MEMOIRS OF THE GEOLOGICAL SURVEY.

ENGLAND AND WALES.

THE GEOLOGY OF
THE COUNTRY AROUND FAKENHAM, WELLS, AND HOLT.

(EXPLANATION OF QUARTER-SHEETS 68 N.W. AND S.W.)

BY

HORACE B. WOODWARD, F.G.S.

PUBLISHED BY ORDER OF THE LORDS COMMISSIONERS OF HER MAJESTY'S TREASURY.

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1884.

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NOTICE.

The part of Norfolk described in the following Memoir is contained in the two Quarter-Sheets 68 N.W. and S.W. It presents no remarkable geological features, being essentially an agricultural district, which owes its fertility to the marls and loams that cover the greater part of its surface. So widespread are these superficial deposits that the underlying platform of Chalk comes to the surface only here and there. One edition of the maps—that on which the drifts are coloured—is therefore sufficient to show the geology, since it is quite impossible to trace any lines under these overlying accumulations, or to be certain how far Pliocene or other deposits may not occasionally intervene between them and the Chalk.

Owing to the difficulty in correlating the Glacial marls and clays, it has been thought advisable to colour the Boulder Clay in one tint, and to express by one colour also all the Glacial Sands and Gravels, although more than one sub-division may in each case be thus united. These deposits are mainly a prolongation of the Contorted Drifts of Cromer, like which, though their grouping and structure seem simple on the map, they are subject to considerable variation and to local, and doubtless glacial, disturbance.

Much detail necessarily of an uninteresting nature is given in this Memoir; but it is here put on record, as it may prove of value in regard to local questions of drainage, water-supply, lime-burning, brick-making, and the supply of road-metal.

ARCH. GEIKIE,
Director General.

Geological Survey Office,
28, Jermyn Street,
December 15th, 1884.

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NOTICE.

The north-eastern corner of the area, east of the River Glaven, and as far south as Holt and Bodham, and the eastern margin to a little south of Barningham Park, were surveyed geologically by Mr. Clement Reid, in the years 1876–77 and 1879–80. The remaining and chief portion of the area was surveyed by Mr. H. B. Woodward during the years 1880–83.

The fossils from the Chalk have been named by Messrs. G. Sharman and E. T. Newton.

The eastern part of the Coast is published in *Horizontal Section*, Sheet 127, by Mr. C. Reid.

H. W. BRISTOW,
Senior Director.

Geological Survey Office.
28, Jermyn Street, London, S.W.
November 1884.

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THE GEOLOGY

OF THE

COUNTRY AROUND FAKENHAM, WELLS, AND HOLT.

CHAPTER I.

INTRODUCTION.

Area.

The two Quarter-Sheets 68 N.W. and S.W. of the Geological Survey Map represent an area of about 237 square miles in Norfolk,and contain the towns of Fakenham and Holt, the large villages of Cawston, Foulsham, and Walsingham, and the port of Wells.

Physical Features.

This portion of country is drained by (1) The *Wensum*, which partly originates from streams rising in the parishes of Colkirk and Horningtoft; (2) the *Bure*, whose sources are entirely in the area, rising in the parishes of Edgefield, Briston, and Melton Constable; (3) the *Glaven*, whose entire course is in the area, commencing at Bodham and flowing by Glandford into Blakeney Harbour; (4) the *Stiffkey Stream* or "*Stew*," which rises at Fulmodeston and, flowing through Walsingham, enters Blakeney Harbour to the east of Stiffkey Meals, having also a course entirely in the area; and (5) the stream which rises at Creake, and then leaves the area for Burnham Harbour. In wet weather, owing to the saturation of the Chalk, this stream (5) rises at a higher level and forms pools and sheets of water south of Compton House.

The form of the ground is gently diversified, and the highest elevations probably do not exceed 300 feet.*

The coast from Holkham to Salthouse is flat, being made up of salt marshes, protected from the sea by hillocks of blown sand. East of Weybourn the land terminates abruptly in cliffs, which continue thence to Eccles.

---

* The highest point in Norfolk *levelled to* by the Ordnance Survey, is 6,725 links N.E. of Aylmerton Church, and 331·4 feet above Ordnance datum. This is in the adjoining area of Map 68 E. *See* T. M. Reade, Geol. Mag., dec. II., vol. x., p. 140

Inland the features are marked out by the courses of the rivers and their tributaries. As a rule, the higher tracts are formed of gravel and sand, the lower tracts of marl or clay. In some instances the valleys are cut down to expose the Chalk, and in all cases there is a strip of alluvial ground of no great breadth, excepting on the coast-line.

The north-east portion of the area is, on the whole, the more picturesque, for the soil of the upland is light (sand and gravel), and heaths, warrens, and commons, with plantations of fir, are intermingled with the ploughed lands. Much of the soil over the central and western parts is of a changeable and "mixed" character, from the fact that the gravel and sand which originally extended over a considerable part of it have left indications of their former presence in the soil. Probably the "heaviest" land is that south and east of Foulsham, at Colkirk and Oxwick. And there is good loamy land at Guestwick, Hindolvestone, and Barney.

Traces of old woodland still remain in the parishes of Thursford and Horningtoft, while hints of the former character of places are given in the names of Wood Norton, Wood Dalling, Plumstead, Elmham, Bintree, Holt, and Thornage.

Formations.

The following beds, exposed at the surface, are represented on the Geological Survey Map of the area:—

Recent and Post-Glacial	Blown Sand	Coast.
	Sand and Shingle	Coast.
	Alluvium.	
	River Gravel.	
Glacial Drift	Gravel and Sand.	
	Boulder Clay and Marl.	
	Loam.	
	Sand and Gravel.	
Pliocene	Crag and Pebbly Gravel.	
Cretaceous	Chalk with flints.	

The following beds were proved beneath the Chalk in a deep boring at Holkham (*see* p. 51):—

Cretaceous	Red Chalk.
	Gault.
Neocomian	Carstone (Lower Greensand).
Oolitic	Kimeridge Clay?

The *possibility* of the occurrence of Coal Measures and older rocks beneath the lowest strata known to occur in the area, at a depth of not less than 1,000 feet, has been briefly discussed in the Memoir on the Geology of the Country around Norwich. (*See* pp. 5, 6, 168, 169.)

Literature.

Excepting the cliff-section at Weybourn, the geology presents no very striking or interesting features, and consequently it has

attracted but little attention from geologists. The zones of fossils in the Chalk have been sketched out by Dr. C. Barrois, while the Glacial Drift has been described in places by Joshua Trimmer (formerly engaged on the Geological Survey in the west of England), by the Rev. O. Fisher, and by Messrs. S. V. Wood and F. W. Harmer. Indeed, the eastern margin of the area, including Salthouse, Holt, Wood Dalling, and Sall, was shown on the geological map of the Crag district (scale four miles to the inch) published by Messrs. Wood and Harmer in 1872.*

A list of Papers, &c. on the Geology of Norfolk (up to 1881), by Mr. Whitaker and myself, was printed in the Memoir on the Geology of the Country around Norwich. Since that date the following works, containing references to the geology of the district here described, have been published :—

1882.

Newton, E. T. The Vertebrata of the Forest Bed Series of Norfolk and Suffolk. *Geological Survey Memoir.* 8vo. London.

Reade, T. Mellard. On the Chalk masses or Boulders included in the contorted Drift of Cromer, their Origin and Mode of Transport. *Quart. Journ. Geol. Soc.*, vol. xxxviii., pp. 222–238.

Reid, Clement. Section of the Norfolk Cliffs, from Happisburgh through Bacton, Mundesley, Trimingham . . . . to Weybourn. Horizontal Section, Sheet 127. *Geological Survey.* With Explanation, 4 pp.

—— The Geology of the Country around Cromer. With Notes by H. B. Woodward. *Geological Survey Memoir.* 8vo. Lond.

Wood, S. V. The Newer Pliocene Period in England. *Quart. Journ. Geol. Soc.*, vol. xxxviii., pp. 667–744.

Woodward, H. B. The Noteworthy Springs and Spas of Norfolk. *Trans. Norf. and Norwich Nat. Soc.*, vol. iii., pp. 318–325; and pp. 525 526 [1883], p. 789 [1884].

—— Notes on the Bure Valley Beds and the Westleton Beds. *Geol. Mag.*, Dec. II., vol. ix., pp. 452–457.

—— Coal in Norfolk. *Fakenham and Dereham Times*, Oct. 7.

1883.

Gunn, John. A Sketch of the Geology of Norfolk. [Reprinted from the 4th edit. of White's Directory of the County.] *Sheffield.*

Holmes, T. V. On Eskers or Kames. *Geol. Mag.*, Dec. II., vol. x., pp. 438–445; and *Proc. Norwich Geol. Soc.*, vol. i., pp. 263–272 [1884].

Howorth, H. H. Traces of a Great Post-Glacial Flood. Part 6. The Evidence of the Rolled Gravels and the Sands. *Geol. Mag.*, Dec. II., vol. x., pp. 413–423.

Reade, T. M. The Highest Point in Norfolk. *Geol. Mag.*, Dec. II., vol. x., p. 140.

—— Chalk Masses in the Cromer Drift. *Ibid.*, pp. 287, 384.

Reid, C. On *Lithoglyphus* from the Weybourn Crag. *Trans. Norf. and Norwich Nat. Soc.*, vol. iii., pp. 503, 504.

* Introduction to Supplement to the Crag Mollusca (*Palæontograph. Soc.*).

Wood, S. V. Chalk-masses in the Cromer Drift. *Geol. Mag.*, Dec. II., vol. x., pp. 334, 335, 430.

Wood, S. V. Reply to Mr. Mellard Reade. *Ibid.*, p. 240.

Woodward, H. B. The Scenery of Norfolk. *Trans. Norf. Nat. Soc.*, vol. iii., pp. 439–466.

1884.

Newton, E. T. Revised List of Vertebrata from the Forest-bed Series. *Trans. Norf. Nat. Soc.*, vol. iii., pp. 654–656.

Reid, C. On Norfolk Amber. *Ibid.*, pp. 601–603.

Woodward, H. B. Earthquakes and Subsidences in Norfolk. *Ibid.*, pp. 637–643.

CHAPTER II.

CHALK.

General Remarks.

The Chalk of the district (west of Weybourn) is, as a rule, harder and less thickly bedded than that at Norwich. Nodular flints are not so abundant, and veins of tabular flint or thin seams of flint traverse the Chalk at various angles. Although exposed at the surface over very limited tracts, the Chalk forms the foundation of the entire area, and would everywhere be reached at varying depths beneath the superficial deposits.

Among the fossils most commonly met with are:—*Belemnitella quadrata, Ostrea acutirostris, Rhynchonella Cuvieri, Echinocorys vulgaris* (better known as *Ananchytes ovatus*), and *Marsupites Milleri*. The last-named genus has been taken to characterise the Chalk of Wells by Dr. C. Barrois—his "Zone à *Marsupites*"*—the middle division of the Upper Chalk. Judging from the breadth of outcrop of the beds, and the well-sections of Holkham and Norwich, the Upper Chalk as defined by Dr. Barrois must be nearly 800 feet in thickness, his own estimates (admittedly vague) tend to make it even more, and this may roughly be divided as follows, in descending order:—

	Feet.
3. Belemnitella-zone of Norwich - - -	500
2. Marsupite-zone of Wells and Walsingham -	200
1. Micraster-zone of Stanhoe and Burnham -	100

No lithological feature appears to separate the Chalk of Wells from that of Cley and Weybourn, in which direction we pass from the Marsupite into the Belemnitella-zone.

A horizontal section showing the divisions of the Chalk is given in fig. 10, plate III., of his work by Dr. Barrois; and it would appear that while the Belemnitella-zone is represented near Holt on the east of the district, the zone of *Micraster coranguinum* is represented at Creake on the west and probably also at Dunton and Sculthorpe. On S. Woodward's Geological Map of Norfolk (1833) the divisional line between the Upper and Medial Chalk is taken (roughly speaking) at the base of the Wells Chalk (zone of *Marsupites*).

* Recherches sur le Terrain Crétacé Supérieur de l'Angleterre et de l'Irlande (1876), p. 163.

Fossils, indeed, are by no means plentiful in the Chalk of the district, and to a casual observer most of the pits appear altogether devoid of organic remains.

Mr. John Rhodes (the fossil-collector of the Geological Survey), however, searched many of the pits for fossils in the autumn of 1881, and (in addition to the species previously mentioned) obtained fragments of *Inoceramus* and *Cidaris* most abundantly, as well as many small spherical flints containing sponges. Having sent some of these flints to Dr. G. J. Hinde, who very kindly examined them, he informed me (17th April 1882) that—

"Unfortunately their condition of preservation is such as not to allow, save in one instance, of a specific determination of the sponges contained in them. The entire spicular structure has been destroyed, and only the cavities remain. One specimen, an elongated cylindrical form, appears to have been the stem supporting a hexactinellid sponge; the other specimens appear to have belonged to the order of the Lithistids, and one may have been a Siphonia (Choanites). The only definitely determinable examples are two of the small globate flints, which on breaking open presented *casts* of the spicules of *Plinthosella squamosa*, Zittel. The *spicules* of this sponge are large and covered with minute tubercles, so that when good casts are preserved they cannot be mistaken for other forms. I discovered some of the detached spicules in the Horstead flint.*

These globules are probably the natural size of the sponge. There are specimens in the [British Natural History] Museum from the South of England, with the spicular *casts* preserved in *Chalk* merely; and the type from Germany (Ahlten, Quadraten-Kreide) corresponds in size with these forms from Wells."

LIST OF FOSSILS FROM THE UPPER CHALK OF THE NEIGHBOURHOOD OF WELLS AND FAKENHAM.

Collected by JOHN RHODES, 1881, and H. B. WOODWARD, 1880–1882.
Determined by GEORGE SHARMAN and E. T. NEWTON.

The letters in the columns refer to the localities; those marked X are inserted on the authority of Dr. Barrois.

The *Confervites fasciculata* mentioned by S. Woodward from fissures in the Chalk near Holt (Geology of Norfolk, pp. 25, 46) was subsequently ascertained to consist of dendritic markings.

It may be mentioned that *Belemnitella quadrata* and *B. mucronata* are considered to be very much alike, and under certain conditions are very difficult to determine. Sharpe, in his Monograph on the Cephalopoda of the Chalk (Palæontograph. Soc.), observes that "The external form of *B. quadrata* is nearly the same as that of some varieties of *B. mucronata*, so that worn specimens which have lost both their outer surface and the upper part of the alveolus may easily be confounded, and there has been confusion in consequence in the synonyms. But it is well distinguished both by the granulations of the surface and the square opening." In *B. mucronata* the "opening is circular," and the markings on the exterior of the test have a very vermiform appearance.

* Fossil Sponge Spicules from the Upper Chalk. By G. J. Hinde. Pl. iv., figs. 35–42, p. 56.

FOSSILS FROM THE UPPER CHALK.

	Guist, Bintree.	Thorpland.	Walsingham.	Wells.	Holkham.	Creake.	Houghton, Barsham.	Sculthorpe, Dunton.	
SPONGIDA.									
Brachiolites, sp.	.	.	.	.	.	C	.	.	
Coscinopora globularis, *D'Orb*	.	.	W	W	.	C	.	.	Holt (*S. Woodward*).
——— urceolata, *Phil.*	.	.	.	W	.	.	.	.	
Scyphia cribrosa, *Roem.*	.	.	.	X	.	.	.	.	*Barrois.*
Spongia, sp.	.	.	W	W	H	C	B	.	
Ventriculites radiatus, *Mant.*	.	.	.	W	.	.	.	.	
——— sp.	.	.	W	.	.	C	HB	S	
Plinthosella squamosa, *Zittel*	.	.	.	W	.	.	.	.	*G. J. Hinde.*
ECHINODERMATA.									
Bourgueticrinus ellipticus, *Mill.*	.	.	.	X	.	.	.	.	*Barrois.*
——— sp.	.	.	.	.	.	.	B	.	W. Rainham.
Marsupites ornatus ? *Mill.*	.	.	.	.	.	.	H	.	
——— Milleri, *Mant.*	.	.	.	.	.	.	H	.	
——— sp.	.	T	.	.	.	.	.	.	
Goniaster, sp.	.	.	.	W	.	C	B	.	
Cidaris clavigera, *König.*	.	.	.	.	.	C	.	.	
——— hirudo, *Sorignet.*	.	.	.	.	H	C	.	.	
——— perornata, *Forbes*	.	.	.	.	.	C	.	.	
——— sceptrifera, *Mant.*	.	.	.	.	.	C	.	.	
——— frag.	G	.	W	W	H	C	B	DS	
Cyphosoma, sp.	.	.	.	.	.	C	.	.	
Echinoconus conicus, *Breyn.*	.	.	.	.	.	X	.	.	*Barrois.*
——— sp.	.	.	.	.	.	.	.	S	
Echinocorys vulgaris, *Breyn.*	.	T	W	W	H	C	H	SD	Holt, Cley (*S. W.*).
(Anancbytes ovatus, *Leske.*)	.	.	.	.	.	.	.	.	
Epiaster gibbus, *Lam.*	.	.	.	X	.	X	.	.	*Barrois.*
Holaster pillula, *Lam.*	.	.	.	.	.	.	.	S	
Infulaster (Cardiaster) rostratus, *Forbes.*	.	.	.	.	.	.	.	.	Near Holt (*S. W.*).
Micraster coranguinum, *Leske*	.	.	.	.	.	C	.	.	
ANNELIDA.									
Serpula, sp.	.	.	.	.	H	.	.	S	
Scalpellum, sp.	.	.	W	.	.	.	.	.	
POLYZOA.									
Pustulopora (Entalophora) pustulosa, *Goldf.*	.	.	.	W	.	.	.	.	
Lunulites cretaceus, *Defr.* (L. radiatus, *Mant.*)	.	.	.	.	.	.	.	.	Holt (*S. W.*).
BRACHIOPODA.									
Crania parisiensis, *Defr.*	.	.	W	.	.	.	.	.	
Kingena lima, *Defr.*	.	.	.	.	.	.	.	.	Letheringsett (*T. Davidson*).
Magas pumila, *Sby.*	G	.	.	.	.	.	.	.	Letheringsett (*T. D.*).
Rhynchonella Cuvieri, *D'Orb.*	.	.	W	W	H	C	.	.	
——— limbata, *Schl.*	.	.	.	.	.	.	.	.	Holt (*S. W.*).
——— mantelliana, *Sby.*	.	.	W	.	.	C	.	.	
——— Martini, *Mant.*	G	.	W	.	.	.	.	.	
——— plicatilis, *Sby.*	.	.	.	.	.	C	.	S	Holt (*S. W.*).
——— var. octoplicata, *Sby.*	.	.	.	.	.	.	.	.	Holt (*S. W.*).
Rhynchonella, sp.	.	.	.	.	.	.	.	.	Blakeney.
Terebratula carnea, *Sby.*	.	.	.	? W	.	.	.	.	
——— semiglobosa, *Sby.*	.	.	.	W	.	C	.	.	*Barrois.*
Terebratulina striata, *Wahl.*	B	.	.	.	.	.	.	.	

