag deposits and showed that this assemblage, even better than the total fauna, proved the southern derivation of the organisms. The summaries given by him are printed below:

Summary of the abundant and characteristic species of Mollusca occurring in the Coralline Crag.

Not known as living (37 per cent).......	89
Living in distant seas........................	8
Living in the Mediterranean...............	133
Living in the West European area........	9
Living not south of Britain.................	1
Total..	240

Species of European Mollusca occurring abundantly in the Coralline Crag.

Southern and not British (28 per cent)...................................	42	
British (rare) and Southern.........	9	
(35 per cent).........		51
British (characteristic) and Southern......		91
British and not Southern....................		1
Total..		143

Mr. Harmer's second paper dealt with the so-called derivative shells in the Red Crag; while admitting that the Eocene species had undoubtedly been derived from an older deposit, the author contended that many of these shells had lived in Britain in much later times, some belonging to the interval which elapsed between the formation of the Red and Coralline Crags. Mr. Clement Reid gave an illustrated lecture on the glacial deposits of Cromer, which were visited later on by a large party under his guidance. The Cromer drift is remarkable for the contortions which it exhibits, and, indeed, it frequently displays all the structural phenomena of the crystalline schists, being sheared, crumpled, brecciated, twisted and kneaded into 'eyes.' The same author in conjunction with Mr. H. N. Ridley described the discovery of a new bed containing temperate plants between the morainic deposits and those with arctic plants at Hoxne, a locality long famous for the palæolithic implements found in its upper strata; he proposes to investigate this deposit still further and to determine the relation of the human remains to the various climates indicated by the plants and moraines.

The following is the section exposed :

	Feet.
Gravelly surface soil..................about	2
Brick earth ; towards the base *Valvata piscinalis*, cyprids, bones of ox, horse, elephant (?), and palæolithic implements	12
Sandy gravel, sometimes carbonaceous, with flint flakes	1
Peaty clay, with leaves of Arctic plants (?)..............................about	4
Lignite, with wood of yew, oak (?), white birch, seeds of cornel, etc...about	1
Green calcareous clay, with fish, *Valvata piscinalis*, *Bythinia tentaculata*, *cyprids*, *Ranunculus repens*, *Carex*...........about	4
Boulder clay...................................	

Recent storms at Southwold, on the east coast, have effected considerable denudation there and have directed attention to the amount of this action which is measurable within recent years; Mr. Spiller estimates this amount to vary between 10 and 84 feet in six years at different points along the coast. Mr. H. B. Woodward describes the section exposed by the storm just mentioned: Norwich Crag below the Chalky Boulder Clay, and above that a bed containing fresh water shells followed by a peaty deposit.

A paper by M. G. F. Dollfus, on the probable extension of the seas during Upper Tertiary times in western Europe, is so important that we give a full abstract of it:

Taking into consideration the positive 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 Cotentin, 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, Cotentin 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 south and eastern sides were undoubtedly shut in by land.

M. Van den Brœck followed with a note on the present state of our knowledge of the Upper Tertiary strata of Belgium. He had determined that the Upper Oligocene strata did not exist in Belgium, but that the Upper Pliocene was probably present there. He concluded that the line of march of the Miocene fauna was from east to west, for Miocene forms present in Belgium were absent from England. That the Miocene formation had been once present in England he inferred from the fact that half the Belgian Miocene fauna was to be found in the Coralline Crag. M. M. Boule described some interesting finds in gravel in France, the deposit containing bones not only of *Elephas meridionalis*, but of *E. antiquus* and of the Mammoth, the former being in contact with palæolithic flints, the latter bearing tusks nearly three metres in length.

Several American gentlemen either read or sent papers to the meeting, including Professors Marsh, W. B. Scott, E. W. Claypole and Mr. R. B. White. The account of Professor Marsh's paper given by the *Times* is as follows:

