by no means weathered as well as the Thanet Sand, and in many cases the passage from the base of the shaft to the chambers is much broader than it originally was. But even now an inspection of the ground-plan shows that in none of them is there any widening out from the base of the shaft like that of the Brightling pit, and that in almost all of them the passage at the base of the shaft is very decidedly narrower than any other part of the pit. It must have been still narrower, at one time, to allow of the continuation of the footholes to the floor of the pit. Then, those deneholes which we were able to enter, though their makers had apparently been restricted to a greatest length of 70 feet, showed certain differences in plan and development such as might be looked for if each denehole were a family hiding-place and storehouse, but unintelligible on the supposition that they were originally pits for chalk.[1] And the care taken at the surface to preserve the flattened contour characteristic of a gravel plateau, is a care that would be simply silly were these deneholes pits for chalk, though absolutely necessary if they were hiding-places and secret storehouses.

I might enter into further details, but trust that enough has been said to make it evident that Deneholes and Bell Pits belong to totally different classes of excavations, the resemblances between them being superficial and the differences fundamental. In short, Deneholes were made for the sake of the excavation, and Bell Pits for the sake of the material extracted from the excavation. The archæological evidence bearing on deneholes ancient and modern and the uses to which they have been put, though of great interest, would seem out of place in the GEOLOGICAL MAGAZINE.

NOTICES OF MEMOIRS.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

BRISTOL, September 8, 1898.

ADDRESS TO THE GEOLOGICAL SECTION, BY W. H. HUDLESTON, M.A., F.R.S., President of the Section.

Introductory.

ABOUT this time last year British geologists were scattered over no inconsiderable portion of the Northern Hemisphere, partly in consequence of the International Geological Congress at St. Petersburg and partly owing to the meeting of the British Association at Toronto. From the shores of the Pacific at Vancouver, on the one hand, to the highlands of Armenia on the other, there were parties engaged in the investigation of some of the grandest physical features of the earth's surface.

The geologists in Canada were especially favoured in the matter of excursions. Everything on the American continent is so big that

[1] It is worth adding that no attempt had been made to extract flint from a prominent band seen in each pit at Hangman's Wood 4 to 6 feet above the floor, or from any other band.

a considerable amount of locomotion is required to enable visitors to realize the more prominent facts. If there be no great variety of formation in Canada, yet the Alpha and Omega of the geological scale are there most fully represented, from the great Laurentian complex at the base to the amazing evidences of glacial action, in a country where it is possible to travel for a whole day without once quitting a glaciated surface. But Russia presented equal attractions, and in Finland almost identical conditions were observed, viz. glacial deposits on Archæan rocks. The great central plain of Russia, too, with its ample Mesozoic deposits often abounding in fossils, offered attractions which to some may have been stronger than the mineral riches of the Urals or the striking scenery of the Caucasus.

It seems almost incredible, even in this age of extraordinary locomotion, that scenes so wide apart were visited by British geologists last autumn. This year we are more domestic in our arrangements, and Section C finds its tent pitched once more on the classic banks of the Bristol Avon, and in that part of England which has no small claim to be regarded as the cradle of English geology. But we may go a step further. For if the strata observed by William Smith during the six years' cutting of the Somersetshire coal-canal imprinted their lessons on his receptive mind, it is also equally true that Devonshire, Cornwall, and West Somerset first attracted the attention of the "Ordnance Geological Survey." And thus it comes to pass that the region which lies between the Bristol Channel and the English Channel claims the respect of geologists in all parts of the world, not only as the birthplace of stratigraphical palæontology, but also as the original home of systematic geological survey.

The city of Bristol lies on the confines of this region, where it shades off north-westwards into the Palæozoics of Wales, and north-eastwards into the Mesozoics of the Midland Counties. There are probably few districts which display an equal amount of variety within a limited circumference. The development of the various formations was excellently pourtrayed by Dr. Wright, when he occupied this chair twenty-three years ago—so well indeed, that his address might serve as a textbook on the geology of the district. In the following year (1876) there appeared the Survey Memoir on the Geology of East Somerset and the Bristol Coalfield, by Mr. H. B. Woodward, who has since contributed important memoirs on the Jurassic rocks of Britain, which are so largely developed in Somerset and the adjacent counties. Since that date many papers also have appeared in various journals, and some of these, as might be expected, give new and perhaps more accurate interpretations of phenomena previously described. In addition to this, portions of the south-west of England have been geologically re-surveyed, and in some cases new maps have been published.