	Guist, Bintree.	Thorpland.	Walsingham.	Wells.	Holkham.	Creake.	Houghton, Barsham.	Sculthorpe, Dunton.	
LAMELLIBRANCHIATA.									
Avicula, n. sp.*	B	T	.	W	.	.	.	.	
——— sp.	.	.	.	W	.	.	.	.	
Inoceramus Cuvieri ? *Sby.*	.	.	.	.	.	C	H	.	
——— Lamarckii, *Park.*	.	.	W	.	.	.	.	.	Gravel flint, Ryburgh.
——— lingua, *Goldf.*	.	.	.	X	.	.	.	.	*Barrois.*
——— (fragments)	B	.	W	W	H	C	H	SD	W. Rainham, Gravel flint; Thursford.
	.	.	.	.	.	.	.	.	
Lima, sp.	.	.	.	W	.	C	.	.	
Ostrea acutirostris, *Nilss.*	GB	.	W	W	H	C	HB	.	
——— hippopodium, *Nilss.*	.	.	.	.	.	X	.	.	*Barrois.*
——— larva, *Lam.*	.	.	.	W	.	.	.	.	
——— vesicularis, *Lam.*	B	.	.	W	H	.	.	.	
——— sp.	GB	T	W	W	H	C	HB	.	
Pecten nitidus, *Mant.*	.	.	.	.	.	C	.	D	
——— quinquecostatus, *Sby.*	.	.	.	.	H	.	.	.	
——— sp.	.	.	.	W	H	.	.	.	
Plicatula sigillina, *S. P. Woodw.*	.	.	.	.	.	X	.	.	*Barrois.*
Spondylus, sp.	.	.	W	W	H	C	.	.	
CEPHALOPODA.									
Belemnitella quadrata, *Defr.*	GB	T	W	W	H	.	HB	.	North Elmham, pit by railway.
PISCES.									
Beryx, sp.	.	.	.	.	.	C	.	.	
Otodus, sp.	.	.	W	.	.	.	.	.	
Bones, scales, teeth, vertebræ	GB	.	W	W	H	C	HB	D	

Local Details.

Weybourn.—The Chalk at Weybourn has been briefly alluded to by Mr. Reid; there it "forms a cliff rising about 20 feet above high-water mark." He describes the Chalk as soft, with many flints, and as corresponding with the beds near Norwich.†

From Letheringsett to the sea the Chalk is exposed at the bottom of the valley, and the steeper slopes thereby formed add much to the boldness of the scenery here, and also in the valley at Barsham, Houghton-in-the-Dale, and Walsingham.

Glandford.—A pit, south of the Church, opened in disturbed Chalk, showed the surface of the rock here and there indented and filled with brown stony sand containing marly streaks like Boulder Clay.

Blakeney.—A pit by the Alluvium to the north-east of the Downs showed about 15 feet of Chalk with large flints isolated for some distance, and yet in comparatively regular lines two or three feet apart. The piped surface was filled with brown sandy loam and boulder gravel, and traces of Marl occurred at the western side of the pit. (*See* p. 22.)

Fragments of *Ananchytes* and *Inoceramus* and one species of *Rhynchonella* were met with in the Chalk.

Stiffkey.—The Chalk is well shown in several excavations in Stiffkey parish on the slopes bordering the village, and there is a pit west of Bacon's Belt. South of the Hall, a large pit showed about 35 feet of Chalk. The upper portion (from 6 to 10 feet in thickness) was a rubbly white Chalk with large nodular lumps of Chalk and rather irregular layers of flint. The Chalk beneath, separated by an irregular black line, was more regularly bedded with layers of flint, but was for the most part stained yellow and brown.

* Mr. C. B. Rose in 1862 says, "A delicate *Avicula*, not yet figured, and which I have ventured to call *nitida*, is rather abundant at Wells." Proc. Geol. Assoc., vol. i., p. 231.

† Memoir on the Geology of the Country around Cromer, pp. 3–5.

Cockthorpe.—In the valley between the Church and the common, a pit showed about 15 feet of Chalk, with two slightly disturbed layers of flint nodules. The upper part of the Chalk was rubbly and overlaid in one part of the pit by Marl and chalky sand, and the whole was covered by 3 feet of brown loamy soil.

Warham.—Rubbly and bedded Chalk with scattered flints was shown in pits south-west of Field Barn, west of Garden Grove, and on Warham Greens. The "Danish Camp" is formed of Chalk rubble.

Wells.—The Chalk is well shown in the cutting of the railway leading to the Quay to the east of the town. It consists of hard flaggy beds with flint, and is much iron-stained in places. In this cutting Mr. J. Rhodes obtained many spheroidal flints containing sponges. (*See* p. 6.)

At the western extremity of the town, by the Alluvium, is a pit showing a line of tabular flint, approximately horizontal but here and there displaced a few inches owing to disturbance. There were a few layers of nodular flint, and Mr. Rhodes obtained a crushed specimen of *Echinocorys vulgaris*.

Several fossils were obtained from the railway-cutting west of the town, also spherical flints containing sponges. [The remarkable bank of gravel here is noticed on p. 36.] At the kiln, south-east of the town, Mr. Rhodes obtained nodules of iron pyrites, a sponge much impregnated with iron ore, many more spherical flints containing sponges, and *Echinocorys vulgaris*. The Chalk here is covered with an old talus of Chalk rubble left when the Marl above was worked. It contains many sand-galls. In the exposure of Chalk east of the railway Mr. Rhodes noticed a bed with *Pecten*, but the species has not been determined.

S. Woodward remarked that "in a pit about one mile east of Wells thin seams of flint are seen traversing the Chalk, both in a horizontal and oblique direction; and in many parts they do not exceed one-eighth of an inch in thickness."* The spot indicated is probably one of the series of exposures through which the railway runs to the north of the Lime-kiln. At the western end of the cuttings, and to the north of the railway, about 20 feet of Chalk was exposed, overlaid in places by Marl. The Chalk was very much disturbed and broken up, as shown by the lines of tabular flint which traversed it in all directions, a feature evidently the result of disturbance and not of original deposition of the flint. A nest of chalky sand occurred in this disturbed Chalk. Further east there is a bluff or face of Chalk, with two layers of nodular flint and one of tabular flint near the base; this rests in abrupt contact with the Marl, and stands out somewhat like a "needle" in the midst of this Glacial Drift. Whether or not we regard this Marl as the product of land-ice, it is evidently of very local derivation, being almost entirely made up of Chalk débris, while the Chalk itself shows signs here and there of superficial disturbance. And we may look upon this peculiar disposition of the strata as affording some indication of the mode of isolation of the huge masses of solid Chalk that occur in the Glacial Drift of the Cromer Coast.† [*See also* fig. 4, p. 24.]

Holkham.—Flaggy hard-bedded Chalk was exposed in the railway-cutting north-east of the Lime-kiln. At the kiln the Chalk is shown with a contorted surface-deposit of loam and Marl, filling pockets in the substratum. The flint-layers are disrupted and the Chalk broken up.

Mr. Rhodes noticed an oyster-bed here and in the railway cutting not far distant, from 8 to 9 feet from the surface; and also in the pit by the marsh land west of Wells. *Ostrea acutirostris* was the prevalent form, but *O. vesicularis* was also present.

Binham Abbey.—North-east of the Priory on the road to Langham, a pit showed the Chalk much disturbed and glaciated, in the mass of the rock were chips of flint and broken flint-nodules, and many included angular lumps of Chalk. This was shown to a depth of 10 feet. Above these was Boulder Clay—a thin layer partly eroded and decomposed into brown clay—2 to 5 feet in thickness, with a nest of sand and clay penetrating downwards into the Chalk.

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* Geology of Norfolk, p. 27.

† *See* remarks on the disturbed Chalk at Trowse. Geology of the Country around Norwich, p. 135.

Walsingham.—At the Town Pit, Old Walsingham, where about 20 feet of Chalk is exposed, the beds are much cut up by vertical joints. A regular "pan of flint" (as the lessee of the pit said), ¾ to 1 inch in thickness, extends along the base of the pit, and "all about the country round." The Chalk is said to be softer underneath. At Town End is another pit, showing rather rubbly Chalk.

In the northern part of New Walsingham is a pit where Mr. Rhodes obtained some fossils, and the oyster-bed with *Ostrea acutirostris*.

Houghton-in-the-Dale.—At the Lime-kiln the Chalk is a comparatively hard white limestone, breaking, when struck, into angular fragments like White Lias. The surface is furrowed with pipes of sand and disturbed Chalk or "dead lime." Here the oyster-bed with *O. acutirostris* was found by Mr. Rhodes at about 10 feet from the surface; as well as many plates of *Marsupites*.

In the railway-cutting the oyster-bed was found at about 12 feet from the summit, beneath Boulder Clay.

Creake.—At the Lime-kiln a fine section of hard white Chalk is exposed, with a layer of tabular flint. Mr. Rhodes noted an *Inoceramus*-bed 10 feet from the surface.

The Chalk is here burnt for lime, made into whiting, and sometimes used for building walls and houses (inside work).

To the south-west of Southgate a pit showed hard bedded Chalk, with few layers of flints.

South-west of Leicester Square, where the Chalk is exposed beneath the Boulder Clay, a few fossils were obtained.

Sculthorpe.—West of the water-mill a pit showed 9 feet of Chalk with flints, capped by chalky soil and a trace of Boulder Clay? The fossils obtained here by Mr. Rhodes were fragmentary.

Chalk was exposed at the base of the gravel by the railway bridge at Shereford.

Dunton.—North-east of the Church hard bands of Chalk occur in softer Chalk. The beds are capped by clay with flints, brown clay, and traces of Boulder Clay. The fossils found by Mr. Rhodes were mostly fragmentary.

Barsham.—Here is a pit in soft thin-bedded Chalk, with tabular flint, and nodules of flint, from which Mr. Rhodes obtained many fossils.

Fakenham.—Chalk is reached at a short distance beneath the sands on which the greater part of the town is built.

Mr. Harmer informed me that he had seen an exposure of Chalk a little south of the Dunton Road, about a quarter of a mile south-west of Highfield House.

West Rainham.—West of the Church is a pit showing Chalk, with Boulder Clay and gravel abruptly resting against it. This is a probably a similar arrangement to that seen at Wells in the old pits east of the town. At first I thought it might be a transported mass of Chalk, but the rock undoubtedly occurs in place not far distant. The Chalk contains large flints and it showed signs of disturbance in an anticlinal arrangement of the flint layers, the fold of which would trend E. and W. The fossils obtained by Mr. Rhodes were fragmentary.

Bintree.—North of Yarrow Fox Covers a Chalk-pit showed soft marly Chalk, with a few scattered flints.

At the pit by the mill Mr. Rhodes obtained many specimens of *Belemnitella quadrata*, and the oyster-bed with *Ostrea acutirostris*. Here the Chalk is thin-bedded, soft, and yellowish in colour, and Mr. Rhodes noticed a layer of tabular flint.

Guist.—The Chalk here was soft, and much jointed in places. It contained a few nodular flints, impersistent tabular flint, and balls of ochre.

In one part of the pit the Chalk was of a very rubbly nature, like that mentioned at Warham Greens. [*See* p. 43.] By the denudation of this rubbly Chalk in Glacial times, we might account for the lumps of Chalk so characteristic of much of the Boulder Clay in the Eastern Counties.

CHAPTER III.

PLIOCENE.

Crag and Pebbly Gravel.

General Remarks.

Excepting in the cliff-section at Weybourn no fossiliferous beds of the age of the Crag have been determined in the district; there the beds comprise sands and pebbly gravel with shells, and seams of clay, altogether about 10 feet in thickness, resting on the Chalk. The usual "stone-bed," made up of unworn and rolled flints, occurs at the base of the Crag.

A particular account of the beds is given by Mr. Clement Reid in his Memoir on the Geology of the Country around Cromer, (pp. 11–14, 17–19, 24, 46, &c.), because the section, although included in the area at present under consideration, forms part of the cliff-section drawn in detail by Mr. Reid.* He groups the beds exposed in the cliff as follows:—

Boulder Clay. (Contorted marl and loam), 14 feet.	
Peaty loams with *Cypris browniana* and *Bythinia*. [Beneath these the beds are penetrated by small roots too much decayed for microscopic examination.] 3 feet.	Upper Freshwater Bed.
Quartzite gravels, belonging probably to the middle Estuarine division of the "Forest-bed;" almost unfossiliferous, nothing having been found in them at this locality except one or two fragments of bone and pieces of wood, 8 feet.	
Sands, laminated clay and loam with marine shells, 10 feet.	Weybourn Crag.
Stone-bed with marine shells, 6 inches.	

Mr. Reid observes (p. 11) that "it cannot be said definitely whether the whole of the beds between the Fresh-water bed and the Chalk belong to the Weybourn Crag, or whether the upper unfossiliferous portion may not in places include the estuarine division of the Forest-bed."

Prof. Prestwich states that "in places near Weybourne the surface of the Chalk under the crag has been pierced by Annelids and by the *Pholas crispata*, whilst pebbles of Chalk bored by *Saxicava rugosa*, (*S. arctica* var. *rugosa*) are met with in the overlying craggy beds."†

Mr. M. R. Stedman obtained an articulation of the limb bone of a large mammal, possibly Elephant, from the loose material

*Horizontal Section, Sheet 127, Geological Survey.

† Quart. Journ. Geol. Soc., vol. xxvii., p. 460.

that had fallen from the Crag Cliff. Mr. S. V. Wood has also noted that mammalian remains are found in the base of the deposit at this locality.*

The following is a list of fossils from the Crag at Weybourn compiled (with a few exceptions) from that published by Mr. C. Reid:— †

MOLLUSCA.

Lamellibranchiata.

Astarte borealis, *Chemn.*
——— compressa, *Mont.*
——— sulcata, *Da C.*?
Cardium edule, *Linn.*
——— grœnlandicum, *Chemn.*
Corbula striata, *Walker and Boys.*
Cyprina islandica, *Linn.*
Leda oblongoides, *S. Wood.*
Lucina borealis, *Linn.*
Mactra ovalis, *Sby.*
Mya arenaria, *Linn.*
—— truncata, *Linn.*
Mytilus edulis, *Linn.*
Nucula Cobboldiæ, *Sby.*
Pholas crispata, *Linn.*
Saxicava arctica, *Linn.*
Tellina balthica, *Linn.*
——— lata, *Gmel.*
——— obliqua, *Sby.*

Gasteropoda.

Buccinum undatum, *Linn.*
Littorina littorea, *Linn.*
——— rudis, *Maton.*
Natica catena, *Da C.*
———helicoides, *Johnst.*§
Purpura lapillus, *Linn.*
Scalaria grœnlandica, *Chemn.*
Trophon antiquus, *Linn.*
——— ——— reversed var.

Other Fossils.

Balanus crenatus, *Brug.*

Bones and vertebræ of Fishes.
Bones of Mammalia.

LOCAL DETAILS.

Considerable difference of opinion has been expressed concerning the Pliocene beds at Weybourn, and the section has been noticed by R. C.

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* Section No. 28, in Remarks in Explanation of Map, &c. 1865. *See also* Sections accompanying Supplement to the Crag Mollusca.

† Memoir of the Geology of the Country around Cromer, pp. 18, 68–70. *See also* Prestwich, Quart. Journ. Geol. Soc., vol. xxvii., pp. 460, 461, and tables on pp. 480–492. Mr. Reid thinks that *Leda lanceolata* of these tables should be *L. oblongoides*; and that *Mactra subtruncata, Venus fasciata, and Natica grœnlandica* require verification. On p. 70 of Mr. Reid's Memoir *Natica clausa* is marked with the locality of Weybourn in mistake for *N. helicoides.*

Taylor, S. Woodward, Lyell, and Wood and Harmer, besides the geologists before mentioned.*

In their notes on the pebbly gravel and its relation to beds above and below, Messrs. Wood and Harmer have expressed their opinion that on the coast the Weybourn Sand (=Bure Valley Beds) passes up by interbedding into the Cromer Till.† This feature was also, in their opinion, exhibited at Guist; while the pebbly gravels around Norwich, that immediately underlie the Lower Glacial brickearth, were considered by them to be, to some extent, the equivalents of the Cromer Till.‡

Neither my colleague Mr. Reid nor myself have seen any evidence to corroborate this opinion: on the contrary, the line between the undoubted pebbly gravels (which are grouped by us as Pre-Glacial) and the overlying Glacial Drift is generally sharply defined.

There can be little doubt that here and there beds of the age of the Weybourn Crag, or upper part of the Norwich Crag Series, are represented in the area by certain pebbly gravels and sand which rest on the Chalk and underlie the Glacial Drift. But as there is no fossil evidence to prove the point, the accompanying details are given under the head of "Pliocene" with reserve. Probably remnants exist only as isolated, and in some cases, partly re-arranged relics of this period.

Mr. Joshua Trimmer first pointed out the extent of the Crag, observing that it did not reach westward of a line taken [roughly north and south] through Fakenham.§

Mr. Reid has described a section at Letheringsett. He says, "From the position and lithological character of the beds there is little doubt that they represent the beach deposit of the Weybourn Crag sea. No fossils were found, but the absence of shells is a common character in shingle beaches. The largest pit, marked *Kiln* on the map, is half a mile north-west of Letheringsett; it shows":—

Soil.		Feet.
Contorted Drift	Boulder Clay, very chalky	5
	Streaky brick-earth and marl	0 to 1
Weybourn Crag	Shingle, almost entirely flint	3
	Loamy sand and large worn flints	1

Chalk, probably 20 feet above the level of the stream.

