ORDINARY MEETING, FEBRUARY 6TH, 1874.

HENRY WOODWARD, Esq., F.R.S., F.G.S., &c., President, in the Chair.

The following Donations were announced :—

“Catalogue of the Library of the Corporation of London.”

“Abstract of Proceedings of the Geological Society,” from that Society.

Henry Alpha Burrows, Esq., was elected a Member of the Association.

The following Papers were read :—

1. ON THE PROBABILITY OF FINDING COAL IN THE EASTERN COUNTIES.

By JOHN GUNN, Esq., M.A., F.G.S.

In my former paper, “On the dip of the Chalk in Norfolk,” I pointed out that the Chalk, which had been horizontally deposited, was upraised about 1,700 feet at Hunstanton, where it crops out together with the Lower Greensand.

The object of my present paper is to show the bearing which this upheaval has upon the prospect of finding Coal in the Eastern Counties, and especially at Hunstanton and along the outcrop of the Kimmeridge Clay. Its effect obviously is to bring the Palæozoic strata proportionately nearer to the surface; but as the intermediate beds between the Cretaceous and Palæozoic are an unknown quantity, and may be of such a thickness as to preclude the possibility of reaching coal at a workable depth, I propose to set before you the grounds on which I have arrived at an opposite conclusion. I will call your attention to other borings besides those at Yarmouth and Norwich, mentioned in my last paper. First to that at Kentish Town, London, which is described by Mr. Prestwich (Quart. Journ. Geol. Soc., February, 1856, and in his Report “On the Probability of finding Coal in the South of England,” Vol. I, page 149, Coal Commission). In 1854-5, he says, a boring was made on the north side of London in search of water through the Tertiary strata and the Chalk to a depth of 1,302 feet. Instead of meeting, as was expected, with the Lower Greensand, which crops out from under the Gault, both to the north and to the south of London, certain red sandstones,

probably of the Palæozoic age, were met with. The following section was thus obtained:—

Well Shaft and Boring at Kentish Town.

Surface ground, 180 feet above the sea level.

			FT.
Tertiary ..	.. {	London Clay	236
		Sands and Mottled Clay..	88½
		Chalk and Chalk Marl..	645
Secondary ...	{	Upper Greensand ..	14
		Gault	130
Palæozoic ..		Red and grey sandstones	188
			<hr/> 1,302 <hr/>

As there is a difference of opinion respecting the age of the red and grey sandstones, and it is desirable to avoid whatever may be considered doubtful or conjectural, I will pass on next to the boring at Harwich, where there can be no doubt the Palæozoic rocks were reached at the depth of 1,025 feet beneath the sea level. We are indebted to Mr. Prestwich also for an elaborate account of this boring (Quart. Journ. Geol. Soc., December, 1857, and Coal Commission, idem).

Section of Well Boring at Harwich.

			FT.
Tertiary ...	{	Earth and gravel	25
		London Clay	23
		Sands, shingle, and Mottled Clay..	28½
Secondary ..	{	Chalk	888
		Upper Greensand	22
		Gault	39
Palæozoic ..		Dark slaty rock	44½
			<hr/> 1,070 <hr/>

After passing through the Chalk, and finding the Upper Greensand well marked and in regular order, and then the Gault, but in diminished thickness, the workmen came, at the depth of 1,025 feet, to a mass of strata denoted as a black slaty rock. The specimens brought up by the boring tools consisted of cylinders about three inches in diameter, which break so as to show the lines of bedding or of cleavage, or possibly of both. Allowing for the smallness of the specimens and the difficulty of very exact determination, it seems probable that these two planes may possibly be

one of dip, about 55° , and the other a rough cleavage plane of about 84° to the horizon.

"Of the direction of the dip," Mr. Prestwich says, "I have no evidence. The overlying beds themselves have not an unimportant dip of about 9° southward." This is, no doubt, of great importance, because, on the principle laid down by William Hopkins, this slight dip of the upper beds is an indication of the direction, if not of the amount, of the dip, also of the Palæozoic rocks.