I would call especial attention to the Survey Map on the scale of four miles to the inch, known as the "Index Map," which has recently been issued. Sheet 11 includes this particular district; but

if a portion of Sheet 2 is tacked on to its southern border we obtain a block of country about 120 miles square, which has not its equal for variety of geological formation in any part of the world within the same space. If Europe is to be regarded as presenting a geological epitome of our globe, and if Great Britain be an epitome of Europe, then, without doubt, this particular block of the south-west, which has Bath for its more exact centre, with a radius (say) of fifty miles, may be said to contain almost everything to be found on the geological scale, except the very oldest and the very youngest rocks; while east of the Severn and south of the Bristol Channel true Boulder-clay is rare or absent.

It may be convenient to consider a few points which have arisen of late years in connection with the geology of portions of the district now under consideration.

Palæozoic.

If we omit the Silurian inlier at Tortworth, the geological history of the country, more immediately round Bristol, may be said to commence with the Old Red Sandstone, whose relations with the Devonian towards the south-west have always presented some difficulty. And this difficulty is accentuated by doubts as to the true Devonian sequence in West Somerset and North Devon. Ever since the days of Jukes that region has been fruitful in what I must continue to regard as heresy until the objectors have really established the points for which they are contending. The uncertainty is to be regretted, since it is through these beds of West Somerset that the system is to be made to fit in with the several members of the Old Red Sandstone.

There is a mystery underlying the great alluvial flats of Bridgewater which affects more than one formation; so much so that one cannot avoid asking why there should be Old Red Sandstone in the Mendips and Devonian in the Quantocks. The line which separates the Old Red Sandstone of South Wales and the Mendips from the West Somerset type of Devonian lies here concealed. I have already suggested[1] that, if we regard the Old Red Sandstone of South Wales as an inshore deposit over an area which was deluged with fresh water off the land, we can believe that further out to sea, in a south-westerly direction, the conditions were favourable for the development of a moderate amount of marine mollusca. This view not only does away with the necessity for a barrier, but it also, in a general sense, suggests a kind of gradation between the Old Red and Devonian deposits. Mr. Ussher, whose practical acquaintance with this region dates from a long period, stated a few years ago that, "As far as Great Britain is concerned, the true connections of the Old Red Sandstone beds with their marine Devonian equivalents have yet to be carefully worked out on the ground."[2] I am not aware that further progress has been made in this direction.

[1] Trans. Devonsh. Assoc., vol. xxi (1889), p. 45.

[2] "Prospects of obtaining Coal by boring South of the Mendips": Proc. Som. Nat. Soc., vol. xxxvi (1891), pt. 2, p. 104.

The Carboniferous Limestone of the Bristol area has attracted the attention of so many distinguished geologists that its palæontology and general features are tolerably familiar. Of late years we owe some interesting petrographic details to Mr. Wethered. The varying thickness of the Carboniferous Limestone and also of the Millstone Grit in this part of England is noteworthy. If we follow the Carboniferous Limestone in a south-westerly direction, across the mysterious Bridgewater flats, a change is already noted in the case of the Cannington Park limestone, which was the subject of so much discussion in former years. Referring to this, Mr. Handel Cossham[1] was so sanguine as to believe that its identification with the Carboniferous Limestone would have the effect of extending the Bristol Coalfield thirteen miles south of the Mendips. However this may be, all further traces of Carboniferous rocks fail at this point. After crossing the Vale of Taunton, when next we meet with them in the Bampton district, the Culm-measure type, with its peculiar basal limestones, is already in full force.

In the new "Index Map" the Culm-measures are placed at the base of the Carboniferous series—below the Carboniferous Limestone. It is no part of my purpose to attempt any precise correlation, but I would point out the somewhat singular circumstance that the change to Culm rock occurs only a few miles to the south-west of the line where, in the previous system, we have already seen that the Old Red Sandstone changes into the Devonian. This curious coincidence may be wholly accidental, or it may be the result of some physical feature now concealed by overlying formations.

Since 1895 a new light has been thrown on the lower Culm-measures by the discovery of a well-marked horizon of Radiolarian rocks. One result of the important paper of Messrs. Hinde and Fox has been to alter materially our views as to the physical conditions accompanying the deposition of a portion of the Culm-measures. The palæontology leads the authors to conclude[2] that "the Lower *Posidonomya*- and Waddon Barton Beds are the representatives and equivalents of the Carboniferous Limestone in other portions of the British Isles; not, however, in the at present generally understood sense that they are a shallow-water facies of the presumed deeper-water Carboniferous Limestones, but altogether the reverse, that they are the deep-water representatives of the shallower-formed calcareous deposits to the north of them. . . . . The picture that we [Messrs. Hinde and Fox] can now draw of this period is that while the massive deposits of the Carboniferous Limestone—formed of the skeletons of calcareous organisms—were in the process of growth in the seas to the north [i.e. in the Mendip area and elsewhere] there existed to the south-west a deeper ocean in which siliceous organisms predominated and formed these siliceous radiolarian rocks."

