NOTICES OF MEMOIRS.

ADDRESS DELIVERED TO THE NORWICH GEOLOGICAL SOCIETY BY THE RETIRING PRESIDENT, MR. HORACE B. WOODWARD, F.G.S., NOVEMBER 4TH, 1879.

After referring to recent palæontological investigations that bear upon the geology of Norfolk, Mr. H. B. Woodward proceeded as follows:—

Leaving now the subject of organic remains, the collection of which possesses a peculiar charm in itself, I pass on to note a few points in physical geology, in the study of which it is not always easy to kindle and maintain an interest. This leads me into my own more particular branch of investigation, and opens up the question, often asked me during my rambles across country, "What is the use of the Geological Survey?" I shall not take up your time by attempting an elaborate answer to this. In each county geology may have different economic applications, and it is hardly a fair answer to tell the Norfolk agriculturist the value of maps and sections in mining districts, when he questions their practical value in his own county. My colleague, Mr. F. J. Bennett, has, however, lately taken up the subject, and in an essay read before the Ixworth Farmers' Club,[1] has called attention to the relations of the Geological Survey to agriculture. The object of the Survey is to portray on maps (the Ordnance Survey Sheets being used) the superficial distribution of the various strata or subsoils. In Norfolk these comprise Chalk, and several kinds of gravel, sand, loam, clay, and marl. Such deposits are classified according to their relative ages; and this is an essential point, because any one understanding their order of superposition, and mode of occurrence, can form a very good idea (from the geological map) of the strata likely to be met with in opening a pit or sinking a well. In short, the map is an index to the underground arrangement, and its applications in reference to economic deposits are at once apparent.

While brick-yards and lime-works mark the principal manufacturing industries connected with the geology of Norfolk, it is to its agricultural capabilities that the county is specially indebted. And in this respect, indeed, it stands almost unrivalled among English counties.[2] Hence it may be felt that it is with the soils, even more than with the subsoils or beds beneath, that a great part of the population is chiefly concerned; and at first sight the bearings of geology upon agriculture seem limited. Nevertheless, looked at in a large way, the rural economy of the country is directly influenced by the geology—partly from the character of the rocks themselves, partly from the physical features which have resulted from them. Thus the older rocks of the north and west of England, rising in rugged hills and mountains, with comparatively little soil, support a herbage suitable for sheep. The new red rocks, the Liassic and Oolitic clays, form pasture land, and upon them the dairy farms

[1] Published at Diss, 1879.

[2] Lincolnshire is said to stand pre-eminent.

abound. The Liassic and Oolitic limestones are largely devoted to cereals and green crops. The chalk areas, where bare of soil, are consigned to sheep-walks, while the Tertiary strata and drifts form rich agricultural districts.

When we look more particularly at the soils, we find a direct relation between them and the beds beneath. It has been spoken of as a sort of agricultural axiom, that the soil follows the contour. And when we remember that the strata over the chief agricultural districts in England are comparatively horizontal, that the valleys expose successive strata beneath, we can readily understand that as they follow the contour, the soils must be influenced by the subsoils. Indeed, if we take the classifications of soils made by agricultural writers, this is apparent. For the sake of example, we may take the general grouping adopted by Mr. C. S. Read, M.P. He divides Norfolk into five heads:—1. The chalk; 2. Blowing sand; 3. Stiffer soils; 4. Naturally good soils; 5. Diluvial soils. The Chalk is most conspicuous at the surface in West Norfolk. The blowing sand corresponds to the Glacial Sands, including the heath-land around Thetford, and that in the parishes of Horsford, Felthorpe, etc. The stiffer soils comprise the Chalky Boulder-clay of the country around Tivetshall, Long Stratton, Attleborough, etc. The naturally good soils, found chiefly to the north-east of Norwich, correspond to the Contorted Drift, and form the best land in the county, including that around Burlingham, Barton, Stalham, Bacton, and the Flegg Hundred. Then we have the diluvial tracts, including the fen land and the alluvial meadows of the river valleys. Thus we see that this division of soils corresponds to the larger grouping of the strata beneath.

After all, soils in most cases are merely the weathered surface of the subsoil, commingled with decayed vegetable and animal matter, and they vary in depth according to local circumstances, and according as the subsoil is suitable for worms, moles, and other burrowing and soil-forming animals. Frequently indeed the subsoil is ploughed up, and it is astonishing to see how often masses of Chalky Boulder-clay are turned over, appearing quite fresh, when one would have expected the calcareous matter to have been dissolved out. The Crag itself is occasionally ploughed up; and, in company with Mr. Sothern, I lately saw at Wroxham a furrow deeply eroded by rain, which exposed a bed of shells. Between Worstead and North Walsham the buff-coloured Glacial Sands are to be seen here and there in the ploughed fields, but in these, as in other cases, more particularly on the hill-slopes, where the soil is liable to be washed away.

