TECHNICAL REPORT WA/88/40

TM 08 NW, NE, 09 SW, SE and parts of
TL 98 NE, 99 SE

Kenninghall, Banham, Attleborough and Old Buckenham

Part of 1:50 000 Sheet 175 (Diss)

S J Mathers

Natural Environment Research Council
BRITISH GEOLOGICAL SURVEY
Geological Survey of England and Wales

TECHNICAL REPORT WA/88/40
Onshore Geology Series

Geological notes and local details for 1:10 000 sheets TM 08 NW, NE, 09 SW, SE and parts of TL 98 NE, 99 SE, Kenninghall, Banham, Attleborough and Old Buckenham.

Part of 1:50 000 sheet 175 (Diss)

S J Mathers

Bibliographic reference

Mathers, S J. 1988.
Geological notes and local details for 1:10 000 sheets TM 08 NW, NE, 09 SW, SE and parts of TL 98 NE, 99 SE, Kenninghall, Banham, Attleborough and Old Buckenham.
Technical Report British Geological Survey WA/88/40.

Author

S J Mathers, BSc
British Geological Survey
Nicker Hill, Keyworth
NOTTINGHAM NG12 5GG

KEYWORTH BRITISH GEOLOGICAL SURVEY 1988

CONTENTS

FIGURES

TABLES

Geological notes and local details for 1:10 000 Sheets TM 08 NW, NE, 09 SW, SE and parts of TL 98 NE, 99 SE (Kenninghall, Banham, Attleborough and Old Buckenham)

Part of 1:50 000 Sheet 175 (Diss)

S J Mathers

1. INTRODUCTION

This report describes the geology of the 1:10 000 sheets TM 08 NW, NE, 09 SW, SE and the easternmost parts of sheets TL 98 NE and 99 SE, all of which lie within the Diss (175) geological map. The area was first surveyed by F J Bennett as part of the Old Series One-Inch Sheets 50 NW and 66 SW (both published in 1884).

The primary 1:10 000 survey of the area was made by S J Mathers, J A Zalasiewicz and A Smith in 1985 under the direction of Dr R G Thurrell as Regional Geologist. Uncoloured dyeline copies of the maps can be obtained from the British Geological Survey (NERC), Keyworth.

The area lies in Norfolk, between Thetford and Norwich, with the town of Attleborough situated on its northern margin. It is predominantly a rural area. In addition to Attleborough, the villages of East Harling, Kenninghall, Banham, Old Buckenham and New Buckenham are the main settlements. The land is largely used for arable farming with wheat, barley and sugar beet as the main crops. The ground in the eastern part of the area forms a broad Boulder Clay plateau generally above 50 m OD. The western parts of the area, however, are dissected by small streams which drain westwards into the River Thet. These western parts generally lie at elevations of 20-40 m OD.

The Upper Chalk underlies the entire district and is exposed on the lower valley sides and in low-lying ground in the south-western parts of the area. In detail its upper surface is very irregular.

Within the area thin Norwich Crag deposits have been tentatively identified from a borehole near New Buckenham; they are not exposed at the surface.

Two compositionally distinct suites of glacial deposits are present. The older suite, the Banham Beds, comprises a lithologically variable sequence of silts, clays, sands, gravels and diamictons (interpreted as tills). These deposits are generally poor in chalk and contain abundant quartz and quartzite pebbles. They are exposed along the flanks of the valleys around Kenninghall and Banham.

The younger suite of deposits is, by contrast, rich in flint and chalk pebbles and comprises an extensive sheet of Till (Boulder Clay) together with water-lain Glacial Sand and Gravel and Glacial Silt and Clay. These deposits are generally regarded as the product of the Lowestoft phase of the Anglian glaciation. The age of the Banham Beds is more problematical; they probably equate with the North Sea Drift (Anglian) but may represent a previously unrecognised pre-Anglian glacial event.

Sediments which post-date the glacial deposits are generally confined to the valleys. They include poorly-sorted clayey and pebbly sands (Head) produced by downslope movement of material. Also sands and gravels which form River Terrace Deposits, and Alluvium and Peat which floor the present valleys. In addition, several isolated Fen depressions occur in the dissected western part of the area. In these several metres of peat, silt and clay have accumulated.

2. GEOLOGICAL SEQUENCE

The geological sequence in the area, together with details of maximum thicknesses and principal lithologies, are shown in Table 1.