This is probably a correct view of the case, but one cannot help wondering that the ocean currents and other causes did not effect

[1] Proc. Cottes. Club, vol. viii (1881–2), p. 20 et seq.
[2] Quart. Journ. Geol. Soc., vol. li (1895), p. 662.

a greater amount of commingling of the elements than seems to have taken place. As a practical result, this discovery of a Radiolarian horizon in the Culm-measures has been of service in enabling surveyors to discriminate between Devonian and Carboniferous in the very obscure area on the other side of Dartmoor. This, I ventured to predict, would be the case when the paper was read before the Geological Society.

The principal features of the Bristol Coalfield are too well known to call for many remarks. It would seem that the Pennant rock was formerly regarded as Millstone Grit, until Mr. Handel Cossham, in 1864, pointed out the mistake. Mr. Wethered gave a good description of the Pennant in his paper on the Fossil Flora of the Bristol Coalfield.[1] It might seem almost unnecessary to refer to the existence of such a well-known formation as the Pennant, but for the fact that in a recent scheme of the Carboniferous sequence in Somersetshire the Pennant rock was wholly omitted.

The interest now shifts from the almost continuous deposition of the later Palæozoics, in one great geosynclinal depression, to an entirely different class of phenomena. Nowhere, perhaps, are the effects of the Post-Carboniferous interval better exhibited than in those parts of the south-west of England where Tertiary denudation has removed the Mesozoic deposits. Here we perceive some of the effects of the great foliations which terminated the Palæozoic epoch in this part of the world. The immense amount of marine denudation which characterizes this stage is particularly obvious in the anticlinals, which were the first to suffer, as they came under the planing action of the sea.

Attention may be drawn to a peculiarity which has no doubt been observed by many persons who have studied a map of the Bristol and Somerset Coalfield. It will be seen that the strike of the Coal-measures is widely different on either side of a line which may be drawn through Mangotsfield to a point north of Bristol. The beds north of this line have for the most part a meridional strike, nearly parallel with the present Cotteswold escarpment; south of this line the strike is mainly east and west, though much curved in the neighbourhood of Radstock and the flanks of the Mendips. Of course, this is only part of an extensive change in the direction of flexure, much of which is still hidden under Mesozoic rocks. Mr. Ussher, in the paper previously quoted, tells us that the line of change of strike may be traced in the general mass of the Palæozoic rocks, from near Brecon in South Wales to the neighbourhood of Frome. This means that within the Bristol district two distinct systems of flexure must have impinged on each other in Post-Carboniferous times. Have we not here, then, another instance of extraordinary change within the limits of our area? This time it is not a mere change in the nature of a deposit, like that of the Old Red Sandstone into the Devonian, or of the Carboniferous Limestone into the Culm-rock, but a change in the direction of the elevatory

[1] Proc. Cottes. Club, vol. vii (1878), p. 73.

forces, which had made its mark on the structure of our Island even at that early date.

At this point I ought to quit the Palæozoics; but there is just one subject of interest which claims a momentary attention, viz., the probability of finding workable coal east of the proved Somersetshire field. I avoid the question of coal south of the Mendips as being too speculative, on account of the chances of deterioration of the Coal-measures in that direction. But in view of the forthcoming meeting of the British Association at Dover, the question of finding coal to the eastward of Bath becomes a specially interesting subject for discussion. It is also a matter of some consequence whether the hidden basin or basins belong to the meridional or to the east and west system of flexures. The latter is most likely to be the case.[1] The Vale of Pewsey has been mentioned as a suitable locality for boring along the line of the recognized axis.

But prospectors should bear in mind the warning of Ramsay, that the basins containing coal are but few in comparison with the number of basins throughout the Palæozoic rocks. No doubt the line indicated is more favourably situated for coal-exploration than the Eastern Counties; where, for instance, the Coal Boring and Development Company has lately gone into liquidation. The unsuitability of East Anglia as a field for coal-prospecting was insisted on in my second anniversary address to the Geological Society,[2] and the results seem to have been very much what might have been expected. If coal is to be found beneath the Secondary rocks the line of search should be carried through the counties of Kent, Surrey, Berkshire, and Wiltshire, though the three latter counties have hitherto been content to leave their underground riches unexplored. The Kent Coal Exploration Company is doing some good work with a reasonable chance of success; though if they wish to find coal sufficiently near the surface they had better adhere as much as possible to the line of the North Downs, since operations on the Sussex side are only too likely to be within the influence of the Kimmeridgian gulf, which was proved to exist at Battle (Netherfield). Mr. Etheridge, I hope, will have something to tell us as to the progress of the Kent Collieries Corporation, who now carry on the work at Dover.

Secondary Mesozoic Rocks.

Commencing a totally different subject, I must now direct attention to the 'red beds' and associated breccias so characteristic of Eastern Devonshire. These rest in complete discordance on the flanks of the Palæozoic highlands, and must be regarded as forming the base of the Secondary rocks of that district.