In some cases it happens that the soil is of a boggy and peaty nature, or it may be formed chiefly from the relics of a deposit that once overspread the district, and which has been almost entirely removed by denudation. Such deposits may not be shown on geological maps; but from what has been said, the map will in all cases be a guide to the nature and capabilities of any tract of ground.

In reference to mining enterprise, geology has more often done good in preventing useless trials for "minerals" than in promoting explorations, and particularly in the matter of coal-boring, in which people seem most inclined to speculate. Black shale is generally enough to stimulate hope, and a man at Shottesham, probably from the testimony of the rocks in a Boulder-clay pit, told me he knew there was coal in the parish. Not a hundred years ago a trial for coal was made within five miles of Norwich. In his account of Framingham (1820), Dr. Rigby says, "There is a traditionary report, also, that even coal has been found here, and some years ago I was induced, in conjunction with the late James Crowe, Esq., who had some property in the neighbourhood, to dig to a considerable depth on a high part of what was then the heath. Near the surface was gravel, and below it clay, which continued until water rose and stopped our progress." He mentions the finding of "two isolated pieces of pure coal" in the clay; but these were probably lignite, being "of a texture very different" from the Newcastle coal. When called upon to give some answer concerning the likelihood of getting coal in Norfolk, I always reply in the affirmative, with these saving clauses, that a shaft be sunk deep enough, say one thousand or fifteen hundred feet, and that the speculator be fully prepared to find no coal.

As the question of the extension of Coal-measures beneath the Secondary and newer strata in England is one which concerns us, I will endeavour to point out the present state of the case. Supposing the chalk, which extends from Flamborough Head and Hunstanton to Salisbury Plain, were to be found now, as no doubt once upon a time it was found, still further west over Somersetshire, Gloucestershire, and the Midland Counties, we might then feel some difficulty and hesitation in sinking for Coal-measures beneath it, over areas where they are now exposed. We might make borings, and come across the Cambrian rocks at Charnwood Forest, the Silurian rocks near Dudley and at Tortworth, or the Old Red Sandstone on the Mendip Hills; and we might altogether miss the Coal-measures of Leicestershire, Warwickshire, South Staffordshire, Bristol, and Somerset. Much in this way have we been groping about in the east and south-east of England, where several borings have been made, which have reached these older rocks. Thus as you well know, in the deep well at Harwich, a dark bluish-grey slaty rock of Carboniferous age was met with at a depth of 1,029 feet beneath the Eocene beds and Chalk. At Kentish Town, beds belonging most probably to the Old Red Sandstone were reached at a depth of 1,114 feet; at Meux's Brewery in the Tottenham Court Road, London, Devonian rocks were met with at a depth of 1,064 feet; and at Crossness, near Blackwall, in Kent, strata classed as Old Red Sandstone, or Devonian, were touched at a depth of 1,004 feet. Further, in May of this year [1879], Mr. Etheridge announced the interesting fact that Silurian rocks (Wenlock shale) had been met with in a boring at Ware, in Hertfordshire, at a depth of only 800 feet below the surface. Moreover, a study of the rocks in Belgium and the north

of France reveals the fact that Coal-measures are found sometimes at depths of only 300 or 400 feet beneath the Chalk and Tertiary strata. And here they are accompanied, seemingly in perfect conformity, by Devonian rocks, like those found under London.

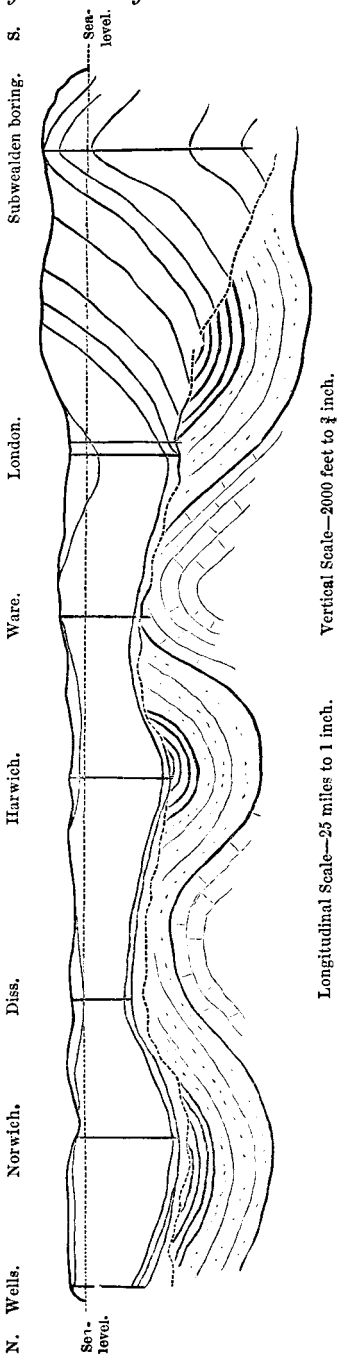
With these facts before us, there can be no question that there is great probability of productive Coal-measures being met with in the east of England. And we must give all honour to Mr. Godwin-Austen for having suggested this before any one of these borings had been made.