3. SOLID FORMATIONS

3.1 CHALK (Middle and Upper)

Chalk is present at outcrop and beneath the Quaternary deposits throughout the entire area. It dips eastwards at about $\frac{1}{2}^{\circ}$. Two deep boreholes (TL 98 NE 3, 99SE 2) in the westernmost part of the area

TABLE 1 GEOLOGICAL SEQUENCE OF THE KENNINGHALL-BANHAM -ATTLEBOROUGH-OLD BUCKENHAM AREA

Geological classification and age				Lithology	Maximum Thickness
DRIFT DEPOSITS	QUATERNARY	Flandrian	Peat	Peat and clayey peat	c 10 m
			Alluvium	Silts and clays, locally humic	3.0 m *
		Devensian/ Wolstonian ?	River Terrace Deposits	Sands and gravels, predominantly flint-rich	9.1 m
			Head	Sandy clays, clayey sands locally pebbly	3.0 m *
		Anglian (Lowestoft Phase)	Glacial Sand and Gravel	Sands and gravels, flint- and chalk-rich	47.2 m
			Till	Diamicton, grey-black clay matrix studded with numerous pebbles dominantly chalk and flint	73.2 m
			Glacial Silt and Clay	Massive and laminated grey silts and clays	12.1 m
		Pre-Early Anglian?	Banham Beds	Laminated and massive silty clays with sporadic pebbles, diamictons, sand and gravel seams, quartz, quartzite pebbles and angular black flint	13.5 m
SOLID FORMATIONS	QUATERNARY	Bramertonian?	Crag	Green sand with pebbles	1.0 m
	CRETACEOUS		Upper Chalk	Fine-grained, white, very pure limestone with courses of black flint nodules	c 200 m
			Middle Chalk		6.7 m+

+ denotes the full thickness of the deposit was not penetrated
* thickness estimated from geological mapping
c circa (approximately)

record the top of the Middle Chalk at depths -89 and -84 m OD respectively. These boreholes were terminated just into the Middle Chalk and only prove a maximum thickness of 6.7 m of grey and white hard chalk with some yellow staining and flint nodules.

Apart from these two records, all the chalk in boreholes and the surface exposures in the south-western part of the area are of Upper Chalk.

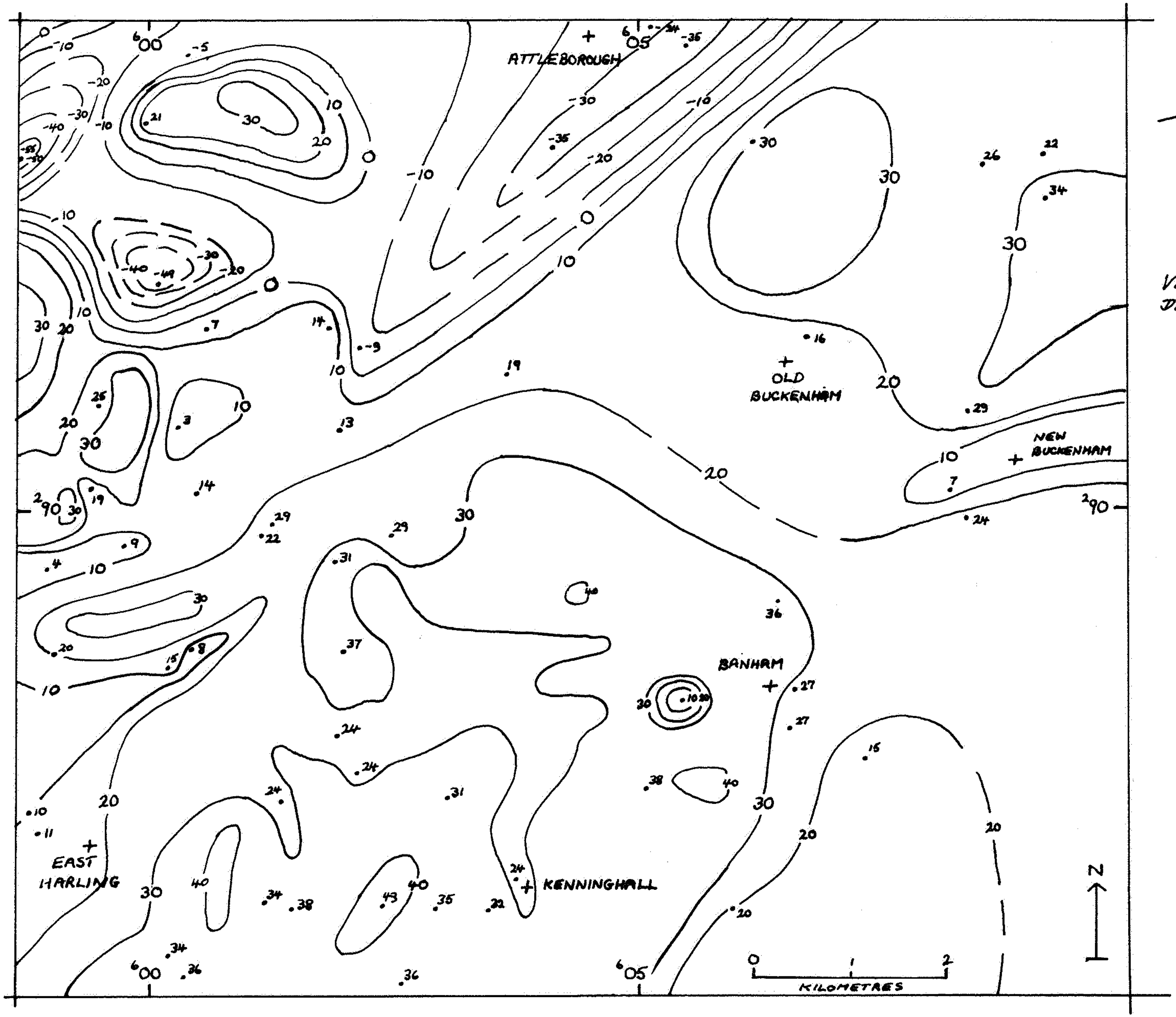
The Upper Chalk comprises up to about 200 m of grey and white, very pure, fine-grained limestones of variable hardness. They contain numerous courses of flint nodules, commonly 100-200 mm in size.