[1] The boring at Burford, where coal was found at a depth of 1,100 feet, below a surface of Bathonian beds, at a point thirty-five miles E.N.E. of the extreme end of the Bristol Coalfield at Wickwar, is not included in this category; since it must belong to the meridional system, and is altogether outside the prolongation of the axis of Artois.

[2] Quart. Journ. Geol. Soc., vol. L (1894), p. 70.

By the Geological Survey this series has hitherto been mapped as Trias, but in the new "Index Map" they are coloured as Permian. There is no palæontological evidence which would connect them with the fossiliferous Permians, usually regarded as of Palæozoic age, but it has been evident for some time past that opinion was inclining to revert to the views of Murchison and the older geologists, more especially as to the position of the breccias so largely charged with volcanic rocks. The subject was dealt with by Sir A. Geikie in his address to the Geological Society, where he speaks of some of these rocks as presenting the closest resemblance to those of the Permian basins of Ayrshire and Nithsdale.[1]

One difficulty which presented itself to the Devonshire geologists in accepting the Permian age of the 'red beds' was, that the whole of the lower Secondary rocks appeared as an indivisible sequence, proved by its fossils to be of Keuper age at one end, and therefore inferentially of Keuper age at the other. Dr. Irving, however, considered that at the base of the Budleigh Salterton pebble-bed there is a physical break of as much significance as that between the Permian and Trias of the Midlands. In the marls which underlie this pebble-bed he recognized a strong resemblance to the Permian marls of Warwickshire and Nottinghamshire; and Professor Hull, who had been studying the sections east of Exmouth about the same time, ultimately acceded to this view.[2] Its acceptance by the Survey thus throws all the Exmouth beds into the Permian; and that formation, according to the new reading, has an outcrop of some 35 miles from the shores of the English Channel to within 3 miles of Bridgewater Bay. The fertility of these red clays, loams, and marls has long been recognized by agriculturists, and it is not improbable that the abundance of contemporaneous volcanic material may in some measure have contributed to this result.

In conformity with the new mapping, the Budleigh Salterton pebble-bed and its equivalents to the northwards are accepted as of Bunter age, and thus constitute the base of the Trias in the south-west. Like most pebble-beds, they are irregularly developed between the Permians and a strip of reddish sandstone (coloured as Keuper), which runs up from the mouth of the Otter to within a short distance of Bridgewater Bay. The materials of the pebble-beds are not of local origin, like so much of the breccia at the base of the Permian. The general resemblance, both as regards scenery and composition, to the Bunter conglomerate of Cannock Chase has been pointed out by Professor Bonney, who seems prepared to endorse the recognition of the Budleigh Salterton pebble-bed as a Bunter conglomerate. He was not impressed by any marked unconformity with the underlying series. To some extent we may accept this view, since whatever may be the age of the Devonshire

[1] Quart. Journ. Geol. Soc., vol. xlviii (1892), p. 161.

[2] Cf. Irving, Quart. Journ. Geol. Soc., vols. xliv (1888), p. 149; xlviii (1892), p. 68; and xlix (1893), p. 79; and Hull, op. cit., vol. xlviii (1892), p. 60.

breccias and 'red beds,' they, in common with the Trias, must have been deposited under fairly similar physical conditions in a sort of Permo-Triassic lake basin.

The bulk of the Trias, including the Dolomitic Conglomerate of the Bristol district, is still regarded as of Keuper age, though it is now admitted, as insisted on by Mr. Sanders years ago, that the Dolomitic Conglomerate does not necessarily occupy the base of the Keuper, but is mainly a deposit of hill-talus, which has been incorporated with the finer deposits of the old Triassic lake as the several Palæozoic islands gradually became submerged. The great blocks which fell from the old cliffs were formerly regarded as proofs of glacial agency, and there are persons who still believe, more especially with respect to the Permian breccias, that such rocks are indicative of a glacial origin.

In the "Index Map" the Dolomitic Conglomerate and the Red Marl are thus included under the same symbol and colour. But this is also made to include the Rhætic—an arrangement which is hardly in accordance with the facts observed in the Bristol area. On a small-scale map so narrow an outcrop as that of the Rhætic could hardly be shown; yet its affinities are probably with the Lower Lias rather than with the Trias. The late Edward Wilson, whose recent death we all deplore, in his paper on the Rhætic rocks at Totterdown,[1] showed most clearly that the 'Tea-green marls,' which had previously been associated with the Rhætic, represent an upward extension of the Red Marls of the Trias, in which the iron had suffered reduction; although there are indications of a change of conditions having set in before the deposition of the Rhætics. The black Rhætic shales which succeed usually have a sharp and well-defined base in a bone-bed with quartz pebbles, etc., indicating a sudden change of physical conditions, though perhaps no marked unconformity. In the South Wales district the Rhætic limestones are said to be largely of organic origin and, in addition to a Rhætic fauna, to abound in the lamellibranchs so plentiful in the lowest Lias limestones.[2]