"Professor Marsh described his restorations of some European Dinosaurs, and offerred suggestions as to their place among the Reptilia. He said that he had examined nearly every specimen in Europe, and, from minute comparison with the eight chief American types, mostly found in the Rocky Mountain regions, had restored four European forms, viz.: Compsognathus, Scelidosaurus, Hypsilophodon and Iguanodon. The Dinosaurs were all land animals, none being known as arboreal or aquatic. They varied in size from that of a chicken to gigantic monsters 80 ft. in length. Most were probably carnivorous; the Iguanodon, however, was herbivorous. The Compsognathus was found in the Jurassic Solenhofen slates near Munich. Its footprints resembled those he had shown Professor Huxley in the mud layers in the Connecticut Valley. Huxley considered them footprints, not of birds, but reptilian, and made by true Dinosaurs, and drew a bipedal animal about the size of a turkey conforming to the size of the footprints. It was a typical example of a true carnivorous Dinosaur. The Scelidosaurus was found in the Lias of England, a quadruped about 30 ft. long, with its back partly covered with a coat of mail. He had restored its fore feet by analogy with the quadrupedal Stegosaurus ungulatus of America, one or two specimens of which he had found, 30 ft. in length, just as the animal had fallen down to die, with every bone in position. The Hypsilophodon was found in the same geological formation. It had an ossified sternum, and in this respect differed from the American allied form. Much doubt had been entertained concerning the Iguanodon till the wonderful discovery of about 30 specimens in Belgium in their exact position at the time of death. As to the question of the true place of Dinosaurs amongst reptilia there had been great diversity of opinion. The crocodilian form Hallopus was regarded as a Dinosaur, but it differed from all other Dinosaurs in the long metatarsus and the backward projection of the calcaneum. But there were certain affinities between Dinosaurs and the crocodilian form

Aëtosaurus. The Dinosaurs were found at the base of the Jurassic strata. There was no evidence for their existence in the Tertiary period, but much against it. Owing to their appearance in the Wealden strata, if the evidence derived from Vertebrates is to be regarded as conclusive, the Wealden must be considered as belonging, not to the Cretaceous, but to the Jurassic formation."

Professor E. W. Claypole's paper on 'The Cladodonts of the Upper Devonian of Ohio' was as follows: Numerous specimens of the Cladodonts of the Cleveland Shale in Ohio have been found by Dr. Wm. 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.

Professor Claypole also read a second paper, illustrated with specimens on 'The Great Devonian Placoderms of Ohio.' 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 similer 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 armor-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 speaker 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 last of the four, *Brontichthys*, of which a description was also published 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 imbedded in the matrix. So far as can at present be determined, all the four are closely related 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 labor of extricating them from the pyritous shale has proved very heavy, and much yet remains to be done in this direction.

Professor W. B. Scott illustrated, with a large number of slides, his paper on 'The Tertiary Lacustrine Formations of America.' In Tertiary times one lake succeeded another, giving an almost complete record of that era in lacustrine deposits. Professor Scott suggested the annexed correlation of these deposits with the standard strata of Europe:—

9. *Equus* beds		Pleistocence.
8. Blanco formation		Pliocene.
7. Loup Fork beds		Upper Miocene.
6. John Day beds		Lower Miocene.
5. White River beds		Oligocene.
4. Uinta beds.	Eocene	Paris Gypsum.
3. Bridger beds.	Eocene	Parisien.
2. Wasatch beds.	Eocene	Suessonien.
1. Puerco beds.	Eocene	Cernaysien.

A considerable break occurs between 3 and 4 and earth-movement then took place, while a second hiatus is seen between 6 and 7. 3, 5 and 7 are each divided into three divisions, and the highest division of the Loup Fork beds, the Palo Duro, may be correlated with the basal Pliocene. The Uinta beds were the evidence of the last lake west of the Rocky Mountains; the lakes afterwards spread east to the great plain.

The paper by Mr. R. B. White, 'On the Glacial Age in Tropical America,' described a number of apparently glacial deposits in the Republic of Colombia, almost under the equator. He spoke of moraines forming veritable mountains, immense thicknesses of boulder clay, breccias, cement beds, sands, gravels and clays, beds of loess, valleys scooped, grooved and terraced, monstrous erratics and traces of great avalanches. It is a significant fact that over part of the area the author supposes the ice period to be contemporaneous with great volcanic activity, so that the glaciers bore on their surfaces little but loads of pumice, ash and ejected blocks; in other places, however, the detritus appears to have been derived from sedimentary rocks. The paper concludes with some remarkable speculations as to the cause of glacial periods.

Dr. H. Woodward read an interesting paper on some decapod crustaceans from the Cretaceous formations of Vancouver Island, in which he described four new species from specimens sent him by Mr. J. F. Whiteaves. These are named as follows: *Callianassa Whiteavesii*, *Palæocorystes Harveyi*, *Plagiophthalmus ? Vancouverensis and Homolopsis ? Richardsoni*. Some of these forms approach very close to European Cretaceous types.

Turning now to the subject of palæontology, a paper which is fraught with far-reaching consequences in the near future, is that entitled 'Notes on the Phylogeny of the Graptolites,' by Professor H. A. Nicholson and Mr. J. E. Marr.