Work on the zonation of the Chalk in Norfolk has been summarised by Peake and Hancock (1970).

Upper Chalk of the *Uintacrinus* Zone (M. Senonian) has been identified on the basis of its fauna from two localities near East Harling at [TM 004 869] and [TM 000 868]. The succeeding *Marsupites* Zone (M. Senonian) has been identified farther east from old chalk pits near Quidenham [TM 021 871] and High Starlings [TM 046 875]. Within the area the Chalk east of a line from Attleborough through Banham belongs to the stratigraphically higher *Gonioteuthis* Zone (M. Senonian).

The Chalk is largely composed of microscopic calcareous plates of coccolithophorid planktonic algae. The thick deposits accumulated over a long period of time on the floor of an extensive tropical sea during the Upper Cretaceous. There is a general absence of terrigenous sediment within the deposit. The numerous flint nodules are thought to have formed diagenetically by remobilisation of biogenic silica principally derived from sponge spicules.

The form of the upper surface of the Chalk is shown in Figure 1. In the northwest several boreholes indicate deep glacially-infilled channels and depressions cut into the Chalk. The exact nature of these forms is difficult to determine due to the limited borehole information. Farther south and east the Chalk surface is more even and generally lies at elevations of 20-40 m OD.



Contour, broken where uncertain

Borehole site

Values in metres above or below Ordnance Datum.

FIG. 1 Contour map of the eroded top surface of the Upper Chalk, derived from boreholes and surface outcrops.

3.2 CRAG

Borehole TM 09 SE 18 [TM 0836 9100], which records 1.0 m of green pebbly sand resting on Upper Chalk beneath Till, provides the only evidence for Crag deposits within the area. The sand is tentatively classified as Norwich Crag on the basis of its colour and lithological similarity to the more extensive Norwich Crag deposits farther to the east. It is a shallow marine sediment. The deposit may belong to the temperate Bramertonian Stage which is recognised in adjoining areas by Funnell, Norton and West (1979).