"Another part of the same pit shows 3 or 4 feet of alternating laminated clay and lines of pebbles. A pit by the R of Rock Hill (on the map), now disused and much obscured, shows similar though more sandy beds resting on the Chalk, which at that point is nearly 50 feet above high-water mark."‖

At Glandford Mill a section showed stratified boulder gravel and sand, with bands of laminated clay and sand, part if not all of which might be Pliocene.

In a pit by the junction of roads south of Thornage Common, very pebbly gravel occurred, but I felt too doubtful about this to map it as Pliocene. [*See* p 42.]

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* References to these papers will be found in Mr. Reid's Memoir on the Geology of the Country around Cromer. *See also* J. H. Blake, Proc. Norwich Geol. Soc., vol. i. pp. 149, &c.

† Geol. Mag., vol. v., p. 452.

‡ *Ibid.*, vol. vii., p. 20. *See also* Wood, Quart. Journ. Geol. Soc., vol. xxxvi., p. 468.

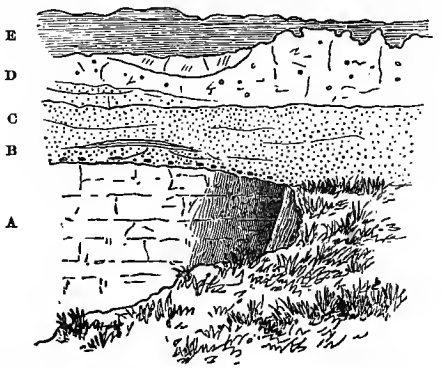
§ Proc. Geol. Soc., vol. iii., p. 185. I was informed by Mr. H. R. Rump that a shark's tooth with adherent phosphatic matter, like a Red Crag specimen, had been picked up on Wells beach. The derivation of such a specimen is of course very questionable.

‖ Geology of the Country around Cromer, p. 49.

Mr. S. V. Wood mentions that "in a pit 4 furlongs east of Copy's Green, Wigton, a sand comes up beneath these (Lower Glacial) beds (represented by a chalky loam) which may be the recurrence of the Weybourn Sand."* I also noticed traces of pebbly gravel on the Chalk in a pit south of Westgate, Binham. [*See* p. 25.]

At Guist chalk-pit the followning beds were exposed :—

FIG. 1.—*Section at the Lime-Kiln, Guist.*



E. Brown stony, and sandy clay.
D. Chalky and sandy Boulder Clay, bedded at base, 5 to 6 feet.
C. Grey and buff micaceous sand and shingle, and laminated clay, with nodules of "race," 5 to 10 feet.
B. Stone-bed.
A. Chalk with flints.

This section at Guist was originally described by Joshua Trimmer† as follows :—

Warp-drift ; sandy loam.
Sand of the Crag.
Chalk (piped).

When I first visited the pit in 1877, in company with Mr. Reid, we were informed that the pit had not been worked for 12 or 14 years, as the marl (Contorted Drift) obtained from a pit adjacent was found to yield a better lime. The Chalk has since been worked. The lower part of bed D in the diagram is sandy and bedded, and doubtless it was this appearance which led Messrs. Wood and Harmer to conclude that the pebbly gravel and Boulder Clay were intimately associated. [*See* pp. 13, 29.]

In their section south-west of Bintree, Messrs. Wood and Harmer suggest that the pebbly sands may be present as at Guist.‡

On the west side of the Great Eastern Railway, north of Broom Green, a pit showed pebbly sand with grey laminated clay seams, resting on Chalk. These beds may be traced in the railway cutting, overlaid in places by Boulder Clay, while on top is a coarse flint gravel.

[*See* also remarks on the railway-cuttings at Pensthorpe and Thursford, pp. 28, 39.]

* Quart. Journ. Geol. Soc., vol. xxii., p. 552.
† Quart. Journ. Geol. Soc., vol. x., p. 236.
‡ Quart. Journ. Geol. Soc., vol. xxxviii., p. 87. Fig. 8.

CHAPTER IV.

GLACIAL DRIFT.

General Remarks.

The Glacial Drift in this area comprises almost every kind of sedimentary or detrital formation from chalk-mud, marl, clay, and loam, to sand, fine gravel, and boulder gravel.

The Map distinguishes, *as far as possible*, the marly and loamy beds from the sands and gravels. At best this is a lithological division, but it is very difficult to be consistently accurate even in this respect, for the beds give evidence of great disturbance or contortion, and also of frequent and often very abrupt changes in lithological character.

An examination of the cliff-sections at Cromer, Sherringham, and Weybourn is the best preparation for the study of the inland geology. The diagram of these sections, which has been drawn by Mr. Clement Reid, shows the uncertain nature of the beds. It displays the occurrence of huge masses of Chalk, or of slightly disturbed Chalk, as at Wood Hill, East Runton; of huge masses or "jambs" of marl, burnt for lime, between West Runton, and Beeston Regis; and it indicates the generally irregular manner in which the sands and gravels occur.

Looked at in a broad way two divisions might be made in the Drifts of the area:—

2. Boulder gravel, fine gravel, and sand.
1. Chalky Boulder Clay, marl, chalky mud, clay, and loam, or brickearth with nests and beds of sand and gravel. The clay is occasionally underlaid by sand and gravel, as near Walsingham.

It is not possible to separate the gravel from the sand on the map; and even the boundary between the brickearth and the marl or Boulder Clay is only approximate.

The drifts of this particular area have received most attention from Joshua Trimmer, and Messrs. S. V. Wood and F. W. Harmer. In the Memoir on the Geology of the Country around Norwich (p. 90), I observed that in certain localities and over limited tracts of ground the following grouping of beds adopted by Messrs. Wood and Harmer might be traced, but that the evidence of this succession was the exception and not the rule:—

4. Plateau Gravel. Coarse Cannon-shot Gravel and Sand - - - } [Upper Glacial.]
3. Chalky or Upper Boulder Clay - }
2. Sand and Gravel. [Middle Glacial.]
1. Lower Boulder Clay. Contorted Drift, &c. [Lower Glacial.]

I then expressed my opinion that so far as the Norwich district was concerned, a sub-division into Upper and Lower Glacial was sufficient. In the present area I have been at a loss to find the persistence of any of the above four divisions.

There is no doubt that in the country from Weybourn through Holt to Corpusty and Heydon we have a repetition and continuation of the Drifts of Cromer, namely, an upper division of sands and gravels and a lower division of marl and brickearth. But several questions then arise. Does the upper division form the equivalent only of (2) the Middle Glacial of Wood and Harmer, or include also equivalents of (4) the plateau gravel? It would seem that these same gravels (or re-constructed portions of them) form the Esker-like mounds and ridges of Glandford and Blakeney, being in this case probably of late Glacial age, like the Elephant-gravel at Wells. The same sort of gravel and sand as at Holt extends southwards in patches from Holkham* to Whissonset, and overlies clay in places precisely like the Chalky or Upper Boulder Clay. But while acknowledging that there may be two or more divisions of gravel and sand, there is often no evidence to distinguish them, and only in a few places could the decidedly later Glacial gravels be separated on the Map. [*See* p. 34.]

Then concerning the relation between the marls and chalky drift (beneath the gravels and sand) of Holt and Heydon, and the chalky clay of Fakenham. On the whole the area on the south-west and south, that is, at Fakenham, West Rainham, Oxwick, Horningtoft, and Gately, at Bintree and Themelthorpe, is most like the so-called Chalky Boulder Clay so largely developed south of Norwich. The area to the north and east is *undoubtedly* the equivalent of the Lower Glacial or Contorted Drift of the Cromer Coast. Can any separating line be drawn between them?

In starting work at Fakenham I mapped the clay in that neighbourhood as the Chalky Boulder Clay, but as I came to trace it eastwards to join on to the area of so-called Contorted Drift of my former work near Aylsham, I found that the one deposit passed into the other. The railway-cuttings instead of helping in the matter only served to render the subject more complicated, for at the Thursford cuttings there were shown all kinds of clay, sand, and gravel jumbled up together, evidently Contorted Drift, and yet containing masses of clay precisely like the Chalky Boulder Clay. In fact, all the railway-cuttings in the district have displayed the extreme irregularity of the beds; and it would appear as if most of the actual sections showed a state of things very different from the order which one might infer from the relative positions of beds on the ground!

Messrs. Wood and Harmer in speaking of the "formation that covers much of north-west Norfolk," the Contorted Drift, observe that it consists "of soft chalk finely ground up by the enveloping land ice-sheet of the period, and spread out from its seaward termination into a deposit that frequently shows stratifi-

* The gravel here is regarded by Mr. Wood as Middle Glacial.

cation (sometimes very fine), and in which occur great sand galls like those so abundant in the red mud portion of it."* They further note that this drift suddenly changes into a sandy stratified silt, or into compact yellow brickearth: as near Guist, where (in their opinion) the valley was excavated out of Contorted Drift prior to the deposition of the Middle Glacial. Whatever theory we adopt, these abrupt changes in the deposits are very evident. In describing the chalky nature of some portions of the Contorted, Drift the same authors observe that the formation "southwards towards Reepham and Holt, and westwards towards Wells, becomes formed exclusively of this marl."† And in his Section No. 16, accompanying a Map of the Upper Tertiaries (1865), Mr. Wood shows the Middle Drift (sand and gravel) resting on the Lower Drift (marl and brickearth) in the country from Weybourn, Salthouse Heath, Glandford, Saxlingham Heath, Field Dalling, Wighton, and Holkham to North Creake. This grouping coincides with the two main divisions previously suggested.

In the valley of the Wensum, however, at North Elmham and thence to Attlebridge, my colleague, Mr. J. H. Blake, has been able to trace out the four divisions of Messrs. Wood and Harmer. These I previously traced in the neighbourhood of Attlebridge and south of Cawston. But from Cawston westwards my difficulties began: and there are difficulties again (in Quarter-Sheet 66 N.W.) west of Costessey, near Easton and Bauburgh.

Between Reepham and Themelthorpe sand and brickearth underlie Chalky Boulder Clay; and again north-west of Foulsham there is evidence of Chalky Boulder Clay overlying sand and brickearth. The cuttings on the new railway, instead of making things clear and definite, showed that in the Chalky Boulder Clay there was a considerable bed of sand of an *impersistent* nature, so that while in part of the cutting one might endeavour to establish a sequence of Upper Boulder Clay, Middle Glacial Sand, and Lower Boulder Clay; in another part of the cutting there was but one Boulder Clay. In these places the Boulder Clay was very chalky; and the same is the case between Foulsham and Guist, where there is distinct evidence of sand, and a considerable mass of it (like the so-called Middle Glacial), overlaid and underlaid by very chalky Boulder Clay.‡ (*See* p. 26.)

There is no doubt that even where a three- or four-fold division of the Drifts can be made, the Lower Boulder Clay becomes in places so much like the Upper Boulder Clay that no one could detect the difference in pit-sections. This was markedly the case in the cutting by the Whitwell and Reepham Station (Eastern and Midlands Railway); and there appears no doubt, as Messrs. Wood and Harmer have stated, that traced to the north-

* Supplement to Crag Mollusca, Palæontograph. Soc. *See* p. xix.

† Geol. Mag., vol. v., p. 455.

‡ In the section accompanying Mr. Harmer's "The 'Testimony of the Rocks' in Norfolk" (1877), the geology is shown of a line of country extending from Docking, across Fakenham, Foulsham, and Reepham. At the two last-named places, Upper, Middle, and Lower Glacial beds are shown.

west from Norwich, the Lower Boulder Clay changes from a brown stony (and occasionally chalky) loam or clay, to a chalky Boulder Clay which only occasionally passes into a stony loam or brickearth, like the Norwich brickearth. That after all the Norwich brickearth is often but a weathered form of Chalky Boulder Clay is an opinion that has been expressed to me by my colleagues Messrs. F. J. Bennett and C. Reid, and I have given a drawing of the actual change horizontally of the Chalky Clay into brown brickearth, that was visible in a new railway cutting near Ashwell Thorpe.* Many other local instances might be mentioned. It would be difficult to say under what conditions the alterations have been produced, or indeed whether the main mass of brown brickearth in east Norfolk is not as much due to original deposition, as to subsequent weathering. And it must be remembered that in that district it rests on the ferruginous sands and gravels of the Crag series, portions of which may have been incorporated with the Drift at the time of its formation.

Another point to be considered is the character of the boulders in the deposits. Mr. John Gunn has maintained that in the Cromer Till or Lower Boulder Clay of the Coast (1st and 2nd Tills of Mr. Reid), the characteristic boulders are of an igneous and distant type, whereas in the Chalky or "Upper" Boulder Clay they are mostly of Secondary rocks, which, as a rule, have not travelled so far. Such a distinction, however, does not apply to the Boulder Drifts or Contorted Drift in the area now under consideration. With the exception of the large boulders hereafter mentioned, Chalk and flint are the prevalent materials. Moreover, the Cromer Till may not actually be represented in the area.

Transported masses of Chalk, such as characterise the Contorted Drift, are found here and there in the district; and further west, near Lynn, I saw, in company with Mr. Whitaker, a section which showed a bed presenting the characteristics of the Lower Glacial or Contorted Drift resting on another having those of the Upper or Chalky Boulder Clay!

Nevertheless, while we find it difficult and sometimes impossible to group the various Drift clays and gravels in sequence, or correlate them with divisions made in other localities; these perplexities may in great measure arise from the disturbances and contortions to which the beds in this area have been subjected.

Mr. Clement Reid in his Memoir on the Geology of the Country around Cromer (pp. 116, 117), has given reasons for concluding that the Chalk masses of the Contorted Drift were driven in by land-ice at the time of the greatest glaciation, when the Chalky Boulder Clay was formed.†

The contortion of the beds, which we witness here and there in the district as at Hindringham, Dunham Hill (Broom Green),

* Geology of Country around Norwich, p. 123, and pl. vii., f. 22.

† Mr. S. V. Wood attributes the introduction of the chalk masses and the formation of the contortions to the grounding of icebergs. Q. J. G. S., vol. xxxvi. p. 472; xxxviii. 668.

and other places, requires some powerful agent to account for it; and if we admit as the agent the ice-sheet which formed the Chalky Boulder Clay, we indirectly admit the occurrence of two Boulder Clays or at any rate two periods of land glaciation.

Mr. Reid observes that "The masses of re-constructed Chalk so common in the Contorted Drift are probably nothing but a later stage of the transported boulders, in this case so shattered and mixed with clay that they form a sort of transition to an ordinary Boulder Clay. *From the very marly character of the Contorted Drift when traced westward it seems not improbable that that portion of the deposit is continuous with and passes laterally into the Great Chalky Boulder Clay.* The general structure of Norfolk and Suffolk appears to show that the whole of the contortions are of one age, that of the greatest glaciation, or of the Great Chalky Boulder Clay, and it is probably to this period that the disturbances on the coast may be referred."*

The remarks made by Mr. Reid, and especially those which I have put in italics, are very interesting. They were penned before I had mapped the Fakenham district, and if (as I believe) they furnish a true explanation, they also account for the difficulties I have met with.

Thus where the later Boulder Clay passed directly over the clayey Lower Glacial beds, it no doubt became incorporated with it, causing one contorted mass, and we cannot separate the two deposits. Where sands intervened they often prevented contortions of the underlying clayey masses.

Mr. S. V. Wood says: "Where the clay rests on the Chalk, that material is sometimes so altered as to form a greasy water-holding marl, and often to graduate almost into the chalkiest form of the clay itself. . . . . In other parts . . . . the chalk is disturbed, and the lines of flint dragged up and displaced to a great depth, as in the case of a chalk quarry at Litcham."† (*See also* fig. 2, pp. 9, 22.)

Messrs. Wood and Harmer, in their MS. geological maps of West Norfolk, endeavoured to draw a line between the presumed Upper Glacial (Chalky Clay) and the Lower Glacial (Contorted Drift). Starting from Fakenham Fields the line was taken eastwards by Kettlestone and Barney Common, to near Raw Hall and Hindolvestone; and thence south of Thurning and west of Guestwick, south of Wood Dalling and west of Sall, to Reepham.

The divisions are shown in Mr. Wood's section, fig. viii., pl. xxi.‡

Roughly speaking, the characteristic Chalky Boulder Clay extends as far northwards as Great Snoring and Sculthorpe, and eastwards by Fulmodeston and Guestwick to Reepham, much as Mr. Wood has indicated. At the same time there is no particular

* Geology of the Country around Cromer, p. 115. *See also* Geology of the Country around Norwich, p. 137.

† Quart. Journ. Geol. Soc., xxxvi., p. 485.

‡ Quart. Journ. Geol. Soc., vol. xxxvi., p. 493.

evidence for drawing a line of separation, and this would be based entirely on the supposition that the divisions exhibited elsewhere are likely to be maintained in the district now under notice. Hence as the only boundaries that could be drawn would be theoretical and doubtful, and devoid of practical value, in the published Map the Boulder Clay has received one colour, to include the marly portion of the Contorted Drift as well as the so-called Chalky Boulder Clay. And I have simply indicated by a dotted line on the Map, in the southern part of the area, from Bintree by Foulsham to Wood Dalling and Reepham, where the boundary between Upper (Chalky) and Lower Boulder Clay (or Contorted Drift) most probably occurs in that region.

Boulders.

In this area as in East Norfolk many large boulders are met with, and these are often placed by the road-side to protect the corners of houses, gate-posts, &c. They are rarely to be observed *in situ*, even in the coast-section. The following are records of the more prominent boulders:—

Field Dalling.—By the road north of the Church are several boulders, and by the farm-building north of Little Marsh there is a granitic boulder measuring 1 ft. by 1 ft. by 1 ft.

Langham.—Blakeney Road. Boulder of Granitic rock, 3 ft. by 2½ ft. by 2 ft.

Bale.—By the cottage south-east of the Hall, there is a large boulder of Schistose rock, 4 ft. by 3 ft. by 2 ft.

Fakenham Heath.—By cottage in lane leading to Great Snoring, rectangular block of basalt (?), measuring roughly 1 ft. by 2 ft. by 3 ft.