The late Charles Moore always deplored the comparative poverty of the Trias in fossils. In his last communication to the Geological Society,[3] he set himself to describe certain abnormal deposits about Bristol, and to institute a comparison with the region of the Mendips. He then suggested, on the faith of a sketch by Mr. Sanders, that the famous Durdham Down deposit, already inaccessible, might have been a fissure-deposit in the Carboniferous Limestone like those at Holwell. He also stated that at one time he had been inclined to regard the Reptilian deposit on Durdham Down as of Rhætic age; but the discovery of teeth of *Thecodontosaurus*, identical with those of Bristol, in a Keuper Marl deposit near Taunton, induced him to refer the Durdham Down deposit to the middle of the Upper Keuper. He had arrived at the conclusion

[1] Quart. Journ. Geol. Soc., vol. xlvii (1891), p. 545.
[2] Ann. Rep Geol. Survey for 1896, p. 67 (1897).
[3] Quart. Journ. Geol. Soc., vol. xxxvii (1881), p. 67.

that the same genera of vertebrata are found in the Keuper and Rhætic beds, though the species, with few exceptions, are quite distinct.

But it is with the Lias that the name of Charles Moore is most intimately associated. Time does not permit me to do more than allude to the wonderful collections of Rhætic and Liassic fossils made by him from the fissure-veins of the Carboniferous Limestone, or of the treasures which are stored in the Bath Museum. There never was a more enthusiastic palæontologist, and nothing pleased him better than to exhibit the fossilized stomach of an *Ichthyosaurus*, stained by the ink-bag of the cuttle-fish, on which it had been feeding, or some similar palæontological curiosity. Everyone here knows how deeply the West of England is indebted to Charles Moore for his unceasing researches, and I have been thus particular in alluding to them because it was under his auspices that I first became acquainted with the geology of this part of the country just thirty years ago.

Amongst more recent work in the Rhætic and Lias I might mention papers by Mr. H. B. Woodward and Mr. Beeby Thompson, each in explanation of the arborescent figures in the Cotham Marble. The latter revives an old idea with modifications, and his theory certainly seems plausible. Mr. H. B. Woodward's Memoir of 1893 does full justice to the Lias of this district, and much original matter is introduced.

It is, however, in the Inferior Oolite that the most important interpretations have to be recorded since the days when Dr. Wright and Professor J. Buckman endeavoured to correlate the development of the series in the Cotteswolds with that in Dorset. To this subject I alluded at considerable length in my address to the Geological Society in 1893, pointing out how much we owed in recent years to the late Mr. Witchell and to Mr. S. S. Buckman. In the following year appeared Mr. H. B. Woodward's Memoir on the Lower Oolitic Rocks of England ("Jurassic Rocks of Britain," vol. iv), wherein he did full justice to the work of previous observers. Meantime Mr. Buckman has not been idle, and his paper on the Bajocian of the Sherborne district[1] marks the commencement of a new era, where the importance of minute chronological subdivisions, based upon the prevailing ammonites, is insisted on with much emphasis. This system he considers to be almost as true for the Inferior Oolite as for the Lias.

There can be no doubt that its application has enabled Mr. Buckman to effect satisfactory correlations between the very different deposits of the Cotteswolds and those of Dorset and Somerset. In subsequent papers also he brings out an important physical feature, viz., the amount of contemporaneous denudation which has affected deposits of Inferior Oolite age in this country. This serves in part to explain the absence of well-known beds in certain areas. For instance, in the Cotteswolds contemporaneous

[1] Quart. Journ. Geol. Soc., vol. xlix (1893), p. 479.

erosion has, prior to the deposition of the Upper *Trigonia*-grit, cut right through the intervening beds, so as to produce in the neighbourhood of Birdlip a shelving trough six miles wide and about 30 feet deep. Thus the extensively recognized overlap of the *Parkinsoni*-zone is accentuated in many places.

We have a further instance of good work in the case of Dundry Hill. An inspection of the 1-inch Survey map would lead one to suppose that the Inferior Oolite there rests directly on the Lower Lias. Recently, owing to the investigations of Messrs. Buckman and Wilson,[1] this apparent anomaly has been removed, whilst beds of Middle and Upper Lias age and even Midford Sands have been recognized. In this way the authors claim to have reduced the thickness assigned to the Inferior Oolite on Dundry Hill by about 100 feet. In the paper above quoted the vicissitudes and faunal history of the Inferior Oolite from the *opalinus*-zone to the *Parkinsoni*-zone inclusive are shown with much detail; whilst the position of the chief fossil-bed in time and place has been well established. The general resemblance of the Dundry fossils to those of Oborne, which I could not fail to notice in working out the Gasteropoda of the Inferior Oolite, now admits of explanation. Although the quondam *Humphriesianus*-zone is richly represented, yet the particular *Humphriesianum*-hemera is held to be absent at Dundry. But if there be a *Sowerbyi*-bed anywhere it should serve to connect these two localities, where, according to Mr. Buckman's phraseology, the principal zoological phenomenon is the acme and paracme of *Sonninine*.