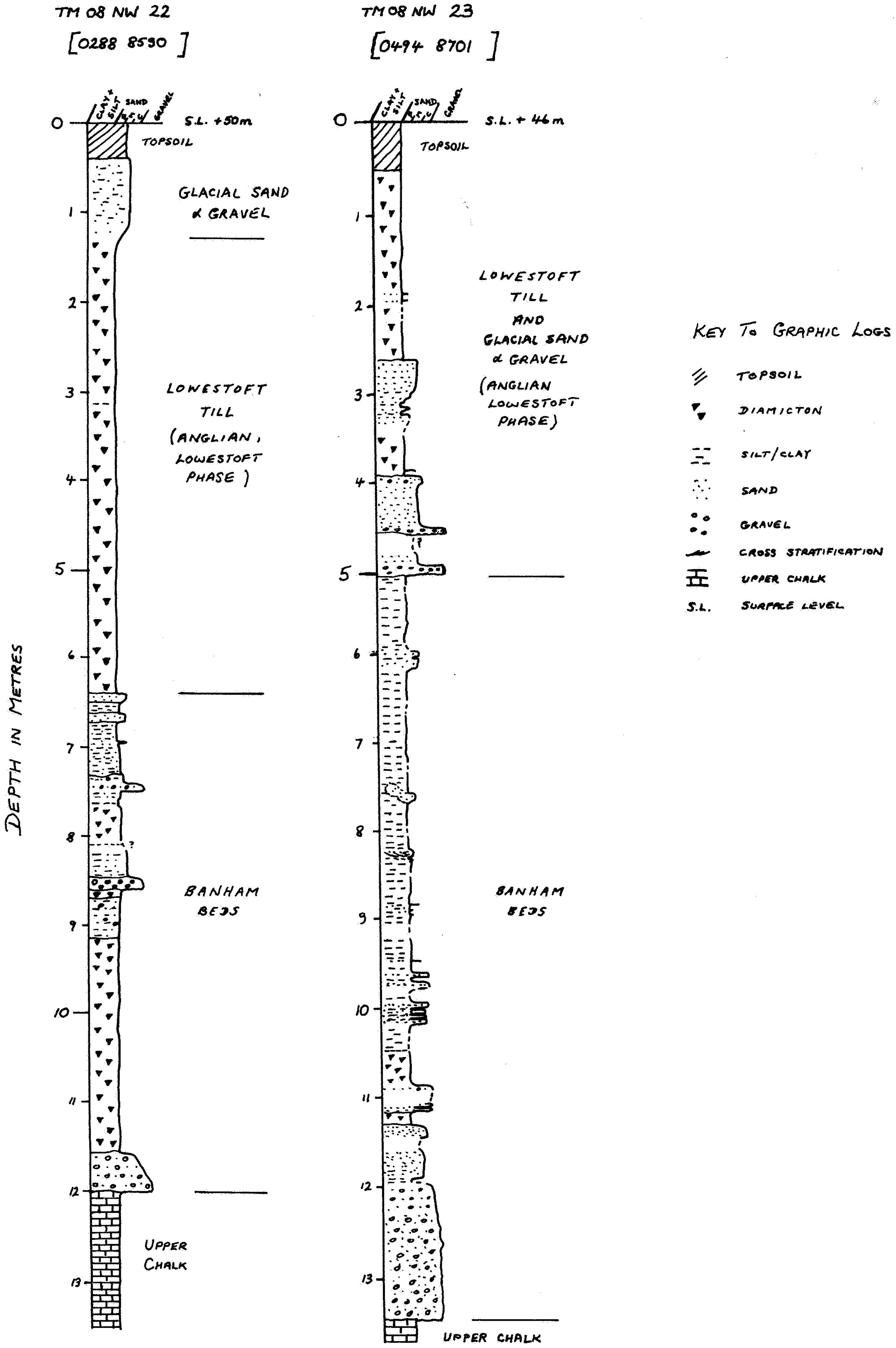
4. DRIFT DEPOSITS

4.1 BANHAM BEDS (? NORTH SEA DRIFT PHASE OF ANGLIAN GLACIATION)

Within the area two main suites of glacigenic deposits can be recognised. The older suite, the Banham Beds (Mathers and others, 1987), comprises a highly variable sequence of interbedded silts, clays, sands, gravels and diamictons which are generally poor in chalk and characterised by an abundance of rounded quartzite and quartz pebbles, together with black angular flints. A thicker layer of quartz-quartzite rich gravel is commonly developed at the base of the sequence (Fig.2). The pebble composition of gravel seams is shown in Table 2. The diamictons comprise strongly overconsolidated grey sandy clays with sporadic angular flints and rounded quartz and quartzite pebbles; they are regarded as tills. The pebble composition from the diamicton layers is shown in Table 3; the dominance of quartz and quartzite pebbles is apparent.

These sediments crop out beneath the younger glacial deposits on many valley sides between East Harling [TL 994 865] and Banham [TM 064 882] (Fig. 3). They are commonly about 5 metres thick but are locally in excess of 10 metres. The maximum recorded thickness is 13.5 m in borehole TM 08 NE 7.

The Banham Beds are predominantly glacilacustrine sediments but include tills (diamictons) and glacifluvial deposits. The marked difference in pebble composition between these sediments and the deposits of the succeeding Lowestoft phase of the Anglian glaciation


TM 08 NW 22
[0288 8590]
TM 08 NW 23
[0494 8701]
CLAY + SILT
SAND f, m, c
GRAVEL
S.L. +50m
S.L. + 46m
TOPSOIL
GLACIAL SAND & GRAVEL
LOWESTOFT TILL (ANGLIAN, LOWESTOFT PHASE)
LOWESTOFT TILL AND GLACIAL SAND & GRAVEL (ANGLIAN LOWESTOFT PHASE)
BANHAM BEDS
UPPER CHALK
DEPTH IN METRES
0
1
2
3
4
5
6
7
8
9
10
11
12
13
KEY TO GRAPHIC LOGS
TOPSOIL
DIAMICTON
SILT/CLAY
SAND
GRAVEL
CROSS STRATIFICATION
UPPER CHALK
S.L. SURFACE LEVEL