The fact that the Harwich boring did reach these rocks was confirmed by the discovery of the impression of a *Posidonomya* upon a specimen of the slaty rock brought up at the depth of 1,050 feet.

I will next call your attention to a boring at Calais which furnished similar results.

Section of the Boring at Calais.

			FT.
Sands and Gravel ..	..	..	80
Tertiary Strata ..	..	..	161
Chalk and Chalk-Marl ..	..	..	762
Upper Greensand?	..	..	3
Gault?	..	..	26
Carboniferous Strata ..	..	..	106
			<hr/>
			1,138
			<hr/>

It appears, therefore, that under the central part of the London Tertiary area, and extending into France at Calais, there is a tract or ridge of the older rocks, which immediately underlies the Chalk and the Gault; and on different parts of this tract the wells of Harwich and Calais, and most probably that of Kentish Town also, have touched.

A question then arises, what is the nature and quality of the coal reached at Calais? It is admitted on all hands to be identical with that of Belgium, and the objection raised by Sir Roderick Murchison that it thinned out as it ranged from Belgium to England, is satisfactorily removed by Mr. Prestwich, who has shown that the thinning out is the effect of denudation, and affords no proof of any deterioration or dying out of the measures, or approach to old shore lines.

Another question arises as to the course which the Coal Measures

take from France and Belgium to Somersetshire, or, in other words, the direction of the great anticlinal from the Ardennes to the Mendips.

In reply to this question Mr. Godwin-Austen, has recourse to the soundest principle by which unseen and hidden subterranean movements can be determined. He states that a good many years ago, at the meeting of the British Association at Southampton, Mr. Hopkins, who had attended a great deal to that subject, then remarked that he thought it was a generalization in which he (Mr. Godwin-Austen) was justified, that "every disturbance has been upon the line of a previous disturbance, and that it has always gone in the same direction ; there was upheaval where there was upheaval before, and depression where there was depression before" (Coal Commission, Vol. II., page 431), and in the preceding page he states that "engineers are now quite satisfied that surface features are guides to what long antecedently has taken place below ; and the reason is this, that the original set of disturbances which affected the old Palæozoic strata have always been the line of subsequent disturbance, and are actually the hinges, as it were, upon which these rock masses have moved since ; and these rocks record these original physical lines in the disturbances which have taken place since."

Taking this principle for his guide, Mr. Godwin-Austen traces the line of the Franco-Belgian Coal Measures along the valleys of the Thames and the Kennet, and keeping the results of the borings at Calais and Harwich in view, he arrives at the following conclusions (Coal Commission, Vol. II., page 432) :—" At Harwich you have most certainly a low part of the true Carboniferous Series, and that adds considerable weight to the consideration that a productive coal-bed may occur in the south-east portions of this country. I have no doubt that between Harwich, where you have this Posidonomya-schiefer Series, and our north Wealden escarpment, which here represents the Boulonnais escarpment, and both which are in strict parallelism with the strike of the old Palæozoic rocks, the whole of that area which underlies the Chalk is Palæozoic of different ages, from one part to another ; and the only question is in what part is it Carboniferous. In Belgium, upon the meridian of Mons, rocks much older come hard upon the coal-basin of the south ; but we also see all the members of the Carboniferous Limestone series spreading out west ; and this identification of the

Posidonomya-schiefer at Harwich is in exact conformity with the line upon which you would place it; it is the very position where you would expect some part of the Lower Coal Measures to exist from the geological structure of central England, and North Belgium, and Westphalia. If such is the case, it is almost impossible to resist the impression that in some intermediate position, as along the line of the Thames Valley, you have a continuation of the Belgian and French coal-basin, passing along in a western direction; I mean that you have an extension of the coal-field of the Pas de Calais. If I have rightly restored these conditions conjecturally, the coal beds would occur beneath our area to the north of the Kentish Chalk range, extending out here in a westward direction, and the productive beds would thicken in the county of Kent, that line representing the strike of the supposed coal basin. Were I a Kentish or Essex landowner, I should be very much disposed to sink along a line parallel to the Chalk escarpment of Kent to the north east of it."