Dunton.—By farm south-east of church. Saccharine Sandstone, an irregular cube, measuring about 1½ ft. each way.

Tatterford.—In this neighbourhood Mr. W. H. Hudleston noticed a boulder of rock like the Cleveland Basalt.

Sall.—Here is a boulder, in size 3 ft. by 2½ ft. by 1½ ft.

Mannington.—By the Church several large boulders 3 ft. by 1½ ft. by 1 ft. (?). (*See also* pp. 34, 39.)

Boulder Clay and Marl.

General Remarks.

This is, generally speaking, a deposit made up chiefly of the débris of Chalk and Flint, the Chalk occurring in the form of small rounded stones in a clayey matrix and with large unrolled and broken flints, and pebbles of flint and quartz. Sometimes stones are scarce, and the Chalk is present in the form of a fine calcareous mud, mixed with a variable proportion of sand and clay. As a rule the Boulder Clay is of a pale cream or white colour, and is sometimes not readily distinguishable at the first glance from the Chalk. At other times we meet with the blue varieties of Boulder Clay, so conspicuous in the country South of Norwich, which

contains many fragments of Kimeridge Clay. Fossils derived from the Lias, Oolites, and other formations are frequently met with.* The thickness of the Boulder Clay is very variable; in the neighbourhood of Holt it is as much as 90 feet, but as a rule it is considerably less.

Agricultural uses of the Boulder Clay and Marl.

Bacon, in his "Agriculture of Norfolk," observes that "There is no county which has been indebted more, if so much, to the manures obtained from its subsoils, as Norfolk, and by none has a larger quantity been used, or with a greater increase of production. Mr. Coke [afterwards Earl of Leicester], when he inherited his patrimony, exhibited by practice how great benefit was to be attained through the application of clay and marl to the surface soil, and its effects were so momentous that his example was immediately followed throughout the Western part of Norfolk, and in some parts of the East. The consequence has been that no county, and certainly no district exhibits to a greater extent the proof of this application, to be seen in the number of clay and marl pits which abound on every farm."†

It was about the year 1725 that Thomas Coke began to enclose the parish of Holkham, an open barren estate; and the result of his improvements was that land which had let for 3*s.* an acre was converted into a domain of unexampled fertility.‡

The reason why so many pits are found, is that the expense of "clay-carting" was more than that attending the digging of the earth on the spot. Hence even in one large field two or more pits were sometimes opened.

The Boulder Clay which is so very chalky is generally spoken of as clay, although in reality it is a marl, whereas the true Chalk is not unfrequently termed marl. An old agricultural writer, Marshall, says that with many farmers "Nothing is marl which is not white."

The "marl" used not only varies much in character, but also belongs to different formations. And we naturally find, in referring to the writings of agriculturists, that opinions differ on the merits of distinct kinds of "marl." These differences arose partly from the nature of the marl, but to a large extent from the nature of the soil and subsoil on which the marl was spread.

Thus Young says, some farmers prefer white marl to the more clayey varieties; the worst are the hard, chalky, and stony marls (= Chalk, &c.), but some prefer even this kind. The quantities of marl put on the land varied greatly, the load being about 36 cubic feet, and from 30 to 60 loads being used per acre. "Thirty years ago the quantity spread from Warham to Holt, was 60 loads an acre, which lasted 15 or 16 years in perfection, then

* *See* C. B. Rose on the Organic Remains of the Diluvium in Norfolk, Quart. Journ. of Sci., Lit., and Art (1828), p. 308; S. Woodward Geology of Norfolk, pp. 39–42.

† P. 267. *See also* Kent, Agric. Norfolk, p. 22.

‡ Dr. Rigby's letters from France, &c., p. x.

they laid on 25 or 30 loads more, which lasted 10 or 12 years longer; repeating it still; so that previous to 1770, that country had much of it, been marled thrice at least."

The country around Hackford, Thurning, Binham, &c., much of it heavy land, has also, according to Young, been marled with from 40 to 60 loads per acre. One field at Waterden was marled with 122 loads per acre and "over-dosed," consequently the crops failed.* The land about Stiffkey (Stewkey) meaning "stiff land," and that about Cley gave rise (according to Munford) to the names of the places.

Much of the best Barley, for which Norfolk is celebrated, is grown in the area west of Cley, Binham, and Hindringham. The subsoil is for the most part Marl, of no great thickness, resting on Chalk, and with often a thin gravelly or sandy soil.

A characteristic feature of the Boulder Clay is the number of primroses whose flowers, in the spring-time, line the ditches and decorate the railway-cuttings.

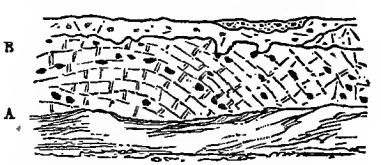
Local Details.

Weybourn.—The Glacial Drift in the Cliff-section is shown in the published Horizontal Section, Sheet 127, by Mr. Reid. (*See* pp. 11, 13.)

Kelling.—"A pit south of Muckleburgh Hill showed 10 feet of laminated marl without stones."†

Morston.—A pit in this parish showed about 20 feet of Chalk with flints, (A) exhibiting an anticlinal arrangement of the beds. Overlying the Chalk was a deposit of contorted chalky marl or Boulder Clay (B), with included masses of brown sand, gravel and loam. The disturbance in the Chalk is most probably due to Glacial action. (*See* pp. 9, 19.)

Fig. 2.—*Chalk-pit at Morston.*



The Rev. O. Fisher, in speaking of the country about Kelland (Kelling) and Weybourn, says:—

"The chalky loam is usually cream coloured, and is much of it horizontally stratified, and contains thin bands of sand and laminæ of mica. This is especially notable in a pit on Kelland heath. There the section of the quarry has a fine ribboned structure, observable in the smallest specimens, exactly like some of the ribboned layers of a fresh water deposit (the Purbeck beds, for instance). The planes of division contain much mica. The formation of this loam is easily explained, by conceiving icebergs to have stranded upon the shoal of Chalk, the margin of which extended to this place, and grinding over the surface under the action of winds and tides, to have raised clouds of chalky mud, which, mingling with the foreign material from the berg itself, settled at a lower level, in horizontally bedded loam, around the confines of the shoal.

"The deep channels cut out of the chalk surface by these bergs, are to be found further to the west. There is a splendid section of such a one in the railway-cutting between Holkham and Wells [*see* p. 36]. The width of it is 120 yards. It is filled with coarse bouldered gravel, and

* Young, Agric. Norfolk, p. 402.

† From Mr. Reid's notes.

fine calcareous sand, containing abundantly fragments of chalk foraminiferæ, and occasionally a fragment of the *Cardium edule*. Here we have the coarser materials from which the finer particles have been carried off to form loam elsewhere (an ancient manufacture of "whiting" on a magnificent scale)."*

Holt.—West and south-west of Holt the gravels and sands are underlaid by a bed of redeposited Chalk, called "Marl," so pure that analysis showed 91 per cent. of carbonate of lime. (*See* also p. 52.)

Analysis of Marl.

From pit one mile south-west of Holt, north of high road.

By Mr. WILLIAM JOHNSTONE (communicated by Mr. W. WHITAKER).

Moisture combined	·490
Alumina phosphate	·600
Ferric oxide	·670
Phosphoric acid	·307
Manganous oxide	·007
Lime	51·050
Magnesia	·286
Sulphuric acid	·008
Carbonic acid	40·126
Organic matter	·500
Insoluble matter	6·685
	100·729

Insoluble Matter.	
Ferric oxide	·500
Alumina	·700
Lime	·270
Barium & strontium sulphates	·320
Magnesia	·006
Phosphoric acid	·002
Silica	4·773
	6·571

In reference to this "Lower Drift" Mr. Wood remarked that soft and marly Chalk is the character of the inland development of the deposit, as it consists of redeposited Chalk so free from admixture with other detritus as to be readily mistaken for Chalk. The beds, in fact, are so chalky as to be commonly known as marl, and to be burnt for lime, as at Cromer lime-kiln, at Metton, and near Holt.†

In his Map of the Upper Tertiaries (1865), Section 19, Mr. Wood gave a diagram of a kiln by the road ¾ m. S.W. of Holt; it showed Lower Drift disturbed by "lateral pressure."

The cutting on the Eastern and Midlands Railway at Ingmote Hill, Holt, showed 20 to 25 feet of sand and boulder gravel, resting on an irregular surface of marl. Seams of dark brown clay intervened in places between the marl and gravel.

Wells.—In the railway-cuttings south-east of Wells are sections of chalky loam (Boulder Clay) resting on the Chalk, and in abrupt contact with it. Referring to this locality, Mr. Wood has remarked that a very fine section is afforded of the Lower Glacial Till and Contorted Drift in the form of a chalky loam resting on the Chalk and partially underlain by boulder gravel.‡ The accompanying diagram taken on the eastern side of the excavations (pictured in Fig. 4.) shows the arrangement of the beds. The gravel is of limited extent, but the section is important in showing

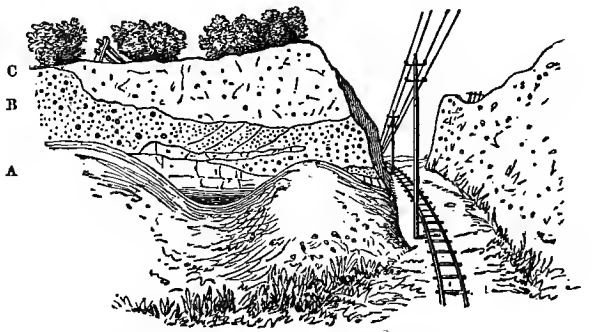
* Geol. Mag., vol. v., 551, 552.

† Remarks in explanation of the Map of the Upper Tertiaries, pp. 2, 4.

‡ Quart. Journ. Geol. Soc., vol. xxii., p. 552.

that gravel of this character sometimes underlies the Boulder Clay. It is not unlike the coarse gravel shown in the cutting west of Wells. (*See* p. 9, and Fig. 11, p. 36.)

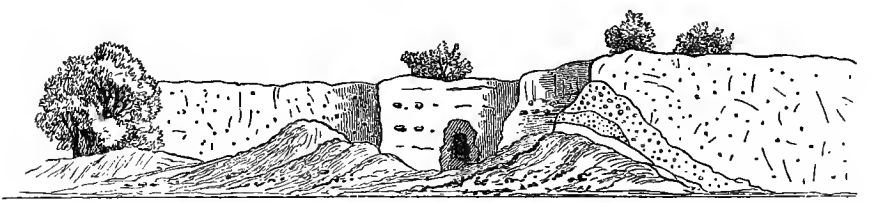
FIG. 3.—*Section by the Great Eastern Railway, near the Lime-Kiln, South-east of Wells.*



c. Marl or Boulder Clay, 4 to 5 feet in thickness.
B. Gravel, made up of rolled chalk and flint, with quartz, red chalk, &c., also false-bedded chalky sand, with included seam of Boulder Clay.
A. Chalk.

Fig. 4 is a general diagram to show the disposition of the strata in the excavations north of the railway and lime-kiln. The central bluff of Chalk is in reality a thin facing of Chalk resting abruptly against marl. The gravel and sand are the same as in Fig. 3. (*See* p. 9.)

FIG. 4.—*Section by the Great Eastern Railway, near the Lime-Kiln, South-east of Wells.*



c. Marl or Boulder Clay,
B. Gravel and sand.
A. Chalk with flints.

Holkham.—To the south-west of the Barn Plantation a large pit showed 12 feet of white marl with flint boulders; while a bed of rather indurated brown sand was shown at the base in one place.

The following section was to be seen north-east of Scarboro' Hill in Holkham Park, the total thickness being about 10 feet:—

5. White marl with stones.
4. Chalky sand.
3. Grey and white marl with few stones.
2. False-bedded chalky sand.
1. Marl with chalk and flint stones.

Another section, by the shed, south of Branthill, showed a somewhat similar arrangement of beds:—

5. Clayey marl, 2 to 3 feet.
4. Chalky marl with flints, 3 to 4 feet.
3. Grey marl, 3 feet.
2. Brown and white chalky sand, 2 feet.
1. Marl.

Warham.—The railway-cutting west of Warham All Saints showed marl with flints, generally at the base, with sand and flint-gravel lying irregularly on the top.

At the Cross Drove a pit showed marl, made up of layers of grey and white chalky clay, resting on rather disturbed Chalk.

Cockthorpe.—East of the Field Barn near Battledore Hill, a pit showed bedded chalky clay, comprising an alternation of sand, marl, and chalk stones in thin layers. The same beds appear in the road-cutting further north, where also are masses of buff sand possibly washed from the bordering hills.

Mr. Wood mentions that the Lower Glacial beds (Cromer Till and Contorted Drift) occupy the surface of the country through Field Dalling, Binham Abbey, and Wighton.*

Wighton.—South of the word *Gate* of *Creak Gate Road* (on the map), marl and sand are interbedded. At the Field Barn there is a deposit of marl with many flints not unlike Chalky Boulder Clay. West of the village the drift is a very chalky bed with chips of flint.

Young remarks that "at Wighton, I saw an extraordinary fine white marle not as in common in globules, but more resembling the equal consistence and texture of white butter."†

Langham.—Trimmer has described a section here which shows the following beds:—‡

		Ins.	Feet.
Loamy warp-drift - - - - - -		6 to	3
Boulder Clay	Comminuted chalk and clay with flints and rolled fragments of chalk (piped to depth of 3 feet) - - - -		9
			12

Saxlingham.—North of the village very chalky clay or marl, like the marl at Heydon, and fine yellow sandy clay have been dug.

Binham.—A pit south of Westgate showed 12 feet of Chalk with flints overlaid by marl, with an intervening bed, 2 to 3 feet in thickness, of pebbly gravel (? Crag). Another pit north-east of Binham, between Manor House and Bluemont Cottage, showed 18 to 20 feet of gravel and sand banked up against marl. The disposition of the beds was probably owing to contortion as in the Contorted Drift. The gravel section was as follows:—

Chalky gravel with seams of sand, and marl or fine chalky drift.
False-bedded chalky sand, 1 to 3 feet.
Chalky gravel with pebbles and boulders of Chalk.

Hindringham.—A pit south of Field House, showed gravel resting on contorted marl, with an included mass of chalky and flinty gravel in it.

Gunthorpe.—At the Turf Moor a pit exposed chalky clay (like Chalky Boulder Clay), sand and brickearth.

Barney.—The beds are very variable; in the churchyard sand, marl, and brickearth have been dug into. The surface-soil in this neighbourhood is for the most part loamy.

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* Quart. Journ. Geol. Soc., vol. xxii., p. 552.

† Agriculture of Norfolk, p. 410.

‡ Geology of Norfolk, Journ. R. Agric. Soc., vol. vii., pp. 468, 484; and Quart. Journ. Geol. Soc., vol. x., p. 237.

Little Snoring.—A pit west of the church showed chalky clay resting on grey and brown false-bedded sand.

Great Snoring.—Boulder Clay is shown in many pits in the parish, north of Thorpland plantation, south-west of New Barn, and to the north and east of the village.

Walsingham.—Messrs. Wood and Harmer have noted Chalky Boulder Clay resting on the Contorted Drift in the railway-cutting at Walsingham Station.* The Boulder Clay of this neighbourhood is, however, inseparable from the Marl or Contorted Drift which extends westwards from Weybourn.

Egmere.—North of Egmere Church a pit showed marl and sand.

Creake.—East of Creake Abbey a pit showed about 15 feet of Chalk with flints, blocky, and evidently rather disturbed, and above it 6 feet of brown gravelly soil with patches of Boulder Clay.

The various beds of sand, gravel, and Boulder Clay, north of Gravers Creak Common, are very irregular and complicated: probably the beds are much disturbed, like the Contorted Drift of the coast.

Houghton-in-the-Dale.—The wooded hill south-east of the Furze plantation showed chalky clay, with chalky sand and gravel in it.

East Barsham.—The section at the Lime-kiln north of the village, showed chalk upon which rested Chalky Boulder Clay, and this again was covered by chalky sand and gravel.

West Barsham.—North of the church a pit showed about 18 feet of marl with included lenticular bed of sub-angular flint-gravel and coarse red sand.

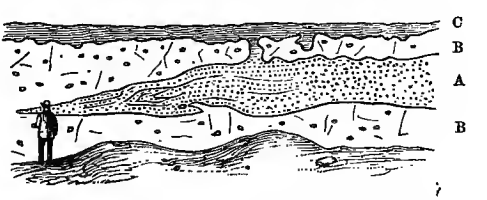
Sculthorpe.—A pit to the north of the Windmill showed the following beds:—

	Feet.
Brown loamy and sandy soil - - - -	2 to 4
Marly Boulder Clay (piped) - - - -	10
Chalk with flints.	

A large pit south-east of Leicester Square, just in the parish of Syderstone, showed 20 feet of chalky clay, with brown sandy beds and veins, resting on Chalk.

Shereford.—South-east of the church, a pit showed about 15 feet of Boulder Clay, with an intervening and lenticular bed of contorted sand and fine gravel. (*See* Fig. 5.)

Fig. 5.—*Pit south-east of Shereford Church.*



C. Loamy soil and decomposed Boulder Clay
B. Chalky Boulder Clay.
A. Sand and fine gravel, contorted.

Hempton.—West of the windmill a pit showed:—

Brown clayey soil with large flints.
Chalky Clay.
Coarse brown stony sand.

* Quart. Journ. Geol. Soc., vol. xxxiii., p. 89.

Colkirk.—East of the Rookery, a pit showed chalky clay with a vein of yellow sand, and gravelly soil on the surface.

Pattesley.—East of the farm, Chalky Boulder Clay was exposed in trenches dug for drains. The field was "clayed" with the material excavated.

Gately.—Stiff Chalky Boulder Clay is well shown in this neighbourhood.

Fakenham.—Messrs. Wood and Harmer have identified the Upper and Middle Glacial beds, and Contorted Drift in this neighbourhood, and the beds are shown by them in a section taken along a line from the River Wensum ¾ mile W. of Fakenham Church to the south end of the railway cutting at East Barsham.* I have, however, not been able to detect any distinction in the clays of the district sufficient to warrant any separation on the map.