The authors note that the number of stipes possessed by graptolites has been looked upon as a character of prime importance, many genera being based on the possession of a certain number. Again, the 'angle of divergence' has been looked upon as an important factor in the diagnosis of families. They are, however, led to believe that a character of essential importance in dealing with the classification of the graptolites, and one which, in all probability, indicates the true line of descent, is found in the shape and structure of the hydrothecæ, the point of next importance as indicating genetic relationship being the 'angle of divergence.'

These views are illustrated by reference to forms belonging to the 'genera' *Bryograptus*, *Dichograptus*, *Tetragraptus* and *Didymograptus*, which appear in turn in this sequence.

Out of nine *Tetragrapti* (and the authors know of no other forms referred to this genus which are represented by well-preserved examples), eight are closely represented by forms of *Didymograptus*, which are closely comparable with them as regards characters of hydrothecæ and amount of 'angle of divergence,' whilst the ninth is comparable with a *Didymograptus* as regards 'angle of divergence' only. Moreover, four of the *Tetragrapti* are comparable as regards the two above-named important characters with forms of *Dichograptus* and *Bryograptus* with eight or more branches, and the authors confidently predict the discovery of forms belonging to these or closely allied many-branched 'genera,' agreeing with the remaining *Tetragrapti* in what they regard as essential characters.

They give details showing the points of agreement of each group of the various series, including a two-branched, a four-branched, and a many-branched form, and point out how difficult it is to understand how the extraordinary resemblances between the various species of *Tetragraptus* and *Didymograptus* (to take one example) have arisen, if, as usually supposed, all the species of the genera have descended from a common ancestral form for each genus, in the one case four-branched, and in the other case two-branched. On the other hand, it is comparatively easy to explain the more or less simultaneous existence of forms possessing the same number of stipes, but otherwise only distantly related, if they are imagined to be the result of the convergent variation of a number of different ancestral types. They allude to similar phenomena which have been shown to exist amongst other organisms; thus Mojsisivics has decribed analogous cases amongst the Ammonites, and Buckman (under the name of heterogenetic homœomorphy) amongst the brachiopods, though in this instance the cases of 'species' and not of 'genera' are considered.

Following the above inferences to their legitimate conclusion, the authors point out how 'genera' like *Diplograptus* and *Monograptus* may contain representatives of more than one 'family' of graptolites, according to the classification now in vogue, which would account for the great diversity in the characters of the monograptid hydrothecæ.

In conclusion, the authors offer a few theoretical observations upon a possible reason for the changes which they have discussed in the paper.

The latter of the foregoing authors, with Mr. E. J. Garwood, also read an important paper on the zoning of the Carboniferous rocks which they had begun in the north of England. The zones so far established were the following:

Zone of *Productus* c. f. *edelburgensis*.
Zone of *Productus latissimus*.
Zone of *Productus giganteus*.
Zone of *Chonetes papilionacea*.
Zone of *Spirifera octoplicata*.

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

With regard to the other papers coming under this heading it will suffice to mention that the attempt to obtain the rest of the skeleton of the Oxford *Cetiosaurus* has not as yet met with any success, and that the report on fossil Phyllopoda by Professor Rupert Jones contained a most valuable table by Professor Lapworth on the distribution of these organisms. The discovery of a new section of Rhætic rocks was described by Mr. Montagu Browne, and Mr. Harrison reported on the flints, supposed by himself and others to have been worked by man, obtained from high level drift in Kent. Mr. Walford gave an account of the succession of rocks occurring between the Inferior Oölite and the Great Oölite in Oxfordshire as revealed by an excavation undertaken there within the year. In a paper on the auriferous conglomerates of Witwatersrand Dr. Hatch concluded that the gold must have been introduced into the rock subsequently to its consolidation, and not derived with the pebbles from an older formation.

Professor J. Milne, in an exceptionally interesting paper on earthquake phenomena, showed that the greater shocks could be felt by delicate instruments for enormous distances, even at their antipodes, and that the waves travelled faster than if the interior of the earth had the elasticity modulus of glass or steel. The observations of slight movements showed one regularly recurring set which the writer suggested might possibly be due to the evaporation of moisture by day and its deposit by night. The Committee engaged in collecting photographs of geological interest had amassed not less than 1,200, which were deposited at the Museum of Practical Geology at Jermyn St., London. Gradually this collection will form a most valuable and reliable survey of geological features and phenomena.