Mr. Buckman, as we have seen, is no longer satisfied with the old-fashioned threefold division of the Inferior Oolite, and his time-table includes at least a dozen hemeræ, with prospect of increase. Granting that it would have been difficult to solve the Dundry problem without a detailed knowledge of ammonite horizons, there arises the question as to the utility of such minute subdivisions for the purposes of general classification. Mr. Buckman has earned the right to put forward, if he pleases, the several stratigraphical rearrangements in which from time to time he indulges. The Inferior Oolite has been his especial playground, and, as the kaleidoscope revolves, this formation is perpetually made to assume different proportions, even to the verge of extinction. But this practice is not without its disadvantages; whilst the invention of new names tends to clog the memory, and the novel use of old ones is apt to produce confusion.

We have not quite finished with Dundry yet, since that classic hill serves to illustrate in Mesozoic times a peculiarity of which I have already pointed out two notable instances in this district, where an abrupt and seemingly unaccountable difference is observed in beds which are approximately synchronous. The problem to be solved is this—Why does the fossiliferous portion of the Inferior

[1] Quart. Journ. Geol. Soc., vol. lii (1896), p. 669. Cf. also Proc. Brist. Nat. Soc., vol. viii (1897), pt. 2, p. 188.

Oolite on Dundry Hill resemble that of the neighbourhood of Sherborne, both in lithology and fossils, rather than that of the Cotteswolds, only a few miles distant?

Nine years ago Mr. Buckman offered an ingenious solution of this difficulty;[1] although his recent investigations at Dundry, and especially his appreciation of the effects of contemporaneous erosion, may have caused him to alter his views. Like most people who wish to account for strong local differences, he placed a barrier of Palæozoic rocks between Dundry and the southern prolongation of the Cotteswold escarpment. At that time it was not fully realized that the Inferior Oolite in the Bath district is, for the most part, limited to the *Parkinsoni*-zone, so that the comparison was really being made between beds of different age as well as different physical conditions. The question resolves itself into one of local details, which are not suited for a general address. Still, I think it may be taken for granted that, notwithstanding the east-and-west barrier of the Mendip range, which acted effectually previously to the *Parkinsoni*-overlap, there was in some way a communication by sea between Dundry and Dorsetshire, more especially during the *Sowerbyi*-stage, and this most probably was effected round the western flank of the Mendips. Thus, without acceding to the necessity for a barrier facing the southern Cotteswolds, we may readily believe that much of the Inferior Oolite of Dundry Hill is to be regarded as an outlying deposit of the Anglo-Norman basin. If this be so, it is difficult to avoid the conclusion that the low-lying area of the Bridgewater flats was, during part of the Inferior Oolite period, occupied by a sea which was continuous from Sherborne to Dundry, and that, although the barrier of the Mendips was interposed, communication was effected round the west flank of that chain. This would make a portion of the Bristol Channel a very ancient feature.

We must now take a wide leap in time, passing over all the rest of the Jurassics, and just glancing at the Upper Cretaceous system, which reposes on the planed-down surface of the older Secondary rocks. The remarkable double unconformity is nowhere better shown than in the south-west of England. Some of the movements of the older Secondary rocks, prior to the great revolution which brought the waters of the Cretaceous sea over this region, have been successfully localized by Mr. Strahan, more especially in the south of Dorset.

Owing to Tertiary denudation the Chalk in this immediate district has been removed, and we have no means of judging the relations of the Cretaceous deposits to the Palæozoic rocks of Wales. If we may judge by results recently recorded from Devonshire[2] the Lower Chalk especially undergoes important changes as it is traced westwards, and, generally speaking, terrigenous deposits seem more abundant in this direction. At the

[1] Proc. Cottes. Club, vol. ix (1890), p. 374.
[2] Cf. Jukes-Browne and Hill, Quart. Journ. Geol. Soc., vol. lii (1896), p. 99.

same time the more truly oceanic deposits, such as the Upper Chalk, appear to be thinning. As regards the possible depths of the Cretaceous sea at certain periods, we are supplied with some interesting material in Mr. Wood's two papers on the Chalk Rock,[1] which has been found especially rich in Gasteropoda at Cuckhamsley, near Wantage.

Tertiary, Pleistocene, and Recent.