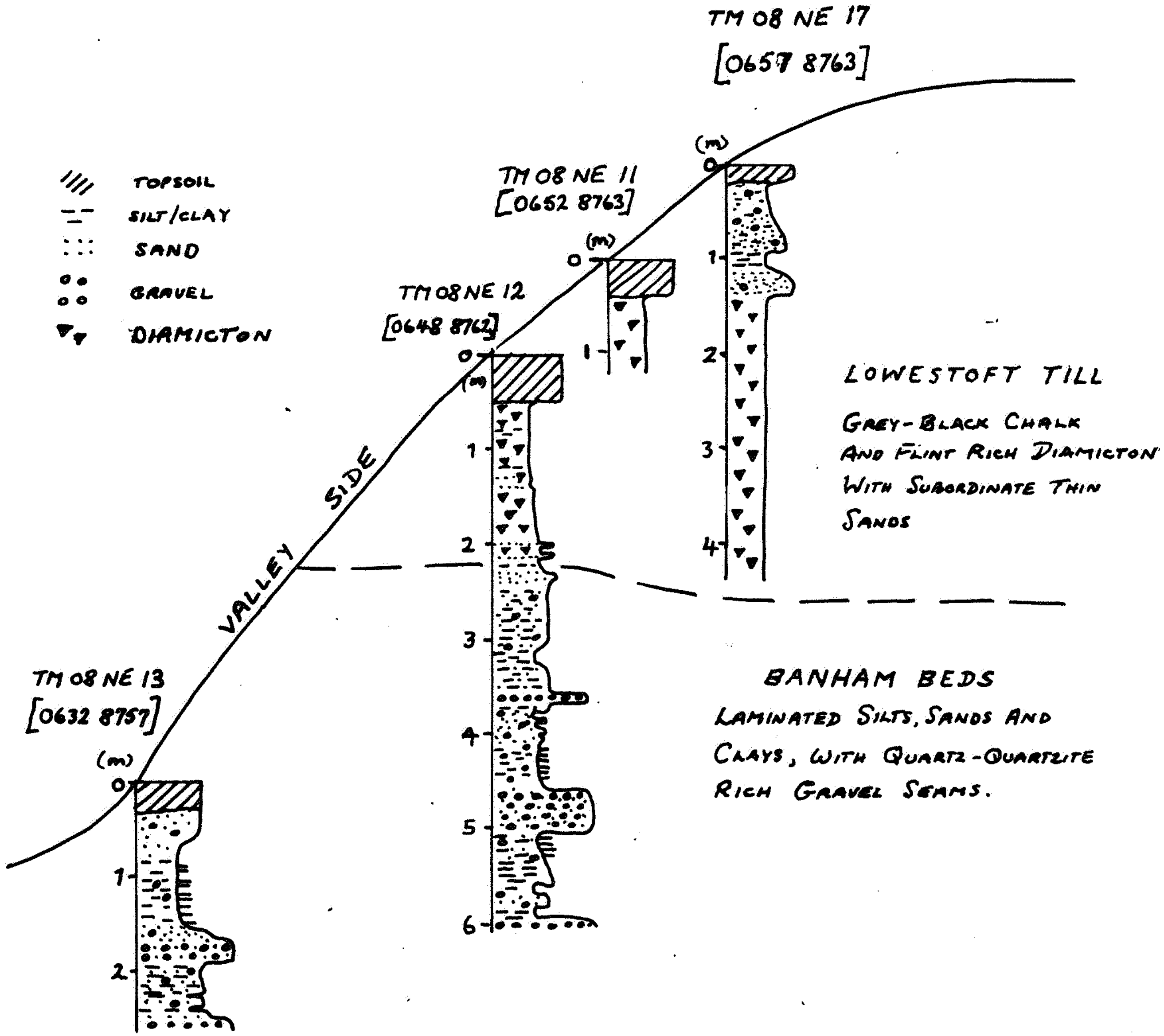


FIG. 3 Graphic lithological logs of extendable auger-holes near Banham, illustrating the stratigraphic relationships and lithologies of the Lowestoft Till and the Banham Beds.

TABLE 2 Banham beds - pebble composition of gravel seams and their comparison with the Ingham and Kesgrave Sands and Gravels.

	% FLINT	% QTZ	% QUARTZITE	% OTHERS	NO. OF SAMPLES
BANHAM BEDS	46	23	45	5	6
INGHAM SAND AND GRAVEL (from Auton 1982)	46	11	39	4	47
KESGRAVE SANDS AND GRAVELS (from Auton 1982)	43	18	36	3	148

TABLE 3 Pebble composition of diamicton layers (tills) in the Banham Beds, located in Figure 2.

SAMPLE NO	Depth	% FLINT	% QTZ	% QUARTZITE	% OTHERS
B12	7.6 - 8.15	31	25	41	3
B20	9.15- 9.70	28	24	39	9
B24	10.25-10.60	34	26	35	5
B27	10.60-11.55	31	21	43	5
MEAN 4 SAMPLES		31	24	39.5	5.5

(see below) argues strongly for the presence of two separate ice-sheets. However, in the Banham Beds there is a total absence of Scandinavian indicator pebbles, the hallmark of the North Sea Drift (Bridge and Hopson, 1985) which lies beneath the Lowestoft phase deposits farther east; correlation of the Banham Beds with this Drift is thus uncertain. The quartz-quartzite rich pebble composition of the Banham Beds may provide evidence for the existence of a previously unrecognised glacial event.

4.2 LOWESTOFT PHASE OF ANGLIAN GLACIATION

A younger suite of glacigenic deposits includes three distinct types of sediment, namely Glacial Silt and Clay, (Lowestoft) Till and Glacial Sand and Gravel; complex sequences result from the interbedding of these lithologies. The deposits are rich in chalk and flint and are thus distinct from the Banham Beds. They are thought to belong to the Lowestoft Phase of the Anglian glaciation (Baden-Powell 1948, Shotton and West 1969, Mitchell *et al* 1973).