On the Continent the Palæozoic rocks are remarkably disturbed, and even inverted, thus presenting many features in common with the strata on the Mendip Hills. It is these disturbances which prevent any accurate calculations being made as to the probable position of the Coal-measures here or there, from the facts at present told by our deep borings.

Professor Prestwich, in his remarks on the Devonian rocks at Meux's brewery, was led to infer that Coal-measures might be met with to the north of a line drawn between Maidstone and London; but he added that "the Palæozoic strata are so disturbed and folded, that neither the dip nor the relative position of the Devonian beds afford any certain guide to the position of the Carboniferous trough."

Since these remarks were made, the Silurian rocks have been detected at Ware. That discovery may, however, in no way affect the matter, as in the Dudley Coal-field, the Wenlock beds rise up in proximity to the celebrated ten-yard seam of coal.

Concerning the slaty rock at Harwich, Professor Prestwich has



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pointed out its resemblance to a bed in the neighbourhood of Mons, in Belgium, that attains a thickness of about 200 feet, reposing on the Carboniferous Limestone, and immediately underlying the Coal-measures. He was disposed to think that this rock at Harwich lay on the north side of a coal-basin, in which case the Lower Carboniferous and Devonian beds would rise beyond it and pass under Suffolk. Considering the disturbances before alluded to, we need by no means conclude that Coal-measures are likely to be absent from Norfolk; on the contrary, the undulations affecting the Palæozoic rocks are quite likely to bring in a coal-basin in some portion of this area. (See diagram, p. 75.)

Mr. Gunn, who has brought this subject before you on several occasions, has recommended a trial-boring to be made at Hunstanton. Of course, in West Norfolk, whether at Hunstanton, Lynn, or Downham Market, we avoid the Chalk, which we know to be over 1,000 feet at Norwich; but we do not know how thick the Oolitic strata may be in this district, and at Lynn the depth of 680 feet has been reached without passing through them. Whereas, in proceeding towards Harwich, we know that the Oolitic strata must gradually die out, for at this locality the Cretaceous beds rest directly upon the Palæozoic rocks. From these remarks it may be gathered that scientific opinion cannot ever do more than assert the *probability* of coal being met with here or there; and at present it can only assert the *possibility* of coal in Norfolk, without mentioning any one locality as more likely than another to yield it.

A very important application of geology is in the matter of water supply. Mr. Sutton has brought the subject before us, and he has pointed out that where water-bearing strata occur beneath an impervious bed, which would keep out all sewage contamination, there we have the most suitable conditions for a well. He stated that the best sources of domestic water in Norfolk are from the Chalk or from the porous sands resting on it, where these are overlaid by some deposit of clay. These "porous sands" are the beds known more familiarly to us as the Norwich Crag Series, including thereby not only the Upper and Lower Crags of Norwich, but the Bure Valley beds. This series is overlain to the north and north-east of Norwich by the Lower Glacial Brickearth; while south and west of Norwich it is extensively overlain by the Chalky Boulder-clay. Water is sometimes held up in this sandy series by one of the laminated clay beds, and where these are absent, the Chalk itself saturated with moisture holds up the water: or again it may be obtained at varying depths from fissures or cavities in the Chalk. Hence Norfolk has no cause to complain of its capabilities of yielding a water-supply, although no single well is likely to yield any very large amount. And it is to be hoped that some day Government will take up the subject, and insist upon good water being supplied to every dwelling in the land.