The best section is in the railway-cutting north of the Great Eastern Railway Station, where there is a considerable thickness of tough blue Boulder Clay. Here I obtained ice-scratched Chalk, fragments of shale, &c. The clay contains an intervening bed of sand, sandstone, and conglomerate.

In a letter (dated Nov. 14, 1880), Mr. S. V. Wood informed me that "low down in the valley at Fakenham town, and not far from the river, Mr. Harmer and I saw (in apparently a temporary excavation) the Chalky clay resting on the Middle Glacial in the usual transitional way."† This was, I believe, somewhere between Hempton Water-mill and the Great Eastern Railway Station, and judging from evidence obtained further east, I believe this Boulder Clay must have been a local mass in the sand and gravel. South-east of the station, by the Alluvium, the ground is very clayey.

Little Ryburgh.—A pit west of the Church showed 10 feet of chalky clay, like Chalky Boulder Clay, with an included mass of sandy loam on the north side of the pit. North-west of the 21st milestone on the Norwich road a cutting showed:—

	Feet.
Chalky clay	3
Stony and sandy loam, with included mass of buff gravelly sand	3
Chalky clay	2

In the Boulder Clay at Ryburgh I obtained *Belemnites abbreviatus*, and many banded flints.

Rainham.—The Marquis of Townshend possesses a large *Inoceramus* found in a clay pit by High-noon's Plantation; and a Ventriculite in flint from the wall of the old church, Rainham. Both these chalk fossils were probably taken out of the Boulder Clay.

North Elmham.—A large pit west of Dunham Hill showed—

Gravel and sand, and brown clay	15 feet.
Marl	
Laminated clayey sand and fine yellow mealy sand	
Stony marl	

West of Broom Green a pit showed 15 to 20 feet of Chalky Boulder Clay containing large boulders of Chalk, flint pebbles, and large flints, the clay having a streaky appearance towards the top.

Bintree.—West of High Cross a large pit showed Boulder Clay, mostly unstratified, but containing in one part of the pit an included bed of loamy sand and Chalky Boulder Clay. The lower part of the pit was in blue Boulder Clay. This may be the section one quarter of a mile east of Yarrow House, referred to by Messrs. Wood and Harmer as showing Chalky Boulder Clay resting on Contorted Drift, with an intervening band

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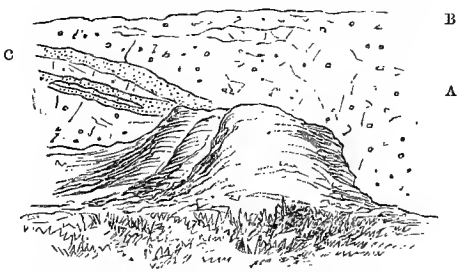
* Quart. Journ. Geol. Soc., vol. xxxiii., p. 87. *See also* footnote, p. 17 of this Memoir.

† *See also Ibid.*, vol. xxxvi., p. 493.

of "Middle Glacial" sand.* The section is shown in the accompanying diagram.

FIG. 6.—*Pit East of Yarrow House, Bintree.*



C. Alterations of brown sand and chalky clay.
B. White marl.
A. Boulder Clay, paler in the upper part, blue towards the base. 20 feet shown.

North-east of Manor House the soil is very mixed, no sand has been dug, the surface is gravelly in places and there is a "kind of brickearth," but I was informed that there were "all kinds of soil but good soil."

Eastern and Midlands Railway.—South of the bridge over the Kettlestone and Croxton Road the cutting showed bluish-brown clay and sand, with a gravelly surface.

The cutting about 15 feet high north of the bridge over the Kettlestone and Croxton Road, showed first brown brickearth and buff sand, in lenticular beds, and then chalky clay (like Chalky Boulder Clay), resting on sand which rose from beneath it further north. Beyond this the cutting showed sand and brickearth most irregularly intermingled, with gravelly soil on top.

The cutting at Wood House showed brown loam with nests of sand and patches of chalky clay (like Chalky Boulder Clay). Stiff clay appeared in places at the base of the cutting. The surface was covered with a thin gravelly soil. Eastwards to Thursford most rapid changes occurred in the cuttings only 3 or 4 feet deep. There was grey chalky clay, grey, buff, and orange sand, grey and bluish-mottled clay and marl.

East of Thursford Station a mass of chalky clay (like Chalky Boulder Clay) rests on sand apparently in a basin, while marl, clay, and sand occur very irregularly here. Further east buff and white sand, chalky gravel, and marl are met with. About a quarter of a mile east of the station, or half way between the bridge and the station, a boss of laminated and micaceous clay and sand with anticlinal bedding makes its appearance. The bed resembled the laminated clay of the Crag Series.

Hindolvestone.—By the church and to the south the land is heavy, and chalky clay appears in the ditches.

Wood Norton.—East of Hall Wood 8 feet of Chalky Boulder Clay was exposed, containing seams of sand, a few pebbles of flint and quartzite, much Chalk and unworn flint, and traces of manganese ore. Messrs. Wood and Harmer identify Chalky (or Upper) Boulder Clay and Contorted Drift in this neighbourhood.

Stibbard, Fulmodeston.—West of the Great Wood, deep drains in a field showed on the east from 3 to 4 feet of brown clay with flints resting on chalky clay, which here and there comes close to the surface; on the western side of the field the ditches exposed marl, like that of Heydon.

Guist.—North of the Carr, a pit showed 3 feet of very fine, buff, mealy sand resting on marl.

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* Quart. Journ. Geol. Soc., vol. xxxiii., p. 115. *See also* fig. 8, Section viii., p. 86; and *Ibid.*, vol. xxxvi., p. 493, fig. xvi., plate XXI.

A pit by the Elmham road, at its junction with the lane leading to Sennowe Lodge, showed from 2 to 10 feet of false-bedded yellow and brown sand and gravel resting on from 10 to 20 feet of marl, with pockets of clay and sand. A vein of stiff brown clay occurred, in places, between the two deposits.

Messrs. Wood and Harmer mention that "at Guist also is a fine section of the Contorted Drift over the pebbly sands, but mostly in this part of Norfolk the pebbly sands have thinned out and the Contorted Drift rests on the Chalk direct."* [*See* Fig. 1, p. 14.]

A pit ¾ of a mile east of Guist, on the road to Foulsham, showed re-arranged Chalk on the Boulder Clay. In the latter, fragments of *Cardium* and *Tellina*? were detected by Mr. Whitaker in 1882.

The same re-arranged Chalk appeared at the base of the loop-line leading towards Fakenham through Dunham Hill.

Foulsham.—Chalky Boulder Clay has been dug in the clay pit south of the town. A pit north-west of Twyford Hall showed Chalky Boulder Clay. S. Woodward has noticed in the drift here *Inoceramus*, also Septaria containing large *Ammonites*.

On Guestwick Hill chalky clay occurs, with a covering of sandy and stony warp in places.

Themelthorpe.—West of the village the cutting on the Great Eastern Railway showed Chalky Boulder Clay resting on brown loamy sand (and loam ?) which rose up to the surface on the east.

Guestwick.—The land here is mostly heavy, but there are few pits showing any sections. A gentle clay slope extends from Guestwick towards Thurning.

Mr. S. V. Wood noticed the occurrence of the Lower Drift at Dalling, Walsingham, and Weasenham: at that time he included the "Middle" with the "Lower" Drift.†

Heydon, Corpusty.—The pit north of the Bullock Shed plantation showed 10 to 15 feet of white marl, whose surface was irregularly furrowed or piped and covered with 2 to 3 feet of brown stony clay. The marl is tolerably homogeneous, of a white colour, but bluish at the base. At one place it was over 30 feet in thickness. Manganese ore occurs in crevices of the marl. The marl is extensively dug for the preparation of lime and cement.

In the collection of R. Fitch, Esq., at Norwich, is a specimen of *Marsupites* from Heydon.

Reepham.—In this neighbourhood there is often a considerable thickness of brown stony loam on Chalky Boulder Clay, and it is most difficult to distinguish between this and the so-called Contorted Drift.

The cutting west of Haw Wood, on the Eastern and Midlands Railway showed stony brickearth on Chalky Boulder Clay.

North-east of Grove End the cutting on the Great Eastern Railway showed Chalky Boulder Clay resting on buff sand, chalky sand, and gravel, which rise in a gentle elevation. Immediately east of the bridge a cutting showed:—

	Feet.
3. Brown clay with patches of Chalky Boulder Clay	3 to 4
2. Fine chalky gravel and buff sand	6
1. Chalky Boulder Clay	3

Further east the bed 3 passed into ordinary Chalky Boulder Clay, which became considerably thicker, while the sand disappeared beneath the level of the railway-cutting. East of Grove End, Reepham, the following beds were shown in a cutting:—

3. Chalky Boulder Clay.
2. Sand.
1. Chalky Boulder Clay.

* Quart. Journ. Geol. Soc., vol. xxxiii., p. 88.
† Quart. Journ. Geol. Soc., vol. xxi., p. 141.

At Reepham Station the following beds were exposed, they were contorted in places :—

		Feet.
? Weathered Boulder Clay	Brown brickearth with flints and a few chalky patches, 6 feet	18 to 20
	Wedge of gravel	
	Strong brown brickearth	
	Sand (about 3 feet)	

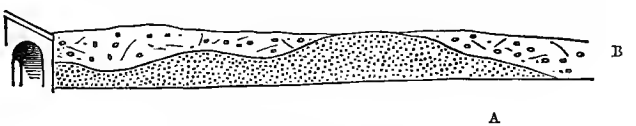
Another section west of the station showed :—

	Feet.
Brown loam with flints	8
Chalky Boulder Clay	5 or 6
White and huff sand	4

Nests of contorted sand occurred in the loam east of the station.

Cawston.—West of the church there was a pit opened in Chalky Boulder Clay, showing an included nest of huff sand. West of Cawston Station the accompanying section, fig. 7, was shown on the south side of the railway :—

Fig. 7.—*Cutting west of Cawston Station, Great Eastern Railway.*



B. Chalky Boulder Clay.
A. Yellow sand.

On the opposite side of the railway the Boulder Clay rests in irregular patches on the sand.

Loam or Brickearth.

The areas where brickearth is prominently displayed at the surface are indicated on the map, but there is no defined line to separate them from the marl and Boulder Clay into which they pass, or against which the brickearth may abruptly lie.

Weybourn.—" A large pit east of the village shows 15 feet of white marl, passing down into stony loam and sand containing fragments of *Cardium edule*, *Mya arenaria*, and *Tellina balthica.*"*

Holkham.—At Peterstone Kiln, near Holkham, 15 feet of brown stony loam, with flint and chalk stones, nodules of "race" and small boulders of igneous rock has been dug. Gravel was reached at the bottom of it.

The pit was opened by Mr. Thomas Coke, afterwards Earl of Leicester, for making bricks for use on his estate. Until this pit was opened the bricks were made from earth obtained in the parish of Burnham Norton.

Ornamental bricks, vases, tiles, and pipes are now made.

It is possible that this brickearth may be of the age of the Hessle Boulder Clay. In appearance it resembles some kinds of the Contorted Drift, but it differs from the ordinary Boulder Clay of the district in its comparative

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* From Mr. C. Reid's Notes. In the Norfolk Archæol. Trans., vol. v., 1859 (pp. 254–256), is a "Notice of an Ancient Potter's Kiln discovered in the parish of Weybourne, in the hundred of Holt." By W. J. J. Bolding. The pottery was Romano-British.

freedom from chalk. It occurs on the lower grounds below the hills which are capped with Boulder Clay, and it is overlaid by sand and gravel of the Esker type. [*See* p. 35.]

Mr. A. J. Jukes-Browne wrote me (August 25, 1883) :—"From your description of the Hessle Clay at Holkham, and from what I have seen near Thornham, the Hessle beds here in Norfolk behave just as they do in Lincolnshire."

East Barsham.—North of Barsham Hall a pit showed—

Chalky clay - - - - -	2 to 4 feet.
Blue and brown brickearth - - -	1 to 1 foot 6 inches.
Chalky sand and gravel.	

Holt.—A pit east of the town on the Baconsthorpe road, showed 15 feet of stony loam beneath a sandy and gravelly soil. The same earth was shown in pits south of Holt near the Lodge.

Warham.—A pocket of brownish-grey brickearth was shown in the cutting of the railway west of Warham, north of the bridge.

Swanton Novers.—Pits on Swanton Common show brickearth and buff sand very irregularly massed, and in places chalky; in fact, nearly all kinds of earth are represented in the pits. Very little business is now done, but I was informed that 20 or 30 years ago this was one of the largest and most important brickyards in Norfolk. Bricks were then sent to Blickling, Heydon, and other places. Bricks, tiles, and pipes are now made, as well as coarse earthenware. The surface of the ground is gravelly.

Barney.—[*See* p. 25.]

Gunthorpe.—Brickearth was exposed at the Turf Moor.

Thursford.—At the old Kiln, East of Thursford Station, 12 feet of blnish-grey clay was exposed in one part of the pit, but the beds were most irregular and changeable, brown brickearth with masses of sand and coarse gravel coming on abruptly. These rapid changes were well shown in the railway cuttings. [*See* p. 28.]

In the field by the *H* of *Stock Heath* (on the map) several trial holes 6 or 8 feet deep were made, meeting sand here and brickearth there in the most irregular way. A pit at the south-eastern corner of the field showed 8 feet of brown sandy brickearth containing occasionally large flints. In the lower part the earth was of a bluish mottled colour. In the south-western corner of the field 8 feet of sand was shown, a little to the north of this by the hedge 3 feet of loam resting on sand was exposed; a hole in the north-west corner of the field showed 9 feet of gravelly sand, and another a little to the east of it showed 4 feet of gravel.

South of the *e* of *Heath* (on the map) sand has been extensively dug to a depth of 20 feet. It seems here to occupy a basin, probably due to contortion.

Brickearth has more recently been dug by the railway bridge between Kettlestone and Croxton.

Fakenham.—I was informed by Mr. M. R. Stedman that bricks were made from earth dug near Alethorpe to the south of the road leading to Fakenham, and were used in the construction of the farm house. Brick-earth was also dug in places on Fakenham Heath by the Victoria Tavern; and bricks have also been made from loam overlying Boulder Clay east of the railway-bridge south of Fakenham Fields. South-west of Langor Bridge, brown and mottled brickearth and buff sand were exposed in the railway cuttings.

Hempton.—At the north-western corner of the brickyard a pit showed 4 feet of stony loam with nests of sand and of chalky clay; further south this was seen to rest on a mass of clay like Chalky Boulder Clay.

Gately.—North east of the church blue and brown brickearth was exposed in the banks of the stream, it may perhaps have been derived from the chalky clay.

West Rainham.—A brickyard between West Rainham and Helhoughton showed 4 to 5 feet of irregular brown clay with flints resting on Chalky Boulder Clay. The chalk stones are here ground up with the clay by means of rollers.

Whissonset.—A section at the brickyard at Whissonset showed—

	Feet.
Sand and gravel.	
Irregular dark grey clay	1 to 2
Clean greenish-grey clay	5 to 6

Horningtoft.—West of Manor Farm, Horningtoft, brickearth was formerly dug.

North Elmham.— South of Broom Green an opening by a gravel-pit was dug to brickearth, and bricks were formerly made.

Guist.—The kiln near Wratnell Cover showed on the western side of the pit the following section:—

	Feet.
Sandy loam with chips and pebbles of flint	3 to 4
Irregular grey clay	2 to 3
Chalky Boulder Clay.	

The Boulder Clay seems to weather into a gravelly soil.

At the northern end of the pit the beds exposed were:—

	Feet.
Grey clay and sand.	
Bedded sand and gravel, very irregular and uncertain	3
Brown stony loam with nests of sand (base not reached)	10

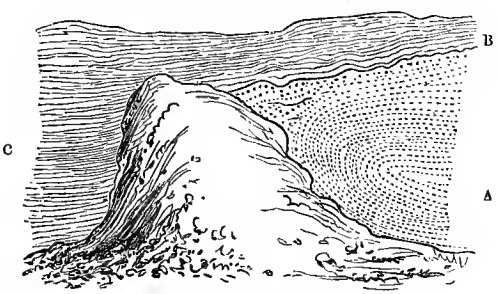
An adjoining pit showed contorted sand and brickearth.

Twyford.—Brickearth was formerly dug in the orchard of Littlemoor Farm.

Foulsham.—The brickyard on the north of the town showed about 20 feet of brown sandy loam, passing down into stiff clay with chalky clay at the base. The beds were capped with a gravelly and clayey soil, and on the occasion of a visit with Mr. Whitaker in 1882, an included mass of rough flint-gravel and sand was exposed.

Stibbard, Guist.—On Stibbard Common is a pit which showed on one side 14 feet of brickearth, and on the other about 4 feet of contorted brickearth, resting on 10 feet of contorted sand. (*See* fig. 8.)

Fig. 8.—*Pit on Stibbard Common, Guist.*



c. Brickearth, 12 to 14 feet.
b. Contorted brickearth.
a. Contorted sand, 10 feet.

A lane by a wood, a quarter of a mile south of Guist Hall, was excavated in brown loam.

On the high road between Langor Bridge and Stibbard, brickearth was to be seen interbedded with the chalky clay, resembling Chalky Boulder Clay. At the kiln between Little Ryburgh and Stibbard, loam, sand, and marl were exposed.

On the northern side of the stream a little more than half a mile north-west of Stibbard church, good brickearth has been dug at the Fulmodeston

Brick-kilns. Here corrugated tiles, pantiles and pavements, drain-pipes, and fancy ware are manufactured.

Hindolvestone.—A brickyard between Raw Hall and Church House showed 6 feet of brown and grey loam and clay, and buff sand, the whole contorted, and evidently belonging to the Contorted Drift.

Loam was exposed in a pit at Ashcroft.

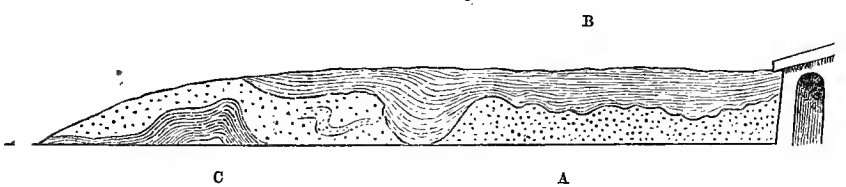
Reepham.—A lane near Reepham Station (Great Eastern Railway) showed 10 feet of loam and sand interstratified, the former mostly on top. (*See* p. 30.)