Although the Tertiaries of the Hampshire basins are within the "Index Map" which we have been considering, they may be regarded as beyond our sphere. Some of the gravels of Dorsetshire, which have gone under the name of plateau gravels, are held by Mr. Clement Reid to be of Bagshot age. Many of the higher hill gravels most likely date back to the Pliocene, and even further, and represent a curious succession of changes, brought about by meteoric agencies, where the valley-flat of one period, with its accumulated shingle, becomes the plateau of another period—an endless succession of revolutions further complicated by the Pleistocene Cold Period, which corresponds to the great Ice Age of the north.

In the more immediate neighbourhood of Bristol, since some date in Middle Tertiary time, the process of earth-sculpture, besides laying bare a considerable amount of Palæozoic rock, has produced both the Jurassic and Cretaceous escarpments as well as the numerous gorges which add so much to the interest of the scenery. These phenomena have been well described by Professor Sollas,[2] when he directed an excursion of the Geologists' Association in 1880. Should any student wish to know the origin of the gorge of the Avon at Clifton, for instance, he will find in the Report an excellent explanation of the apparent anomaly of a river which has been at the trouble of sawing a passage through the hard limestone, when it might have taken what now seems a much easier route to the sea by way of Nailsea.

The origin and date of the Severn Valley is a still bigger question, and this was broached by Ramsay, some five-and-twenty years ago, in a suggestive paper on the River-courses of England and Wales.[3] He there postulates a westerly dip of the chalk surface, which determined the flow of the streams in a westerly direction towards the long gap which was being formed in Miocene times, near the junction of the Mesozoic with the Palæozoic rocks. The still more important streams from the Welsh highlands had no doubt done much towards initiating that gap; and by the end of the Miocene period, if one may venture to assign a date, the valley of the Severn, which is one of the oldest in England, had already begun to take form, though many of the valleys of Wales are probably much older.

[1] Quart. Journ. Geol. Soc., vol. lii (1896), p. 68, and vol. liii (1897), p. 377.
[2] Proc. Geol. Assoc., vol. vi (1881), p. 375.
[3] Quart. Journ. Geol. Soc., vol. xxviii (1872), p. 148.

We may now be supposed to have arrived at a period when the physical features of this immediate district did not differ very materially from what they are at present. The great Ice Age was in full force throughout Northern Europe, and, according to views which meet with increasing favour, the German Ocean and the Irish Sea were filled with immense glaciers. What was taking place at that time in the estuary of the Severn?

This is a case which requires the exercise of the scientific imagination, of course under due control. There is probably nothing more extraordinary in the history of modern investigation than the extent to which geologists of an earlier date permitted themselves to be led away by the fascinating theories of Croll. The astronomical explanation of that 'will o' the wisp,' the cause of the great Ice Age, is at present greatly discredited, and we begin to estimate at their true value those elaborate calculations which were made to account for events which in all probability never occurred. Extravagance begets extravagance, and the unreasonable speculations of men like Belt and Croll have caused some of our more recent students to suffer from 'the nightmare.'

Nevertheless Croll, when he confined his views to the action of ice, showed himself a master of the subject, and his suggestions are often worthy of attention, even when we are not convinced. Writing in the GEOLOGICAL MAGAZINE in 1871, he points out that the ice always seeks the path of least resistance; and he refers to the probability that an outlet to the ice of the North Sea would be found along the natural hollow formed by the valleys of the Trent, the Warwickshire Avon, and the Severn. Ice moving in this direction, he says, would no doubt pass down into the Bristol Channel and thence into the Atlantic. Again,[1] referring to the great Scandinavian glacier, he says: "It is hardly possible to escape the conclusion that a portion of it at least passed across the south of England, entering the Atlantic in the direction of the Bristol Channel." These views were not based on any local knowledge, but merely on general considerations. The problem as to whether there are any traces of the passage of such a body of ice in the basin of the lower Severn must be worked out by local investigators. Irrespective, too, of the hypothetical passage of a lobe of the North Sea glacier, we are confronted by a much more genuine question, namely, what was the possible termination towards the south of the great body of ice with which our more advanced glacialists have filled the Cheshire plain.

A recent President of the Cotteswold Field Club, of whom unfortunately we must now speak as the late Mr. Lucy, took a lively interest in the Pleistocene geology of the district, and his papers in the Proceedings of the Cotteswold Field Club have always attracted attention. His map of the distribution of the gravels of the Severn, Avon, and Evenlode, and their extension over the Cotteswold Hills, prepared in conjunction with Mr. Etheridge, is a valuable contribution

[1] GEOL. MAG., Dec. II, Vol. I (1874), p. 257.

to the history of the subject.[1] Again, he wrote on the extension of the Northern Drift and Boulder-clay over the Cotteswold Range,[2] and on this occasion described the interesting section in the drifts presented by the Mickleton Tunnel. In his previous paper Mr. Lucy had carried the drifts with northern erratics to a height of 750 feet, but he now claimed that "the *whole* Cotteswold Range had ceased to be dry land at the time the Clays and Northern Drifts passed over it." We perceive from this passage that Mr. Lucy was a 'submerger,' and in this respect differed from Croll, who most probably would have attributed the phenomena to the action of his great ice-lobe traversing the south of England.