4.2.1 GLACIAL SILT AND CLAY

Several small patches of Glacial Silt and Clay have been mapped within the area, most of which occur on the floors or low down on the sides of valleys. Thick sequences of the deposits may locally infill buried channels, as with the maximum recorded thickness of 12.1 m in borehole TL 98 NE 8 [9993 8829]. More commonly the deposits are 3-4 m thick, as in borehole TM 08 NE 10 [0642 8915]. They generally comprise grey to buff silts and clays, which are commonly finely interlaminated; they rarely contain thin sand laminae.

4.2.2 (LOWESTOFT) TILL

Till is widely exposed in the eastern part of the area where sequences over 30 metres in thickness are common. Farther west the Till sheet is dissected and the thinner deposits are commonly blanketed by Glacial Sand and Gravel. Exceptionally thick sequences such as the maximum recorded of 73.2 m in borehole TM 09 SE 14 [0546 9476] occur where the Till infills a deep depression cut into the Chalk (Fig. 1).

The deposit is a diamicton with a grey-black silty clay matrix studded with chalk and flint clasts. The clasts range from small granules to large boulders. Other clasts include Jurassic limestone, shells, ironstone and Red Chalk. The matrix of the deposit is largely derived from the Kimmeridge Clay. Most of the Till is hard and compact and is probably a lodgement till. The upper one to two metres are commonly decalcified, oxidised to a brown colour and cryoturbated. Thin Till layers, probably formed by flowage of material, are present within sequences of Glacial Sand and Gravel and Glacial Silt and Clay (Fig. 4).

Within the area the Till has been dug extensively to marl light sandy soils.

4.2.3 GLACIAL SAND AND GRAVEL

There are extensive outcrops of Glacial Sand and Gravel, predominantly in the more westerly parts of the area. The deposits rest on Till and also cut down into the Banham Beds and Chalk. The distribution of these deposits, as with that of the Glacial Silt and Clay, suggests that the area had assumed its present broad physiography by the end of the Anglian glaciation. In addition to the surface outcrops, Glacial Sand and Gravel is present within and beneath the Till, especially where thick glacial deposits are preserved in deep channels cut into chalk. A borehole TM 09 SW 8 [041 937] in one such channel SW of Attleborough proved 47.2 m of Glacial Sand and Gravel in the lower part of the Drift sequence, the maximum recorded thickness in the area. Elsewhere Glacial Sand and Gravel deposits are substantially thinner, commonly less than 10 m. South of the River Wissey 1.2 m of sand or pebbly sand overlies Till and Banham Beds. These thin deposits are often cryoturbated, leading to some mixing with the Till.

North of the River Wissey, on the high ground around Snetterton Heath [TM 010 898], thick coarse gravels, sand and pebbly sands overlie and cut into the underlying Till (Fig. 5). Locally they are contorted and cut by near-vertical faults, suggesting that they were either deposited on ice which upon melting resulted in the sediments collapsing or, alternatively, were disturbed by active ice-movement.