The brickyard east of Haw Wood showed on top traces of Chalky Boulder Clay, and beneath alternations of loam and sand. In one part of the pit there was 8 feet of brown stony loam with nests of ochreous gravel. In another part of the pit the section was as follows:—

	Feet.
Brown clay with flints and pockets of gravel - - -	3
Loam with nests of sand - - - -	9
Sand with scattered pebbles.	

The cutting north of Haw Wood Brickyard, on the Great Eastern Railway, showed brown and blue clay and loam, (B) resting irregularly on buff sand, (A) contorted in places, with contorted brown loam and chalky clay at the base (C). (*See* Fig. 9.)

Fig. 9.—*Cutting north of Haw Wood Brickyard, Great Eastern Railway.*



Cawston.—By Eastgate the brickyard showed—

	Feet.
False-bedded buff sand and fine gravel - - -	3 to 5
Brown stony loam - - - - - -	7

The surface of the loam was irregular and apparently eroded.

Brickearth has also been worked north-west of Southgate.

Sall.—A brickyard west of Newell Wood showed 5 or 6 feet of sand and gravel resting on the same thickness of brown stony loam. At Sall Barn loam has also been dug; their boundaries with the marl, which replaces them, is indefinite.

Irmingland.—West of Oulton Hall a pit showed 6 feet of brown loam with flints, which had been worked as brickearth.

Saxthorpe.—About half a mile south-east of the church, bricks have been made, and the pit showed 5 feet of brown stony loam.

Gravel and Sand.

General Remarks.

The gravel is composed most largely of flint in the shape of sub-angular stones, pebbles, and large masses or boulders. Quartz, quartzite, and hard sandstones are not uncommon; and chalk stones or grains are often present both in the gravel and sand. Trimmer mentioned also Red Chalk, ferruginous sandstones

porphyries, &c.* At Shereford railway-bridge the gravel contained a large ice-scratched boulder of (greywether ?) sandstone, in size 2 ft. by 8 in. by 9 in.

Much of the gravel in the area, especially that resting on the Boulder Clay, is a coarse "cannon-shot" gravel, with large masses of flint, much rolled. As a rule the gravel and sand rest on the Boulder Clay, but here and there near Wells, Walsingham, Fakenham, Foulsham, and other places, sand and gravel underlie or are intercalated with Boulder Clay. (*See* Figs. 3, 5, 6.)

In the area of Quarter-Sheet 68 S.W. an effort has been made to distinguish some of the newer Glacial gravels, which may be grouped with the coarse gravels overlying the Chalky Boulder Clay in the country around Dereham to the south. Such deposits occur at Elmham Heath, Ryburgh Plantation, Whissonset, Toft Trees, Hempton, and Tatterford. But over the greater part of the area under consideration, there is no evidence to warrant us to make any divisions in the gravels and sands, owing to their irregular mode of occurrence. Locally they do appear at various horizons in the Glacial Series, but the difficulty in distinguishing the Upper and Lower Boulder Clays prevents any definite grouping with the Middle Glacial, of the sands and gravels that overlie the widespread deposit of Boulder Clay.†

The thickness of the gravel and sand is very variable and seldom as much as 25 feet; but in the neighbourhood of Holt and Weybourn the beds in places attain a thickness of 40 feet or more. (*See* p. 52.)

The gravel and sand are sometimes cemented into a hard conglomerate and iron-sandstone, as near Thorpland, at Hindolvestone, at Horningtoft, &c.; and there is a large block of conglomerate in Hindringham village. Such masses are sometimes used for horse blocks.

Gravel pits are sometimes spoken of as "Stone Pits," especially where Boulder Gravel has been dug, and the material used for the purposes of building or paving. At Wiveton and Cley the walls are built of flint-boulders mixed with occasional ends of brick. At Whissonset and Toft Trees houses have been erected of the same material. The Rev. A. R. Abbott believes that certain pits near Weybourn are remains of early British workings for the oxide of iron in the gravel; he has obtained from them some large lumps of iron silicate or slag.‡

Some of the gravel hills and ridges assume the form of Eskers or Kames. These are "ridges and mounds of gravel and sand which owe their existence, and in the main their shape, to their having been heaped up by the action of water in the positions in which they are now seen."§

* On the Detrital Deposits of part of Norfolk, between Lynn and Wells. Proc. Geol. Soc., vol. iii., p. 185.

† The same difficulty was experienced in the Norwich area (*see* Quarter-Sheets, 66 N.E. and S.E.), so that all the Glacial gravels and sands are coloured pink on the maps.

‡ Mid. Nat., Vol. VI. p. 102.

§ *See* paper by T. V. Holmes, Geol. Mag., Dec. II., vol. x., p. 438.

It was not until the autumn of 1881, while engaged in mapping the country between Wells and Cley, that I came across many of these singular gravel hills, and especially the gravel ridge that forms the Blakeney Downs, a ridge that looks in places like a great railway embankment, running in a serpentine course for about two miles. (*See* Fig. 10.) In the same neighbourhood are many little hills of gravel, standing out in the midst of ploughed fields; and being uncultivated, and covered with gorse and broom, they form striking objects. I was at first much puzzled in trying to account for them; but having had the advantage a short time previously of seeing some Esker ridges in Cumberland, under the guidance of Mr. T. V. Holmes, the possibility of there being Eskers in Norfolk dawned upon me. About the same time, if not beforehand, Mr. Whitaker arrived at a similar conclusion in reference to some gravel hills near Great Massingham. These views have since received the support of Mr. Holmes.

Near Blakeney the Eskers rest on the Lower Glacial Drift, they have most probably been derived from the sandy and gravelly accumulations grouped as Middle Glacial by Mr. Wood; and they may be newer than the Upper Glacial Chalky Boulder Clay. They appear to be the last relics of the "Great Ice Age" in the district, and to have been formed by the floods and torrents that attended its passing away.

FIG. 10.—*Esker Ridges near Blakeney.*

Scale, an inch to a mile.*

The method of formation of some of the gravels has been thus described by Mr. S. V. Wood. After referring to the melting of the land-ice that occupied portions of East Anglia, he remarks:—"It is to the currents of water thus poured from this mass of ice, after the shrinkage began, that I attribute those extensive beds of gravel which have been described by Mr. Harmer and myself under the name of "Cannon-shot," the principal extension of which is in the west of Sheet 66. Here, for the most part, they consist of thick beds of flints rolled into the shape and dimensions of the now obsolete cannon-shot of from 12 to 32 lbs. calibre, and even larger; and we attributed their origin to some local modification of the Chalky Clay formation by powerful currents, for we sometimes found imbedded in the gravels heaps of sand formed almost wholly of chalk grains."†

* This wood-cut is printed from a block kindly lent by Dr. H. Woodward.

† Quart. Journ. Geol. Soc., vol. xxxvi., p. 500. *See also* Wood and Harmer Supp. to Crag Mollusca, p. xxvii.

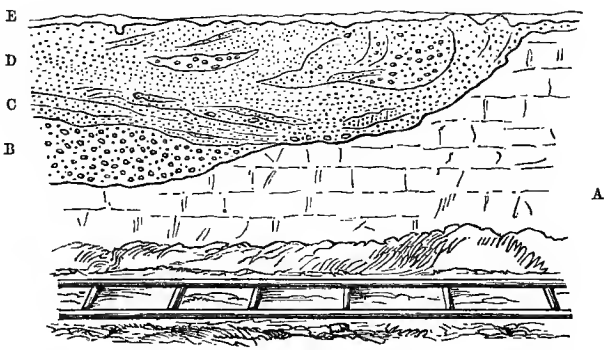
Local Details.

Holkham.—South-east of the railway station a pit showed 8 feet of buff and brown sand. West of Lucas Hill Lodge a sand pit was opened.

Burnham.—Three-quarters of a mile west of the Holkham Triumphal Arch there is an Esker-like gravel hill showing a section of sub-angular flint gravel, with many large masses of flint and quartzite. Mr. Wood regards the gravel in this neighbourhood as Middle Glacial.*

Wells.—The town is situated on an outlier of gravel of variable thickness and composition. In the railway-cutting to the west of the town the following section was to be seen :—

Fig. 11.—*Railway-Cutting west of Wells.*



E.	Gravel and chalk rubble, piped in places	
D.	White sandy marl, with beds of gravel and sand	15 to 20 feet.
C.	Chalky sand	
B.	Boulder gravel, made up of chalk and flint.	
A.	Chalk	

This section was originally figured by the Rev. O Fisher. [*See* p. 22.]

In a gravel pit adjoining this cutting on the north-east side, I obtained fragments of *Cardium*; and also *Inoceramus*, *Ostrea*, and *Belemnitella* derived from the chalk. The main mass of the gravel, of which 15 feet was exposed, consisted of very chalky boulder gravel, so full of chalk as to present a white appearance; in the upper part there was much false bedded chalky sand, and patches of white clay: the overlying deposit was a brown boulder gravel, made up mostly of flint. This rested on a piped surface of the chalky beds, and was evidently the weathered portion of similar gravel and sand from which the chalk had been dissolved. Chalk with a few layers of flint-nodules and tabular flint was exposed at the base of the pit.

In the loop-line connecting the Wells and Hunstanton line with the Wells and Fakenham line, just south-east of the railway station at Wells, I was informed by Mr. H. R. Rump that a tusk, about 4 feet in length, of *Elephas primigenius* had been obtained from the base of the gravel, as well as several teeth, some of which are preserved in his collection.†

Mr. Rump and Mr. F. Long also informed me that a very large Palæolithic implement had been obtained when the cutting was made, and had been in the collection of Mr. Garwood of Wells. Mr. Rump remembered seeing it in this collection. Unfortunately I could obtain no further information respecting this specimen, and it was not to be found in the collection, which is now in the possession of Miss Elizabeth Garwood of the Butt lands.

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* Quart. Journ. Geol. Soc., vol. xxii., p. 552.

† Mr. Rump has kindly presented specimens to the Museum at Jermyn Street.

Mr. Rump informed me that teeth of the Mammoth had been dredged up in Wells Harbour; and one specimen, in the possession of Major H. W. Feilden, was obtained from a sandbank in Holkham Bay.

Remains of this elephant were also obtained at Stiffkey during excavations for a cellar in the western part of the village.

Warham St. Mary.—East of the church a pit showed 6 feet of brown sand with gravelly seams.

Warham All Saints.—South-east of the Field barn, N.W. of the village, a pit showed 6 feet of angular flint-gravel with much chalk, really a white chalky gravel, "piped" with brown gravel and sand.

Stiffkey.—A pit by the Salt marshes south-east of Stiffkey Greens, showed 10 feet of flint-shingle with a few sub-angular flints, pebbles of quartz, quartzite, jasper, and beds of sand.

South of Stiffkey Mill a large pit on the wooded slope, showed gravel resting on Marl, and this again rested on Chalk with flints. The face of the pit was much obscured by talus. A pit in the eastern part of this outlier showed buff sand with chalk grains and boulders of chalk, flint, and other stones.

At Stiffkey sluices the hill to the east is composed of shingle, not unlike some beds seen on Blakeney Downs, though the pebbles are for the most part smaller. The deposit itself may from its position be Recent Marine.

The plantation south of Stiffkey Church stands on brown chalky sand.

Binham.—North-east of the village, a large pit showed about 20 feet of marl, sand, and gravel abutting against marl. At one part of the pit the section was as follows:—

Marl.
Chalky gravel with seams of sand and marl or fine chalk-drift.
False-bedded chalky sand, 1 to 3 feet.
Chalky gravel with boulders and pebbles of chalk and flint.

Field Dalling.—North-east of the village is a pit in marl and fine chalky sand and gravel, with a few flint stones.

Langham.—North of the village a pit showed 14 feet of white false-bedded chalky sand, with carbonaceous grains, covered with a white marly soil.

South of the *y* of *Bilsey Hill* (on the map) is a pit that showed 25 feet or more of cannon-shot gravel, with included beds of grey and brown clay, reminding me of the beds at Strumpshaw.

Saxlingham.—Coarse gravel occurs at the Barrow, east of Saxlingham Field.

Blakeney, Morston.—In this neighbourhood are many hills of gravel, seemingly with very little sand. They rise abruptly from the level tracts of marl, and are often conspicuously covered with broom, bracken, and gorse, in marked contrast to the cultivated land around, often in the same field. Where bare, the hills seem densely packed with stones.

In many places the marl is covered with a gravelly soil, such patches occur between Cockthorpe Common and Love Lane. At Galleyhill Plantation the gravel is chalky.

East of Blakeney Manor House a pit showed about 30 feet of buff sand capped by and interbedded with angular gravel. The whole of this might be Recent Marine. [*See* p. 35.]

At the Howe pits marl was shown with patches of pebbly gravel on top.

West of the southern downs of Blakeney, a pit showed about 20 feet of gravel of variable nature: in places mostly flint-shingle, it passed from fine gravel to boulder gravel with large boulders of flint, and pebbles of white grit and quartzite; in other places false-bedded sand was to be seen. In one part of the pit the gravel occurred mostly on top, the sand beneath, and white marl occurred at the base. By the New Barn cannon-shot gravel was exposed.

At the middle Downs a pit showed gravel and marl in abrupt juxtaposition, reminding me of the pit at Sheets Hill (Quarter-Sheet 66 S.E.). At the northern Downs boulder gravel was exposed.

East of the Stiffkey stream there are beds of pebble-gravel, whose upper surface shows the stones in many cases with their longer axes vertical.

Young observed that "at Morston, near the sea, there is some land so covered with stones as to appear to the eye to contain little besides; but excellent for corn."* This description well applies to the Eskor-like hills before-mentioned. [*See* p. 35.]

Glandford.—At the Mill a pit showed stratified boulder gravel, and sand with bands of laminated clay and sand. (*See* p. 13.)

Where the roads meet, south of Glandford Church, there is a pit showing 20 feet of cannon-shot gravel and sand, and fine gravel. The rude bedding or false-bedding has an inclination westwards. To the west of this a marl-pit showed 15 to 20 feet of marl resting on white and buff sand, exposed to a depth of 8 feet.

In describing the Glaven valley, Messrs. Wood and Harmer have expressed their opinion that the gravels and sands which crown the bordering heights, and sweep boldly down into the valley, belong to their "Middle Glacial" group; and they consider that, as the Contorted Drift occurs in places high up on the slopes and near the tops of the hills, there was considerable interglacial erosion of the area. At the same time they admit that the valleys have been deepened in Post-Glacial times.† This feature of the occurrence of gravel and sand in the valleys may be compared with the great basin-shaped contortions in the Contorted Drift, on the Cromer coast, shown in Mr. Reid's section; and there seems no reason to doubt that the same kind of contortions has led to the position of some of the gravels and sands in this area. In other cases these beds have been re-deposited in the form of Eskers.

Holt.—The railway-cuttings in Common Hill show brown and white sand and gravel, mostly with coarse gravel on top. Between the two Lime-kilns and Common Hill, the section showed fine buff sand, like blown sand, with here and there clayey seams, and ferruginous layers.

Between Telegraph Hill and Edgefield Hall a pit by the roadside showed 9 feet of buff sand; two or three chains to the east was a gravel and sand pit.

The following notes are by Mr. C. Reid:—

A gravel pit east of Holt showed—

	Feet.
Coarse flint gravel - - - - - -	15
Sandy gravel and sand - - - - - -	8

Another pit at Holt Mill showed—

	Feet.
Bedded sandy gravel - - - - -	8
Bedded marl and sand, in places a little contorted -	10

At the north-west corner of Holt Wood a pit showed marl dovetailing into boulder gravel. South-west of the windmill the ground is known as the "Horn pits."

Weybourn.—On the Heath the thickness of the gravel appears to be about 35 or 40 feet. West of the *W* of *Weybourn Heath* (on the map), in the road cutting, the following beds were exposed:—

	Feet.
Bedded sand and gravel, the upper part coarse - -	25
Loam and marl - - - - - -	5

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* Agriculture of Norfolk, p. 11.

† Quart. Journ. Geol. Soc., vol. xxxiii., p. 90, and Section XI. Mr. Wood has published sections showing "Middle Glacial" Sands at Saxlingham, Salthouse, Weybourn, and Kelling Heaths, resting on the "Lower Glacial" Marl in the Glaven Valley, *Ibid.*, vol. xxii., pp. 549, 552.

The beds appeared to dip into the hill.

Bodham.—The old pit north of Bodham Street appears to have been in gravel, but is now entirely overgrown. The pit a few yards to the north-east shows gravel, perhaps mixed with loam.

C. Reid.

Baconsthorpe.—A sand-pit between the village and Lower House, showed gravelly veins at a high inclination.

Hempstead.—At Gravel Pit Hill by the pool, a pit showed 18 feet of boulder gravel resting on buff sand, about 3 feet of which was shown. In the pit was a boulder of sandstone, measuring 1 ft. 6 ins. by 1 ft. by 1 ft. Immediately south of the first *e* of Hempstead Hill (on the map) was an excavation in fine gravelly sand.

Edgefield.—East of the Dale a pit was opened in fine gravel and sand. Boulder gravel and buff sand occur on the heath.

Barningham.—Gravel has been worked at the bottom of the valley at Barningham Green; this is, perhaps, washed down from the higher grounds.

Corpusty.—South of the Common the cutting on the railway showed stratified buff and brown sand and gravel. South of Pee Wit Farm the cutting showed coarse boulder gravel and sand interstratified.

On the Eastern and Midlands Railway, north of Barge Tubs, Brinton, a patch of rough gravel and sand is exposed; on the east it is from 6 to 8 feet in thickness, it tapers away on the west. On the high road south of Thornage the foundations for the railway bridge showed 8 feet of streaky marl, capped by brown clay, loam, and sand from 4 to 6 feet in thickness.

Egmere.—A pit east of Bunker's Hill showed 10 feet of coarse tumultuous gravel and sand.

Creake.—Over much of Creake parish the soil is gravelly but not always of sufficient thickness to be mapped.

West of Gravers Creak Common is a pit in fine buff mealy sand, with very fine and sometimes wavy laminæ in places, altogether from 12 to 15 feet in thickness. This was capped by an irregular brown stony clay, with traces of marl.