It would be a matter of surprise to me, and of extreme regret if the opinion of so distinguished a geologist as Mr. Godwin-Austen, who has devoted himself so many years to the subject, were not acted upon. It is true that his views have not been unanimously supported by scientific men, and that objections have been raised by one no less eminent than the late Sir Roderick Murchison, but they can scarcely be said to be adverse since they amount merely to a question as to the thickness of the seams and the quantity, and not to the existence of coal on this side of the French coast, and they have been satisfactorily replied to by Mr. Prestwich in his report on the Coal Commission as above mentioned.

I am convinced of the soundness of Mr. Godwin-Austen's views, and, therefore, in recommending an experimental boring for coal in the Eastern Counties, I give the preference to South Essex over Hunstanton and the outcrop of the Kimmeridge Clay; but at the same time I am so strongly impressed with the probability of finding coal at the above localities that I will proceed to state the reasons why I should recommend a boring there also.

The subject will, I think, be rendered most intelligible if I trace the progress of my inquiries from the commencement to the present time. I began to break the ground at the meeting of the British Association at Nottingham in 1866. The following is a brief abstract from the "Athenæum" of September 8th, 1866, of a

paper read by me "On the Anglo-Belgian basin of the Forest-bed of Norfolk and Suffolk, and the union of England with the Continent during the Glacial period:"—"A question of the greatest importance had been raised by Mr. Godwin-Austen with reference to the extension of the Belgian Coal Measures into this country. It was evident that, at the close of the Mesozoic period, the continuous ranges of Chalk in Belgium, France, and England formed a basin in which Tertiaries were deposited. The writer of the paper, after researches carried on for upwards of thirty years, had come to the conclusion that the Forest-bed was the estuarine deposit of some 'great river' or rivers flowing westward, closed on the south by a ridge of Chalk hills and open to the sea on the north, as was proved by the mixture of the bones of whales with those of land animals; and that such ancient river or rivers were now represented by the several rivers flowing into the German Ocean between the mouths of the Scheldt and the Rhine. Thus there might be said to be on the English coast the remains of an estuary without a river, and on the Belgian side of a river or rivers without an estuary. After describing the deposits of the elephantine and other remains, which indicated an immense period of time, and several alternations of levels, the reverend gentleman stated his impression that the Forest-bed and the Crag-series could only be studied with advantage in connection with and as part of the corresponding beds of the Continent. A very animated and rather lengthy discussion arose upon the questions raised in this paper. The President said he began to strongly suspect that even the valley of the Thames might be filled with Glacial Drift, showing that it was submerged during the Glacial period."

Such is a sketch of my attempt to describe the Anglo-Belgian basin and the changes of levels incident to it. Judge, then, of my surprise on reading a paper by Sir Roderick Murchison at the same meeting to find that Norfolk and Suffolk, the site of the Forest-bed, were included within the tracts in which "no productive coal could reasonably be looked for."

Fully impressed with the soundness of the axiom respecting the repetition of subterranean disturbances on the same spot, and of its applicability to the Anglo-Belgian basin, I read another paper at the meeting of the British Association at Brighton, the purport of which was to show that the site of that basin had been alternately

dry land and water, and had been occupied by a succession of them from the earliest times. In support of the existence of this basin, I referred to the correspondence of the strata on both sides of the estuary, and I stated that the old Forest grew upon the estuarine soil when it was upraised, and when it went down the denudation of the Forest commenced, and patches of lignite were left. One of these was noticed by Mr. Henry Woodward, F.R.S., in an excursion with me to Happisburgh, who observed that such lignite would, under favourable conditions, be converted into coal. I mentioned this as a repetition of what has taken place, and there can be little doubt did take place during the Carboniferous epoch in a similar basin.