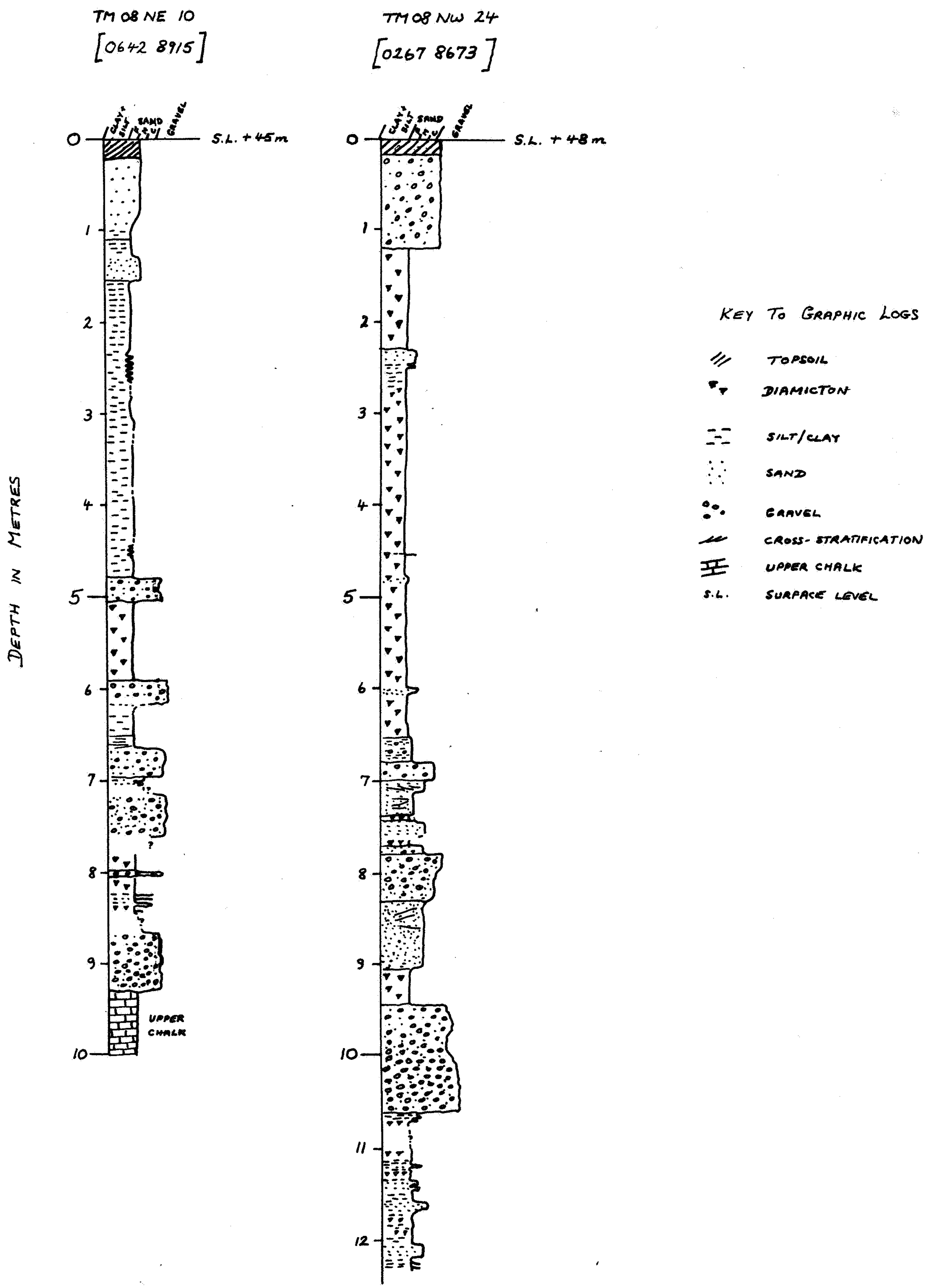


FIG. 4 Graphic lithological logs of boreholes TM 08 NE 10 and NW 24, illustrating the variability of the deposits of the Lowestoft phase of the Anglian glaciation.