Quarles.—By the wood south-east of the Triumphal Arch was a pit showing chalky clay with a boss of fine buff sand underlying it and coming almost to the surface.

West Barsham.—South-east of the Old Hall is a pit showing 8 feet of rough flint gravel.

The cutting on the Great Eastern Railway S.E. of East Barsham, shows coarse gravel on boulder clay and sand. South of the Tunnel the section was boulder clay, sand, and Chalk in descending order. Further on, towards Walsingham, the same series was shown, the intermediate bed being thin pebbly gravel. South of Walsingham Station are cuttings of chalky sand, and ochreous sand and gravel.

Sculthorpe.—Gravel was passed through in a well at Cranmer Hall, as I was informed by Sir Willoughby Jones.

Dunton.—A pit south-east of the last *n* of *Dunton field* (on the map) showed gravel and sand resting on Chalk with intervening traces of chalky clay. At Dunton patch a pit showed from 8 to 10 feet of chalky sand of a brown colour on top.

Tatterford.—North-east of Tatterford coarse gravel rests on the chalky clay.

Shereford.—North of the church a coarse, rough, flint-gravel was exposed containing patches of chalky clay. I was at first disposed to group part of this with the valley gravel. By the cross-roads, south of Shereford field, is a pit showing flint gravel with many large flints, large boulders of chalk and flint pebbles.

North of Shereford Church, coarse flint gravel, with patches of clay and chalky clay, were exposed. The beds probably rest directly on the Chalk.

Fakenham.—West of Pensthorpe a cutting on the Eastern and Midlands Railway showed sand and coarse gravel, very much false-bedded: in one place sand, in another gravel, and in places interblended, the deposits presented an aspect rather like the pebbly gravels of the Crag Series.

To the west of this is a deep cutting in gravelly sand, and pockets of chalky clay rest here and there on the gravel on the borders of the Alluvium.

North-east of Waterhall is a pit showing 10 feet of brown sand, with seams of brown clay near the top, and beds of fine quartzose gravel.

At Thorpland Hall and near Thorpland farmsand and gravelly sand have been dug. [*See* p. 34.]

On Hempton Common is a pit showing—

Coarse gravel made up chiefly of flint boulders Chalky boulder clay with flints (impersistent) Chalky sand.	25 to 30 feet.

Brown irony and white false-bedded chalky sands, "piped," were shown to a depth of 15 feet, south-east of the Abbey Farm. The beds were "faulted" in places as if let down by subsidence.

Similar chalky sand occurs at the base of the coarse gravel north of Toft Farm, Toft Trees.

At the large gravel pit on Hempton Common, material for road-mending has been obtained for many years. The stone is also used for building walls and cottages. Many fossils have been obtained from the flints by Mr. Frank Andrews, of Fakenham. The Rev. James Lee-Warner has a large specimen of *Inoceramus* from the gravel.

Colkirk.—At the Rookery there is 8 or 10 feet of gravelly and sandy soil on the chalky clay.

Pattesley.—South of Pattesley a pit showed coarse gravel and brown sand.

Whissonset, Horningtoft.—In these parishes are several large pits opened up in coarse gravel to a depth of 25 feet, and in places even more.

East of the Rectory at Whissonset a large pit, now overgrown, was strewn with a number of huge blocks of gravel conglomerate, cemented with iron-oxide.

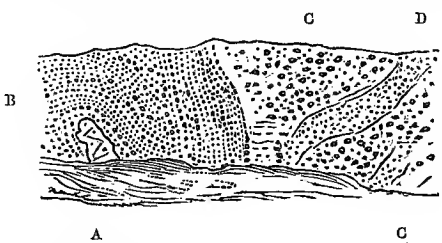
South-east of Horningtoft Wood the soil is gravelly in patches, and in this neighbourhood stones are picked off the fields of Boulder Clay to be used in road-mending.

Gately.—North-east of the church is a pit showing from 2 to 3 feet of coarse flint-gravel.

Walsingham.—East of Edgar Farm a pit showed 8 feet of fine yellow and brown sand.

Hindringham.—The pits marked on the map north-west of Godfreys exposed sand and marl and chalky gravel. The accompanying section showed 7 feet of very disturbed beds of gravel, containing boulders of flint and quartzite:—

FIG. 12.—*Pit by valley south-west of Field House, Hindringham.*



A. Marl.
B. Sand and gravel, vertical in places.
C. Coarse gravel.
D. Sand.

South of the Lower Green a small gravelly patch occurs in a field between two marl pits. By the church are traces of gravel and mealy sand resting on the chalky clay.

Bale.—The following section was shown in a pit west of the village:—

	Feet.
Sand and angular gravel - - - - -	3
White marl with flints - - - - -	3 to 5
Gravel with many boulders of flint - - - -	6

Gunthorpe.—At Bullfair Grove is a pit showing boulder gravel resting on marl.

Thursford.—By the cross-roads north of the church is a large marl pit, disused, showing marl capped by 15 to 20 feet of gravel. East of the Hall sand is exposed in a lane-cutting. North of Gibbons Wood a shallow cutting showed coarse gravel and sand resting on loam (?).

Great Snoring.—Boulder gravel has been worked north-west of the rectory. South of the church the soil is gravelly but to no particular depth. Sand has been dug east of Thorpland plantation.

Little Snoring.—At Snoring Field there is a thin and irregular covering of gravel on the chalky clay; the latter supports numerous pools of water.

Kettlestone.—In forty-acre wood are gravelly patches on the marl. North-west of the *K* of *Kettlestone Heath* (on the map) is a pit showing 10 feet of coarse gravel and sand.

Barney.—Greenish-grey and buff sand were exposed by the stream south of Barney Wood.

Swanton Novers.—At the Little Wood sandy patches occur on the clay. In Kennel Wood is a sand-pit, and further south, pits west of the park show gravel and sand.

Fulmodeston.—On Fulmodeston Gorse is a thin irregular gravel, with traces of iron-pan in places. In the Severals there are occasional gravelly and sandy patches. South-west of the Manor Farm is a pit showing 7 feet of buff sand and fine gravel. This appears to belong to a mass rising up from beneath the marl.

Little Ryburgh.—South of Vinegar hill a gravel pit showed from 5 to 6 feet of coarse irregular flint gravel, with some large blocks of micaceous sandstone. By the railway, west of Ryburgh Mill, is a pit in coarse gravel. This gravel is washed over the chalky clay in the valley to the north.

Stibbard.—North and west of the Heath Farm are pits in coarse boulder gravel and sand, opened to a depth of 10 feet.

North Elmham.—South-west of Broom Green a gravel pit showed 8 feet of coarse flint gravel, the stones in which appeared mostly to have their longer axes vertical.

South-east of Heath House other pits have been opened, and from one of them I was informed that "stone" had been sent to Norwich for paving.

In the Great Eastern Railway-cutting north-west of the bridge at Dunham Hill, the gravel is much contorted. It comprises buff and brown sand and gravel, and white chalky sand, with masses of ironstone conglomerate (gravel cemented by iron-oxide). The chalky sand is like that to be seen on Hempton Common. S-shaped contortions affect the beds, and a mass of marl occurs in them, reminding one of the Contorted Drift near Sherringham and Cromer. Further south the cutting showed gravel and sand, resting on an irregular surface of marl. (*See* p. 14.)

Hindolvestone.—On the Common and at Roundabout, gravelly and sandy patches rest on the clay in a very irregular manner. Stones are sometimes picked off the fields for road-mending. In the village the soil is a thin and irregular gravel with traces of "pan" resting on clay.

South of the Severals Farm, a gravel pit showed 15 feet of coarse gravel and sand containing flint-boulders.

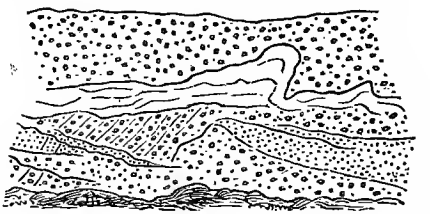
At the railway station, Hindolvestone, buff sand with gravelly seams was exposed beneath a brown gravelly soil.

Wood Norton.—A thin irregular patch of gravel occurs on Holver Hill; and here and there irregular patches of sand are met with. Sand was exposed in a pit by the rectory, and this probably extends into the Great Wood.

Thornage.—Gravel occurs here at various levels, and is of all kinds, coarse and fine. North-east of the Brake a pit showed 15 to 18 feet of coarse

gravel and buff sand. South of the wood east of Honeybeck House, sand was opened up in a pit. The following section shows the extremely irregular nature of the beds, which were exposed to a depth of 8 feet:—

Fig. 13.—*Pit south of Thornage Common.*



E. Coarse gravel.
D. Loamy beds and streaks of clay.
C. Iron-stained gravel.
B. Buff and whitish sand.
A. Buff gravel.

The beds presented an appearance that reminded me of the Crag Series, and it is probable that, if not actnally represented, much of the gravel may have been derived from this series.

Stody.—South of the church is a pit in gravel, containing rounded flint boulders, rudely bedded with sand.

Hunworth.—By the road-side south of Hunworth Green, coarse boulder gravel, hardened slightly into conglomerate was exposed.

Briningham.—South-west of the church is a large gravel pit, opened in coarse flint gravel to a depth of 15 feet, tumultuously arranged; a boss of marl protrudes into it from below.

Melton Constable.—Near the western entrance to the park is a pit showing 10 feet of coarse flint gravel.

The railway cutting by Bellevue plantation showed the following beds:—

	Feet.
Coarse gravel, clayey in places Buff and brown sand, and chalky sand, in places contorted Marl peeping up in irregular "jambs."	10 to 15

In one place there was a lenticular mass of marl underlaid by gravel.

West of Melton junction the cuttings showed similar beds of sand and gravel resting on marl.

Briston.—To the north of the Common, and west of the Mill, is a sand-pit. By the first *m* of *Common* (on the map) is a pit showing 7 feet of sand and coarse boulder gravel. Pebbly gravel is also exposed in places. On the surface the flints are mostly bleached.

Thurning.—Gravel occurs low down at Crimers (or Craymere) Beck.

Wood Dalling.—East of the Manor Farm is a pit showing 8 feet of fine ochreous gravel with veins of sand. Some of the pebbles were coated with Manganese ore. South-east of Tyby, near the Alluvium, is a pit opened in coarse gravel and sand.

Guestwick.—I was informed that sand had been dug at Guestwick Green; this was probably a nest of sand in the chalky clay of the district.

Foulsham.—A large sand pit at Littlemoor showed about 25 feet of buff sand and loam interbedded. Near the top was a mass of brown loam, like Norwich brickearth (Lower Glacial), and in the middle was another mass of brickearth. During a visit paid in company with Mr. Whitaker he found shell fragments in the lower bed of brickearth.

Heydon.—West of Norwich Road Plantation a pit showed 8 feet of coarse and fine gravel, made up chiefly of flint.

Cawston.—At Blue Stone Hall rough subangular gravel occurs; and at the railway station a fine section of sand containing fragments of shells, and streaks of brown clay was exposed. (*See* Fig. 7, p. 30.)

CHAPTER V.

POST-GLACIAL AND RECENT DEPOSITS.

Blown Sand.

Hillocks or dunes of Blown Sand, locally called Meals,* fringe the coast line at intervals from Holkham to Blakeney. Rising from a few feet to 50 or 60 feet in height, they form picturesque objects when seen from a distance, especially at sunset, their outline being quite mountainous in appearance. Overgrown by the marram grass (*Carex* (*Arundo*) *arenaria*, Linn.) they are in some measure protected, but their form and position have altered considerably from time to time.

In the Blown Sand, east of Wells, I noticed shells of *Pecten*, as well as of *Helix aspersa*, *H. nemoralis*, &c.

The sand is blown over the Alluvium here and there. The general inclination of the sand bedding was westerly near the Lodge.

These Meals are fronted by a "shoal shelf" of sand from Holkham to Blakeney Harbour, forming the Cockle Strands of Stiffkey.

Stiffkey Meals are low and patchy and very thin in the middle. Morston Meals form a low and irregular bank of sand with tufts of marram grass. No sand-hills appear at Agar bank.

Recent Gravel.

There is much difficulty in determining the age of the gravels bordering the Salt Marshes. They may be Recent Marine, they may be Alluvial, or they may be of Glacial Age. Unquestionably the gravel of Blakeney Downs is of Glacial Age and that comes down close upon the Alluvium. At Morston, Stiffkey, and Wells, I could obtain no positive evidence to decide the questions. In fact, the Glacial Gravel may here and there have been disturbed and re-assorted by Alluvial action and again by recent Marine action. (*See* p. 36.)

In a letter dated 1st Dec. 1881, Mr. C. Reid says, "I did not get decisive evidence as to the patch at Cley Chapel, but from the level and the angularity of the stones ploughed up I thought it was more likely to be an old [alluvial] brickearth than Recent Marine; however, I was very doubtful at the time."

On Stiffkey Green there is a chalky gravel formed probably by the sea, which at times comes up to the bank. The rubbly nature of the Chalk by Warham Greens may be due to the influence of the sea.

At the Danish Camp, Holkham, there occurs sand with flint-pebbles and other stones, and at the southern end of the camp, chalky gravel was to be seen at the base of it.

* This is perhaps a word of Icelandic derivation. *See* De Rance, The Superficial Geology of the country adjoining the coasts of South-west Lancashire. 1877, p. 115.

Recent Marine and Alluvial Deposits.

The Salt Marshes consist for the most part of clay or loam of an Alluvial nature. The physical characteristics of the area suggest that this low ground was originally an old river valley, and that the heights which bordered it on the north have been destroyed by the ravages of the sea.

At Holkham Bay "the bottom is clay, and excellent for holding, vessels well found having ridden in it during strong gales."

"Wells Harbour is formed by a salt-water creek. Entering a flat foreshore of shingle and sand it passes between two ridges of sand-hills, and then through the marshes up to the town, having an irregular course nearly three miles in length; it then turns easterly, sending off several branches into the marshes. Many alterations have been made in the channel of late years; dams have been placed across the mouths of the eastern creeks or fleets, to cause the whole force of flood and ebb to pass the quay at Wells, and a straight embankment has been carried from Wells to the western sand-hills for the reclamation of Holkham marshes. This harbour, like that at Blakeney, has been much injured by the embankment of marsh lands."

"The bed of the creek from the bar to the town is dry at low-water, except at the pool, the general berthing place, where the depth is never less than 5 or 6 feet."*

The embanking of the Holkham marshes was commenced in 1659 by John Coke who enclosed 350 acres; subseqently the first Earl of Leicester enclosed about 400 acres.

High tides often flood the salt-marshes east of Wells, and even overflow the quay, as was the case in February 1882.

Mr. J. Rhodes was informed (that men now living had been told) that at Wells, oyster-boats used to be moored near the Railway Station on what is now Alluvium.

West of the Lodge, north-east of Wells, clay and sandy clay were here and there exposed on the foreshore. At the brickyard, east of Wells, Alluvial clay is brought from the marshes opposite (the property of the Earl of Leicester) to be manufactured into bricks.

The estnary of Blakeney is cut out of an Alluvial flat made up of laminated clay and sand.

At Morston meals the foreshore is partly made up of spits of sand and shingle, while the subsoil, as it were, is a greenish-grey sand and clay with rootlets, much eroded, and covered here and there with sand showing ripple-marks, and coarse shingle. The beds very forcibly reminded me of the Pliocene Rootlet Bed and associated strata of the Cromer sections. The local unconformity in some places of the recent marine sand and shingle on the recent alluvium is instructive: while in other places the formation of tidal alluvium is going on in close proximity with the beach sand and shingle, separated by hillocks of Blown Sand. Hence a laminated clay, like the so-called Chillesford Clay, might be formed at the same time, and at the same level, as shingle and sand.

"The entrance to Blakeney Harbour, 12 miles to the westward of Cromer, and S. by W. ¾ W., 16 miles from Dudgeon light-vessel, is well marked by the Hood, a sand-hill one mile to the eastward, remarkable as being higher than any of the sand-hills about it. The harbour is formed by the Ler, a salt-water inlet or creek, which runs in a south-westerly direction for half a mile, and then turns abruptly to the south-eastward. Abreast Blakeney it divides; one branch running to that place, and the other to Cley, where it takes the name of the Glaven.

"The prosperity of Blakeney as well as of Cley has declined of late years, owing to the deterioration of the harbour which followed the en-

* The North Sea Pilot. Part III. 1882, p. 147.

closure of 12,000 acres of marsh lands. Sixty years ago, vessels drawing 9 feet could reach Cley; now, 5 feet is the greatest draught seen there, and the channel is, besides, too narrow to allow of a vessel swinging."*

Blakeney bar is a shifting one; an old chart of Blakeney Harbour, by Capt. G. Collins (date about 1685), shows that 200 years ago the tidal channel flowed across what are now called the Fresh Marshes to Cley, and that the River Glaven consequently flowed out this way to the sea.

Blakeney Beach consists of fine and coarse shingle in irregular shoals or patches: the stones are mostly flint, with also quartz, jasper, carnelian, grits, &c. A large increase of sand and shingle has during the past 9 years (1872–81) been made at Lower Point west of the Signal Station, and this increase is still taking place. Thirty years ago the old mouth of the river ran out by the Beach Way between the *a* and *k* of Blakeney Beach (on the map). The ground above water to the west of this and at Long Hills, is shingle with tufts of blown sand. The Lifeboat House stands on Blown Sand, and the Hood is composed of it. To the east of this, between the Preventive Watch Boat and Skate Nose, spits of sand and shingle are met with in the Alluvium.

The spring tides rise 15 feet at Blakeney bar, 9 feet at Blakeney, and 5½ feet at Cley. During neap tides the rise is 3½ feet less at Blakeney and Cley. The tide comes rapidly up the creeks, and near Stiffkey I noticed that shells of *Scrobicularia* and *Mytilus* were carried some distance along, occasionally subsiding when they came in contact with an obstruction.

Salthouse marshes were drained and embanked in 1851; formerly they were noted as the resort of hundreds of wild fowl in the "hard weather."

Mr. Reid remarks that "at Weybourn the Chalk cliffs are protected by a shingle beach about seventy yards in width, which only allows the cliff to be touched by very exceptional tides. Since I have known the coast very little has been lost here."† This beach presents some features in common with the Chesil Bank, but without the gradual variation in the size of the beach pebbles.