The question which more immediately concerns us relates to the value of the evidence which would require either a glacier or a 'great submergence' to account for these things. The alleged phenomena are in many cases capable of other interpretations. We have the authority of Mr. Etheridge that little or no true Boulder-clay occurs in the Cotteswold area.[3] On the other hand, the distribution of much of the erratic gravel is probably due to agencies of earth-sculpture long anterior to the great Ice Age. There remains one special piece of evidence adduced by Mr. Lucy in favour of his contention, and this he considered of so much importance that it formed the principal part of the subject of his annual address to the Field Club on quitting the chair in 1893.[4]

He there referred more especially to the discovery *in* the Inferior Oolite, on Cleeve Cloud, of quartzose sand and of a boulder of a similar character to some described in his previous papers. The sand and the boulder, he says, belong to the period of the great submergence. Similar sand also appears in several places on the hillside. He had previously recorded boulders of Carboniferous Limestone, Millstone Grit, etc., in the northern Cotteswolds, but not at so great an elevation. He further proceeds to account for the absence of striæ, and of the fact that the Cotteswold rocks are not *moutonnée*, on the supposition that the soft oolites would not retain striation, but would be crushed by pressure. Consequently, he claims the top of Cleeve Cloud as a fine example of 'glacial denudation,' whatever that may mean. The boulder from Cleeve Cloud is now in the Gloucester Museum, and might well become a bone of contention between the submerger and the glacialist as to how it got into its elevated position of over 1,000 feet. Fortunately there is a third explanation, which, if it be correct, shows how dangerous it is to build theories, as well as houses, upon sand. Other distinguished members of the Cotteswold Club are of opinion that the whitish sands on Cleeve Common belong to the 'Harford Sands,' which constitute an integral part of the Inferior Oolite itself. There may be some difference of opinion as to the concretionary nature of the boulders,

[1] Proc. Cottes. Nat. Club, vol. v, pt. 2 (1869), p. 71.
[2] Op. cit., vol. vii, pt. 1 (1878), p. 50.
[3] Proc Cottes. Nat. Club, vol. xi (1893), p. 83.
[4] Vol. cit., p. 1.

though these may well be nothing more than the 'doggers,' or 'potlids,' so characteristic of calcareous sandstones. Mr. Winwood believes that "the so-called foreign boulder" in the Gloucester Museum evidently came from the 'Harford Sands.'

So far, therefore, the evidences of glacial action in the Cotteswolds do not rest on a very sure foundation. Yet the Severn Valley separates that range from an area on the west, where there are clear evidences of local glaciation, as described in the Annual Report of the Geological Survey for 1896. Portions of this material find their way into the river bed and elsewhere as Drift which has most probably been rearranged; hence the so-called Boulder-clay and Drift in the bed of the Severn. Once more, then, in the cycle of geological time we perceive that our district lies on the confines of two distinct sets of phenomena. West of the Severn and north of the Bristol Channel the evidences of considerable local glaciation are obvious, whilst this can hardly be said of the Cotteswolds, the Mendips, or the Quantocks.

To the more recent geological history of our district it will be sufficient to allude in the briefest terms, when I remind you of the paper by Mr. Strahan on the deposits at Barry Dock, and the still later one by Mr. Codrington on the submerged rock valleys in South Wales, Devon, and Cornwall. Here we have important testimony to certain moderate changes of level which have taken place, and a picture is presented to us of the Bristol Channel as a low-lying land-surface, with streams meandering through it. Thus a depression of something like 60 feet appears to be the most recent change which the geologist has to record in the estuary of the Severn.

REVIEWS.

I.—Contribution à l'Étude Micrographique des Terrains Sédimentaires. I. Étude de quelques dépôts siliceux secondaires et tertiaires du Bassin de Paris et de la Belgique. II. Craie du Bassin de Paris. Par Lucien Cayeux, D. ès Sc. 4to; pp. 589, pls. x, and 20 figures in the text. (Lille: Le Bigot Frères, 1897.)

IN this elaborate work Dr. Cayeux gives the results of an extended series of investigations into the minute structure of the sedimentary rocks mainly of the Paris Basin, but including as well some in the North of France and adjoining areas in Belgium. The age of the rocks treated of ranges from the Jurassic to the Eocene, but the greater number belong to the Cretaceous Series, from the Albian to the Senonian, or, in English terms, from the Gault to the Upper Chalk with *Belemnitella mucronata*. The author's aim has been, by a close study of the present characters of the deposits, to ascertain their natural history, and to trace the effects of the various mechanical, chemical, and physiological agencies to which they