Beneath the Forest-bed, it may be proved, the Chalk and other members of the Cretaceous series successively have been deposited in the same basin, but more extended. Again, it, or the margin of it, was occupied by Palæozoic rocks, including the Posidonomya-bed of the Carboniferous Limestone at Harwich. Sir Roderick Murchison contended that, because the coal seams thin out, as he erroneously termed it, near the Pas de Calais, that, therefore, they cannot be productive of good coals on this side of the water. He was impressed with the idea of the continuity of the older rocks and the dying out of the coal seams, and overlooked the probability of coal-bearing basins intervening between the two countries. That a basin exists and has existed since the period of the Carboniferous Limestone, and has been subject to repeated elevations and depressions, cannot be questioned. Arguing by analogy, Mr. Gunn observed it appeared highly probable that such was the case when the Harwich slaty limestone might have formed one of the sides of the basin. It appeared, therefore, taking all these facts into consideration, that Norfolk and Suffolk should be excepted from "the tracts of land in which no productive beds of coal can reasonably be looked for."

On sending this paper in, I had begged the attention of the members to it, and I felt grateful both to those who opposed and to those who supported my opinions.

In a lengthened discussion, Professor Hull most decidedly expressed his opinion that no coal could be expected to be found in Norfolk and Suffolk, and he stated that there was little doubt that the Harwich Carboniferous Shales were to be looked for towards the south, and not in the direction of Norfolk, over which district he affirmed there had extended from

Scandinavia, a tract of barren Palæozoic rocks, which would not have admitted of coal-growth. Professor Phillips also most decidedly discouraged any attempt to bore for coal in Norfolk, but said that no one knew the direction of the dip of the Harwich slaty rock, and that he did not coincide with Professor Hull as to the extent of the Palæozoic unproductive rock. The President of the section, Mr. Godwin-Austen, observed, "as to the probabilities of finding coal north of the axis of disturbance, he would mention that it was there in that direction that all the coal-fields lay. The question of the overlying Secondary rocks, as at Hunstanton, was no argument against the extension of the Coal Measures. With regard to what Professor Hull had said concerning the dry land area of Scandinavia, and the Eastern Counties, he could not altogether assent to it. . . If the Norfolk people desired to have a boring, they ought not to discourage them. Everything depended upon the ancient physical geography of the area . . . He thought it possible there might be a continuity between the central coal-fields and East Anglia: one thing he was thoroughly convinced of, that at no distant period considerable areas of coal would be worked under the Secondary strata."

Mr. Seeley made a very telling and important statement, which was opposed to Professor Hull's sweeping assertions that no Coal-growth could have taken place in Norfolk, namely, that pebbles of Primary rocks were found in the Secondary strata of Norfolk. This indicated that the ancient surface had been denuded, so as to lessen the chances of finding Coal, but it rather affirmed that Coal had originally been deposited there.

Several years before reading this paper at Brighton, I had noticed the inclined plane of the Chalk in Norfolk, upon which the several beds of the Forest and the Craggs, and the Chillesford Sands and Clays, had been transgressively laid down, and upon which the *Mastodon arvernensis*, *Elephas meridionalis*, *E. antiquus*, and other mammals had lived in succession; and my former paper was accompanied with a diagram, which I had prepared for and had exhibited at the meeting of the British Association at Norwich. But it was only recently that I became aware of the important bearing which this upheaval of the Chalk had on the prospect of finding coal in Norfolk at a workable depth. In consequence of this conviction, I sent a paper to the meeting at Bradford, the object of which was to show that the Coal-Measures, if they existed at Lynn (for I traced the dip of the Chalk from that place to

Yarmouth), had been brought at Lynn nearer to the surface by the amount of the upheaval.