[After referring to the recent floods in Norwich, the President continued:—] A study of the present physical aspect of our land cannot fail to interest us. Who of us in wandering over

the cultivated surface of Norfolk is not glad to find here and there, though very rarely, a tract of wild country that helps to lead back the imagination to those good old times when as yet the hand of Man had not materially altered the face of the country; when Nature, in fact, had it pretty much her own way. In thus looking back we are at once faced by the conclusion that Man is older than most of the present minor features of Norfolk. The deposits in which the earliest remains of Palæolithic man have been obtained, when he was associated with the Mammoth, Rhinoceros, Hippopotamus, Bison, Musk-sheep, Hyæna, and the old British Lion, are older than the present valleys in East Norfolk. For we find no records of any Palæolithic implements in the valley deposits of the Bure, the Wensum, the Yare, or the Waveney. The finding of an implement at Cringleford by Mr. Harmer is significant, but it is quite possible that the deposit in which this occurred, like that at Hoxne, in Suffolk, was cut through during the formation of the present valley. And this locality of Cringleford, together with that of Runton, are the only ones in the eastern half of Norfolk which have yielded Palæolithic implements. What the general aspect of the country was at this period of Man's early habitation, I cannot pretend to say; nor can I attempt to discuss the relations of the three divisions of Palæolithic man, which Mr. Skertchly has been led to establish from his observations in the west of Norfolk, and which are separated one from another by the periods of glaciation assigned to the great Chalky Boulder-clay, and to the Purple Boulder-clay of Yorkshire and North Lincolnshire. Great changes came about after these beds were formed. A large part of the country was submerged, as much as 1,300 feet in Wales, and subsequently re-elevated. Severe glacial conditions again desolated the northern tracts during the formation of the Hessle Boulder-clay. These gradually ameliorating, the climate became once more suitable for man, the present drainage system of Norfolk was established, and from this period we date the introduction of our modern fauna and flora.[1]

Then Britain was united to the Continent; the Chalk of Dover was not then separated from the main land, for, as Verstegan remarked in 1605, in speaking of the wolf, nó man "would ever transport any of that race for the goodness of that breed, out of the continent into any Isles." And over this connecting area did the animals and plants migrate. Norfolk became a land of heath, woodland, and swamp, tenanted by the Wolf, Brown Bear, Reindeer, Irish Elk, and other Deer; by the long-fronted Ox or Celtic Shorthorn, the Urus, and the Beaver; and I may add, also, the Fresh-water Tortoise discovered at Wretham, and brought to our notice more recently from Mundesley. Since then Great Britain has been isolated from Ireland and the continent, and the coast of Norfolk has undoubtedly been encroached upon to an extent we can scarcely calculate—it may be two or three miles. Land has, however, been gained in our eastern valleys and in the Fenland. Beyond the widening and deepening of valleys, the actual surface of the country would not seem

[1] See J. Geikie, Great Ice Age, 2nd ed. p. 570 (table).

to have been greatly modified in feature, considering the many remains of Neolithic art scattered over the country; while the old flint workings called Grimes' Graves, near Brandon, still remain to tell of the Neolithic workers, considered by Mr. Skertchly to be the direct ancestors of the modern flint knappers, whose labours he has so lately described and illustrated. Even the pit dwellings of the early British or Iceni, described as occurring on the heaths of Weybourn, Marsham, Mousehold, and other places, remain as if to bear witness against any great subaerial denudation. But it must be borne in mind that in porous districts material is often removed by springs at the base of hills, and the general level lowered without the surface features being much altered.

Partly owing to its situation, but partly also to its agricultural capabilities, Norfolk was one of the earliest inclosed districts. The woodlands were effectually cleared, so that, not even in name, has any old forest been handed down to us, beyond what perhaps the derivation of such a word as Holt may indicate. The settlements became numerous—each inclosure or abode being marked by the names of places ending in -ham, -ton, -wick, -by, -stead, -field, -thorpe, -hall, -worth, etc., so that eventually a larger number of parishes was formed in Norfolk than in any other county.

Hence we may trace some connexion between geology and the modern aspect of each country. And for my own part I do not like to end the geological story at what is called the Prehistoric or Neolithic period, as if that marked any particular or world-wide change. Geological history, so far as we can read it, is a "story without an end." Our lives are wrapt up in it. Geology is continually teaching us the influence of the past on the present. And, setting aside the practical benefits, we learn that the truer benefits it bestows are in the influence its teachings have or ought to have on the happiness of mankind.

The account of a well-boring here, or the name of a fossil found there, are but the means by which we can realize geological history—the means by which the picture is painted.

In a novel we judge of the sequel according to the story in progress, we anticipate the ultimate triumph of good over evil. And in the evolution of the earth, while it may be difficult enough to see evidence of good design in every animated object, and in the evils to which all are subject, yet there is so much of beauty and harmony, that we need not spend our lives in lamenting over the evils and afflictions. Surely the diversified scenery, the infinite variety of plants and animals, of rocks and soils, and their adaptation to the wants of man, though they be the results of evolution, and of interaction of causes one upon the other, are not merely the wayward expression of natural forces, unthought of and disregarded.

And in our attempts to anticipate the sequel of geological history—seeing so much that is good and true and beautiful—we feel that the story can have but one end, that the more we learn of the great truths of Nature, the more do they compel our reverence and admiration, the more do they inspire our faith.