Alluvium and River Gravel.

The ordinary river Alluvium presents no very remarkable features.

At the "Alder Car," north of Wighton, the soil is gravelly; but this may have been partly brought here for the sake of fir trees lately introduced. East of Warham St. Mary Church the Alluvium is made up of gravel.

South-west of Whey Curd Farm peat has been dug. Peat was also dug at Cley, and used in burning the Chalk for lime.‡ A portion of the skull of a horse was obtained from the Alluvium near Stiffkey, by Mr. H. R. Rump.

North of Godfreys, Hindringham, the banks of the stream show a thin gravel resting on Chalky Boulder Clay; a similar thin stratum is found in the valley west of Saxlingham Field.

North-east of Irmingland Hall the gravel shown in the pit by the plantation may be valley gravel.

Between Melton Constable and Briston a thin alluvial gravel occurs on clay, having an irregular boundary. At Gunthorpe there is a small Turf-moor. In the bottom of the valley at Barningham Heath gravel and peat occur, the former is mostly bleached.

West of Tyby, near Wood Dalling Hall a gravel-pit, has been opened on the borders of the alluvial ground. The pit exposed 4 feet of gravel and white sand, with many pebbles of quartz as well as flint and grit. If Alluvial this gravel was almost directly derived from Glacial beds in the vicinity. (*See* p. 47.)

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* North Sea Pilot. Part III. 1882, pp. 143, 144.

† Geology of the Country around Cromer, p. 128.

‡ Kent, Agriculture of Norfolk, p. 216.

There is valley-gravel at Doughton, near Dunton, Sculthorpe, Hempton, Broom Green, and Guist. In one place south of the water-mill at Hempton the gravel is cemented into a conglomerate.

At Pudding Norton Plantation some of the Glacial gravel may have been re-deposited as valley-gravel, but there was not sufficient evidence to distinguish this on the Map.

Floods.

The floods which attained such serious proportions at Norwich in 1878, also affected the higher portions of the Wensum and other valleys in the area under consideration.

At Great Thornage, the stream which crosses the road near the common, and which is spanned by a bridge, on part of which a house is built, was greatly swollen by the rain. About half-past 8 o'clock the pent-up waters of the stream burst up the arch under the house, and during the night the whole of the back part of it fell down.

At Letheringsett the Glaven overflowed its banks, and the meadows were flooded.

Walsingham and the district suffered considerably. During the week the rivulet, which runs through this town and empties itself into the sea at Stiffkey (hence frequently called the Stiffkey River), had swollen to a rapid torrent, and overflowing its banks had converted the meadows into lakes of no small dimensions. From Barsham to the sea all the parishes suffered; but Walsingham was the most unfortunate, as some of the houses in Church Street were inundated to a depth of 3 or 4 feet.

At Fakenham the waters rose so furiously on Saturday, November 16th, as to seriously threaten the safety of the Hempton Mill, while at the Fakenham Mill very grave results were anticipated. Notwithstanding every possible precaution taken, the waters quickly poured through the mill and the adjoining residence of the miller with a depth and a rush of a most alarming character. From the engine-house away up to Hempton Grove the waters poured in a strong current over the embankment. The public way was soon filled to the depth of from 2 to 3 feet in some parts, and all foot traffic with Hempton was now completely arrested this way, as it had already previously been for some days by the Hempton Mill. The back water-course quickly overflowed, filling the Mill lane to a considerable depth, and the brick wall enclosing the north side of the pool in from the mill was seen to be in danger, and finally several yards of it gave way and fell into the pool. Very grave fears were entertained for the safety of the high bridge which crosses the main road at this spot. At the same time many tons of water were pouring with irresistible force through the mill and the house adjoining, and it quickly became evident that some additional means must be used to relieve the surcharged river, or the mill itself would be very seriously endangered. A number of hands were therefore set to cut a channel across the broad footway leading to Hempton, and forming the embankment of the river, from the engine-house to the meadow adjoining Hempton Grove. Soon a channel, about 10 feet wide and from 2 or 3 feet deep, was made. This afforded considerable relief. During the whole of Sunday vast volumes of water continued to pour down through the river, the wide trench cut in the causeway for its relief, and through the mill with its adjoining premises, and the Mill lane.

In some of the cottages in Holl Staithe the water had reached a depth of 2 or 3 feet.

The accumulation of water in the neighbourhood of Ryburgh mill was very great.*

* These Notes are taken from the East Anglian Handbook for 1879.

CHAPTER VI.

MISCELLANEOUS.

Springs.

Iron-stained waters are very common in the district, issuing from the ferruginous Glacial and Alluvial sands and gravels. A spring of this nature is met with north-east of Guist Bridge, one issues from the lower end of Rainham Lake, there is another at Holkham, and one south-west of Skitfield, Guestwick, running from the east into the main stream. The gravel by the Alluvium near Skitfield is stained red, and there are deposits of bog iron ore in the ditches. Such springs seem generally to flow out where there is valley gravel.

Of springs whose virtues are entirely legendary, may be mentioned the "Wishing Wells" situated in the Abbey grounds at Walsingham. They were described by the Rev. H. J. Lee-Warner as being slightly chalybeate.* There are two of these wells situated close together in the Alluvial ground bordering the Stiffkey stream, and whatsoever virtue they possess is probably owned also by the little river which keeps up their supply. In the same enclosure of the Abbey grounds is a larger well, which may have been a baptistery, or a pool for healing the afflicted, or simply a bathing-place for dusty pilgrims; its original purpose has long been lost sight of.

Blomefield mentions that "at Olton (or Oulton) near Aylsham is a fine spring called the Spaw, being a strong *Mineral*, much frequented formerly, before the Spaw at Aylesham had gained its reputation."†

The freshwater springs to which Wells-next-the-Sea owes its name, flow into the tidal creek at the quay, and may be seen at low water running through the piles, or rising out of the mud.

At Holt, Letheringsett, and Hempton there are more or less copious springs. That at Holt rises on the west side of the town, at the junction of marls and brickearths with overlying sandy and gravelly beds, all belonging to the Glacial period. Although frequently spoken of as an "Artesian" water, it simply flows from the surface, through the porous strata, until arrested and thrown out by the marly and clayey beds beneath. It was remarked of this spring (in 1829) that it "affords, in summer and winter, in drought or in wet seasons, an equable stream of very soft and very pure water."‡ (*See* p. 52.)

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* Norf. and Norwich Arch. Soc., vol. iii., part 2, pp. 51–56.
† History of the County of Norfolk, vol. iii. (1769), p. 617.
‡ Chambers, Gen. Hist. of County of Norfolk, vol. ii., p. 775.

The spring at Hempton, which issues from the Glacial sands on the grounds of the Abbey Farm, was analyzed by Mr. F. Sutton, and although bright and palatable, it was found to contain minute quantities of iron (so I was informed by Mr. J. A. Miles), which render it undesirable as a water for drinking.

Mr. Miles drew my attention to the fact he had noticed a difference of temperature between the two streams, sources of the Wensum, which unite to the east of Tatterford Common. In bathing he had found that the one proceeding from Tatterford was decidedly warmer than that which flows from Rainham. This difference is most probably due to the direct influence of the sun's rays, the Tatterford spring being more open and exposed than the other, which flows through the wooded tracts of Whissonset and Rainham.

About 3 furlongs north of Stibbard Church there is a spring known as "Stibbard Spoy," by the stream to the east of the road between Stibbard and Fulmodeston. I was informed by Mr. S. F. Sainty, of the Ordnance Survey, that "people have walked miles to drink it."

Subsidences of the Ground.

Owing to dissolution of the Chalk or Chalky Drift, subsidences of the ground have taken place at various times. But they may be in part due to other causes, as, for instance, in the following case, where subterranean denudation, or removal of sand by springs, may have led to the falling in of small tracts of ground.

In 1718 Mr. P. Le Neve gave "An Account of the Sinking of three Oaks into the Ground at Manington in the County of Norfolk."*

This may refer to some of the large holes in Mossymere Wood. The occurrence took place on Tuesday, July 23rd, 1717, in the grounds of Sir Charles Potts Bart., in the parish of Manington, "in the day time, to the great astonishment of those that were present; first, one single Oak, with the Roots and Ground about it, was seen to subside and sink into the Earth, and not long after, at about 40 yards distance, two other Oaks that were contiguous, sunk after the same manner, into a much larger Pit; being about 33 Foot Diameter, whereas the former is not fully 18. . . . When the first Tree sunk, it was observed, that the Water boyl'd up in the Hole; but upon the sinking of the greater Pit, that Water drain'd off into it, from the former, which now continues dry.

"The depth thereof to the firm Bottom is nine Foot three Inches; . . . In the Bottom of the greater Pit, there is a Pool of Water about 8 Foot Diameter, whose Surface is 11 Foot 3 Inches below the Ground. . . . The soil on which these Trees grew, is Gravelly; but the Bottom is a Quick-sand over a Clay, upon which there are Springs, which feed large Ponds adjoyning to Sir Charles Potts' House, at about a quarter of a Mile from these Holes.

"The Nature of the Soil seems to afford us a reasonable conjecture at the Cause of this odd accident, which some perhaps may be apt to reckon as a Prodigy. The Springs running over the Clay at the bottom of a Bed of very minute Sand, such as your Quicksands usually are, may reasonably be supposed in many Ages to have washt away the Sand, and to have thereby excavated a kind of Subterraneous Lake, over

* Phil. Trans., vol. xxx. (No. 355), pp. 766–768.

which these Trees grew: And the force of the Winds, on their Leaves and Branches, agitating their Roots, may well have loosened the Sand, under them, and occasioned it to fall in, more frequently than elsewhere; whereby in length of time the thin Bed of Gravel being only left, it might become unable to support its own weight and that of the Trees it bore."

I was informed that Mannington Mere arose from a subsidence of the ground which took place in 1704.

The following is an account of other subsidences in the district:—

"At Bristan [Briston], in Norfolk, near the seat of Sir Edward Astley, Bart. the neighbourhood were alarmed by a considerable sinking-in of the earth near the road, on Saturday the 21st of June [1788], in the night; but on the Sunday following, in the evening, a much larger sinking took place in a plough-field adjoining the road, the figure nearly circular, 210 feet in circumference, 60 feet in diameter, and in depth about 27 feet, with an irregular slope; upon examination, another falling-in was discovered about 90 feet in circumference; and all these without any agitation in the air, shock of an earthquake, or the least subterraneous noise. Holes have fallen in since, but none to produce a serious alarm."*

* Gentleman's Magazine, vol. lviii. Part II. July 1788, p. 649. I am indebted to Mr. Whitaker for the reference.

APPENDIX.

WELLS AND WELL-BORINGS.

Colkirk.

In some places reservoirs are dug in the Boulder Clay for water-supply.

Egmere.

Communicated by Mr. Massingham.

		Feet.
[Glacial Drift.]	A little sand - - - - -	60
	Blue marly clay - - - -	

Fakenham.—At Mr. Mansell's, Norwich Street.

		Feet.
[Glacial Drift.]	Clay and sand - - - - -	29
	Chalk, in which water was obtained almost directly.	

Fakenham.—The Heath (1880).

		Feet.
[Glacial Drift.]	Soil and Chalky Boulder Clay - - -	7
	Loam - - - - -	3
	Sand - - - - -	about 40

The wells on the heath vary from 45 to 60 feet in sand and gravel.

Fakenham.—Cemetery Road.

[Glacial Drift.] Sand.
Brickearth. (?)
Well 35 feet deep.

Fakenham.—Sculthorpe Road, new cottages.

		Feet.
[Glacial Drift.]	Boulder Clay - - - - -	40
	Sand - - - - - -	
	Chalk - - - - - -	

Foulsham.—Level-crossing S. of Guestwick Station.

		Feet.
[Glacial Drift.]	Grey Boulder Clay - - -	about 30
	Slate-blue Boulder Clay	
	Water.	

Fulmodeston.

The wells here are about 12 feet in depth.

Great Ryburgh.

Well immediately south of the railway station, commenced in Chalky Boulder Clay, and dug into it for depth of 20 feet.

Great Snoring.—Well north-east of Thorpland Plantation.*

	Feet.
Boulder Clay - - - - - - - -	28
Sand.	

Holkham Hall, 1867.

Communicated to Mr. Whitaker,† by Mr. Shellabear, Agent to the Earl of Leicester.

Thirty feet above mean sea level. Shaft 58 feet, the rest bored. Supply abundant, 540 gallons a minute have been pumped. Overflow of 100 gallons a minute passes off by a pipe 14 feet below the floor, but when this is closed, the water rises to the surface.

		Feet.
Gravel - - - - - - about		20
Chalk, 635 feet	Chalk with flints; the last of three masses of flint, each 3 to 4 feet thick, at a depth of 510 feet - - - -	519
	Chalk without flints - - - -	116
Red marl ["Red chalk"] - - - - -		8
Blue gault, like that in Colman's well, Norwich - -		10
Neocomian, 70 feet	Very hard red sandstone - - -	½
	Sandstone - - - -	14½
	Green sand - - - - -	8
	Sand ? - - - - -	39
	Soft carstone - - - -	3
	Hard carstone - - - -	5
Total, to very tenacious clay [Kimeridge or Neocomian ?] -		743

Another account of this well was published by C. B. Rose (Geol. and Nat. Hist. Repertory, 1869, p. 257).

Commenced Oct. 1864, completed Aug. 1866. First 29 feet dug with diameter of 6 feet, the rest was sunk with a 6 in. bore.

	Feet.
Sharp small gravel and shingle - - - -	27
Chalk rubble - - - - - -	2
Chalk with flints - - - - - - -	510
At this depth, 510 feet, there "occurred two other beds above the bottom one, separated from each other by only 6 inches of chalk, whilst, as is usually the case, the beds of flint recurred at spaces varying from 3 to 6 and 8 feet."	
Chalk without flints (including bed of hard grey chalk) -	145
Red chalk, with varying degrees of colour - - - - -	8
Blue gault - - - - - - - - -	10
Reddish-brown ferruginous sandstone - - - -	8
Dark coloured "carstone" - - - - -	6
Loose sand - - - - - - -	36
Kimeridge clay touched at depth of - - - -	752

* Communicated by the Rev. James Lee-Warner.

† *See* Proc. Norwich Geol. Soc., vol. i., pp. 16–18.

Holt.

At this town the water-supply has been mostly obtained from the spring called "the Spouts" that issues to the south-west of the town at a spot called Spout Hill, at the junction of the glacial sands and gravels with the brickearth and marl beneath. This has been advertised as "the purest water in England," and as an Artesian Well; it is, however, an ordinary land spring. [*See* p. 47.]

From this spring most of the inhabitants of Holt have been supplied, the water being carried to various houses in the town by tub-carts and buckets.

The copiousness of the spring is no doubt due to its receiving the drainage of a considerable tract, although the direction and extent of its numerous sources cannot be determined from any surface evidence. The irregularities and local inclination of the beds might allow the waters that fall on the brow of Kelling Heath on the north, to flow southwards in devious subterranean courses to help to swell the Holt spring. Issuing as the spring does from immediately beneath the town of Holt, it is of course particularly liable to contamination from the leakage of cess-pits, &c. in the town; and this is reported to have been actually the case.

There are few private wells in Holt, but there are two pumps about 50 feet deep which help to supply the houses.

Holt.—Waterworks.

Section of Trial Bore Hole at Spouts Common.

Communicated by E. Easton to W. Whitaker. 1883.

Level 135 ft. 10 in. above datum. Dug 4ft. 5in. The rest bored.

		Ft.	In.	Ft.	In.
	Topsoil and peat	1	6		
[Glacial Drift.]	Beach sand and pebbles	11	0	12	6
	Brown sand	4	0	16	6
	White clay	23	6	40	0
	Light blue marl	21	0	61	0
	Dark blue marl with sand	10	0	71	0
	Sandy clay with very minute stones	16	0	87	0
	Sandy clay with chalk	19	0	106	0
	Soft clayey chalk*	8	9	114	9
	Flints	0	3	115	0
	Chalk.				

Holt.—Well at the Brewhouse.

		Feet.
[Glacial Drift.]	Gravel (sunk)	60
	Marl (bored)	90

Well at the "Lion" Inn.

	Feet.
Sunk	99
Bored in marl ?	49
Water from sand beneath the marl ?	

(C. Reid.)

Melton Constable.—Railway Station.

		Feet.
[Glacial Drift.]	Sand and brickearth with nests of sand Marl	30 or 40

* This may be part of the very chalky Boulder Clay or Marl. (*See* p. 23.)

SCULTHORPE.—Cranmer Hall.

		FEET.
[Glacial Drift.]	Gravel and sand - - - -	22
	Chalk - - - - - -	

THURSFORD.—Between the Railway Station and the "Crawfish" Inn.

		FEET.
[Glacial Drift.]	Sand and brickearth - - - -	10

WALSINGHAM.*

Town well about 50 feet deep.
The wells are mostly about 30 feet deep.
Well at Toll bar, 60 feet deep.
Chalk near to surface.

WELLS.—(Town).

Deepest well 70 feet, other wells 60 feet and less.

WELLS.—Farm south of old toll gate, south-east of Railway Station.*

		FEET.
[Glacial Drift?]	Gravel and sand - - - - -	9
	Chalk - - - - - -	41
		50

WIGHTON.

		FEET.
	Chalk - - - - - - -	20
	(Water.)	

WOOD NORTON.

In seeking for water in the rectory grounds, by means of an Abyssinian tube, the Rev. C. Martin informed me that "In one place we found nothing but clay. In another a blowing sand from 18 to 31 feet," and a small supply of water was then obtained.

* Communicated to Mr. J. Rhodes.

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Lancashire.

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15. Ireleth.	85. Standish, &c.
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48. Colne, Twiston Moor.	92. Bickerstaffe, Skelmersdale.
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55. Whalley.	93. Wigan, Up Holland, &c.
56. Haggate.	94. WestHoughton, Hindley.
57. Winewall.	95. Radcliffe, Peel Swinton,
61. Preston.	96. Middleton, Prestwich.
62. Balderstone, &c.	97. Oldham, &c.
63. Accrington.	100. Knowsley, Rainford, &c.
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2. Gateshead.
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Durham—*continued.*

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