The committees on the erosion of sea coasts and on the circulation of underground water completed the labors on which they have been engaged for so many years, but still continue to act and now proposes to extend its scope to Scotland, where the local committee has ceased work for some years.

Amongst the papers on glacial subjects one of the most important was by Professor Sollas on artificial glaciers (or 'poissiers') made of pitch, and their bearing on theories of glacier movement and transport. Troughs were prepared of various shapes and while these were inclined they were filled with pitch in such a way that when placed in position its surface had a slope of about 12 degrees. The pitch was put in in layers, various substances, such as rice, sago, pigment, etc., being placed on each layer as it was completed, to serve as indexes of the movements within the mass. In this way it was shown that against barriers opposed to the movement of the ice, an upward movement occurred like that which had long since been postulated by geologists to account for the upward transport of erratics. A similar upward movement also was detected in the pitch where it was driven into a narrow gorge. Another point illustrated was that pitch sometimes overrode heaps of loose materials just as glaciers are known to override their moraines. Pitch conformed to all the laws of fluid motion and differed only in the element of time, and it was found that practically similar results could be obtained with Canada balsam, glycerine and even water. This enabled Professor Sollas to project on the screen not only photographs of his results, but the actual experiments themselves taking place. The author had been able to imitate experimentally some of the phenomena recently described by Mr. Chamberlin.

Several papers dealing with old, pre-Glacial valleys were read. One by Mr. Beeby Thompson called attention to the following varieties of such valleys: (1) New valleys without drift and having old, filled-up valleys near at hand; (2) Those that drift on one side and rock on the other; (3) Streams re-excavating old, drift-filled valleys; (4) Re-excavated valleys with the drift all washed down into gravel. Mr. E. Hill described a similar valley in Suffolk, and Mr. T. V. Holmes one in Essex.

Mr. P. Kendall and Mr. Lomas read a

remarkably interesting paper on modern glacial striæ, of which unfortunately no report is available: Mr. W. W. Watts contributed a note on the basins of some of the tarns near Snowden. One very small one seemed to occur in a rock basin, one was dammed at both ends by scree and stream detritus, and two larger lakes, Glaslyn and Llyn Llydaw, were either confined in true rock basins or else were not more than about 40 feet deep.

A large number of excursions was planned and carried out chiefly under the leadership of the President and Mr. Clement Reid. The various localities for the Coralline and Red Crag deposits were visited and the relations of the deposits studied, and the last two days were devoted to a pretty thorough examination of the remarkable and classical glacial deposits of Cromer on the coast of Norfolk.

W. W. WATTS.
GEOLOGICAL SURVEY, LONDON.

A COURSE IN ASTRONOMY FOR ENGINEERING STUDENTS.

AT the present time our engineering schools tend more and more strongly to technical curricula which deal with professional subjects to the exclusion of nonprofessional matters, and the author of the present paper, approving this tendency, purposes to state here his conception of a brief course in spherical and practical astronomy as a part of the technical training of the future engineer. The purposes of such a course should be:

(A.) To give the pupil some training in the precise use of instruments of precision. His course in surveying has given the student an introduction to the use of such instruments, but the nature of that work and the circumstances under which it is done preclude the placing of any considerable emphasis upon precision of results. To demand all the accuracy which a transit or level can be made to furnish is in general bad surveying practice, but only the man familiar with refined methods of instrumental work is competent to form an intelligent judgment of the manner in which those methods should be modified and their rigor relaxed in any given case. The course in astronomy, therefore, comes as a supplement to that in surveying, and the pupil should now be taught:

(a.) That it is his business in each of his problems to obtain from his instrument all of the precision that it can be made to furnish.

(b.) He should be taught to obtain this precision with a minimum expenditure of care and time. The instinctive tendency of the student mind to execute every part of a given task with equal painstaking needs to be curbed and the pupil taught what things require minute care and what may be, and ought to be, dealt with in a summary manner.

(c.) As a subordinate matter he may be introduced to the use of instruments of a higher grade than those employed in his course in surveying.

(B.) A second purpose of the course is to train the student in the art of computing (ciphering). Model forms of record and reduction for his several problems should be placed before him and the advantage of compact and orderly arrangement of all numerical work should be strenuously insisted upon.

(C.) As the concrete outcome of the above training, the student should acquire the ability to determine latitude, time and azimuth with such instruments as he will use in the ordinary practice of civil engineering. The sextant and engineer's transit furnish quite as good an equipment for the course here contemplated as the elaborate outfit of an observatory. The latter belongs to a more advanced stage of study.

The details of a course of study such as is above suggested depend upon the amount