This is not a matter of conjecture or of theory, but of fact and demonstration; and a more important fact in an economical as well as geological point of view can scarcely be conceived. The result of this is that if the Coal Measures at Hunstanton, or anywhere near the outcrop of the Kimmeridge Clay, were as deep as they have been calculated to be in Lincolnshire, viz. 2,700 feet, they have actually been brought nearer to the surface by about 1,700 feet, and would be within a workable depth. It appears to me from Professor Phillips' remarks, that he did not so much found his objection to the contemplated boring at Hunstanton upon the presumed absence as upon the depth of coal there, and, therefore, I may hope for the concurrence of that veteran geologist.

Again, another most important result is that this upheaval of the Chalk affords a complete refutation of Professor Hull's assertion, that the Eastern Counties were covered by Palæozoic barren rocks during the Carboniferous epoch, from which no coal growth could be expected. He (Mr. Hull) arrived at this conclusion by observing that the dip of the Harwich slaty rocks was most probably to the south, and if so, he concluded that these old rocks rose to the north, and were incapable of coal growth. Now it is proved by the boring at Norwich that the Palæozoic rock must be upwards of 100 feet lower than at Harwich, and the Gault was not pierced when the boring reached 1,182 feet, consequently the old rocks at Norwich would have been much lower than at Harwich, instead of rising, as Professor Hull supposes, so as to form a high and dry surface upon which no coal growth could have taken place. Perhaps this difficulty may be solved by supposing that there was another anticlinal ridge parallel to the Thames, of which the Harwich rocks formed a part, and so the dip to the south might be accounted for, and also to the north, forming a margin to the basin on the other side, which I have inferred by analogy to have existed from time to time.

Another very interesting result is that the Palæozoic rocks have at times been raised above the horizon, and at other times depressed in accordance with the alternations of level, which we have noticed, and being covered with only a slight envelope as it were of Secondary and Tertiary strata, would have been acted upon by subterranean movements which have repeatedly taken place. This is just what appears to have been the case, judging by the frequency of

small faults in the Craggs and the disruption and the displacement of the Chalk and contortion of the sand and clay. These, I am persuaded, from personal observation of similar contortions at Corfu, in the Eifel district, and in Savoy, are not altogether to be attributed to ice action, but are due to subterranean movements near the surface. I hoped to have been prepared with sections to prove the point, and I trust I may be permitted to submit them to the Geologists' Association at some future time. In the meanwhile, as I am suggesting what is at variance with the received opinions of some, and have not entered into those of others, all I can request of you is to allow me a fair trial.

I wished to make some observations respecting the boulders and pebbles of older rocks referred to by Mr. Seeley as evidence of denudation, and, if weather and time had permitted, I should have been glad to have searched for and produced some at this meeting, and also to have brought under your notice the *supposed* Anmer coal-boulder, or Kimmeridge shale, which furnished the coal stated in Edward's History of Lynn to have been carted into that town and sold by the meter about 200 years ago. This, of course, is merely conjectural, but is worthy of inquiry.

The only other purpose to which I will apply this upheaval of the Chalk is the observation of inclined planes, which form the surest means to determine the thinning out of aqueous deposits against them, and *vice versa*. Thus, at Harwich, as the slaty rock is covered with Cretaceous deposits, we may be assured that the intermediate Triassic, Liassic, and Jurassic deposits have been stayed in their progress there. Professor Hull has rendered good service by observing the gradual thinning out of the Secondary strata in their progress eastward; but the same story is told with infallible certainty by observation of the dying out of beds as they approach to higher land or a shore line, and the presence of higher land may be inferred by the thinning out of the aqueous deposit.

In conclusion, I must apologize for so often referring to my own works, but I am glad to do so in self-defence in order to prove that I have not taken upon myself to recommend a boring for coal in the region of the Forest-bed rashly and without much consideration; and also I hope I have been enabled to make a complex subject more intelligible by showing how, step by step, I have advanced in search of coal; and, I trust, I may be still further allowed to avail myself of the indulgence of the Geologists' Association to promote the object I have in view.