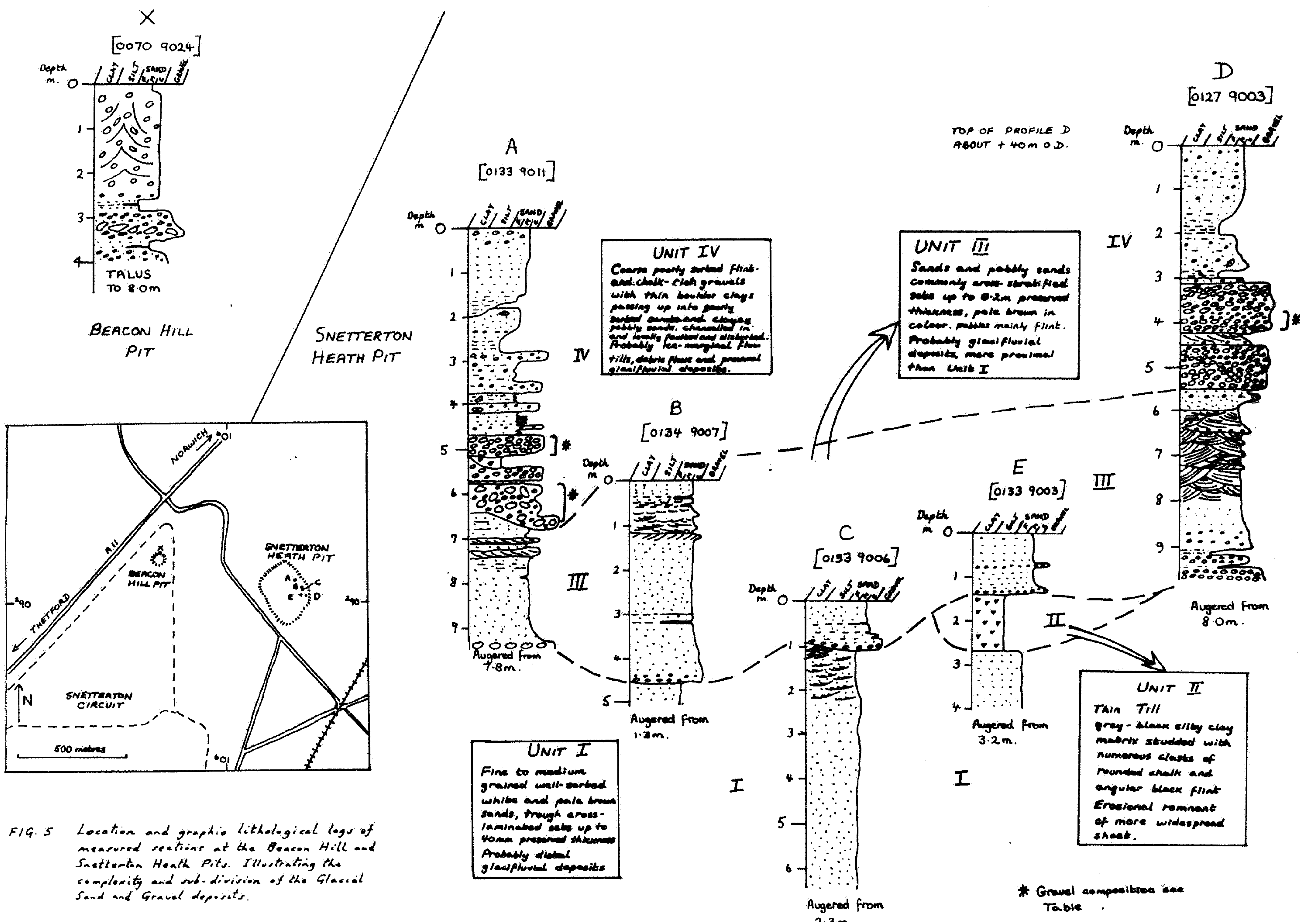


FIG. 5 Location and graphic lithological logs of measured sections at the Beacon Hill and Snetterton Heath Pits. Illustrating the complexity and sub-division of the Glacial Sand and Gravel deposits.

TABLE 4 Pebble Composition (+8-16 mm % by number) from Snetterton Heath Pit, located in Figure 5.

SAMPLE	SECTION A 4.7-5.2	SECTION A 5.8-6.4	SECTION D 3.8-4.2
% FLINT	59.2	23.5	94.7
% QUARTZ	1.6	1.4	2.6
% QUARTZITE	3.0	0.5	1.9
% CHALK	28.5	61.7	-
% IRON CEMENTED SANDSTONE	7.4	1.4	-
% OTHERS	0.3	11.5	0.8
NUMBER OF PEBBLES COUNTED	365	217	266

North of Snetterton Heath the Glacial Sands and Gravels commonly form a thin (1-3 m) discontinuous capping to the Till. Old gravel pits to the east around Old Buckenham Hall [TM 065 901], however, show that adjacent to river valleys the deposits are 6-8 m thick in places. This suggests that these valleys may have been choked with gravel during the stagnation of the ice-sheet. Alternatively, these gravels may be ice-contact deposits whose distribution does not relate to the present morphology.

The Glacial Sand and Gravel is commonly poorly sorted and variably clayey. The gravel fraction is dominated by angular and nodular black flints and, where the deposit has not been decalcified, by chalk. Details of the composition of the gravel-sized clasts in the Glacial Sand and Gravel at Snetterton Heath Pit are given in Table 4.

The Glacial Sand and Gravel at and near the surface is largely the result of ice-marginal and proglacial glacifluvial processes during the stagnation of the Anglian ice-sheet. These deposits are probably closely associated with the dissection of the western part of the area at this time. The deeply buried Glacial Sand and Gravel deposits, especially those within channels, are more likely to represent subglacially deposited sediments.

The Glacial Sand and Gravel is being dug for aggregate and hoggin at Snetterton Heath Pit [013 901].

4.2.4 SEQUENCES OF LOWESTOFT PHASE DEPOSITS

In simple terms, three types of sequence can be recognised, each corresponding to a distinct glacial process.

Firstly, in the east of the area the plateau is underlain by Till, commonly over 30 m thick, which in many places rests directly on Chalk. Thin beds of Glacial Sand and Gravel are sometimes present beneath the Till but are rare within or on top of it. These sequences comprise thick lodgement tills produced during the main phase of ice-advance.

Secondly, there is a more complex sequence in the western part of the district, where the till sheet is much thinner (only partly due to erosion) and is interdigitated with Glacial Sand and Gravel, and Glacial Silt and Clay. This sequence was probably deposited at the margin of a stagnating ice-sheet where periodic ponding of meltwaters led to deposition of the silts and clays. When the ice retreated, the erosive action of the meltwater streams is thought to have produced a dissected landscape which was, excepting minor modifications in post-Anglian times, similar to that of today.

Thirdly, in some areas, as for example near Attleborough, very thick variable sequences of Till and Glacial Sand and Gravel infill deep channels (or possibly hollows) cut into the Chalk (Fig. 1). The Glacial Sand and Gravel commonly lies near the base of these sequences and was probably deposited by subglacial meltwaters flowing along the deep channels.

4.3 HEAD

Head deposits have accumulated within several of the smaller valleys of the area where river flow is restricted or absent. They are generally less than 2 m thick and comprise clayey sands, sandy clay, and pebbly clays, deposited by solifluction and mass-movement of material downslope into the valleys, predominantly during cold climatic conditions since glaciation.

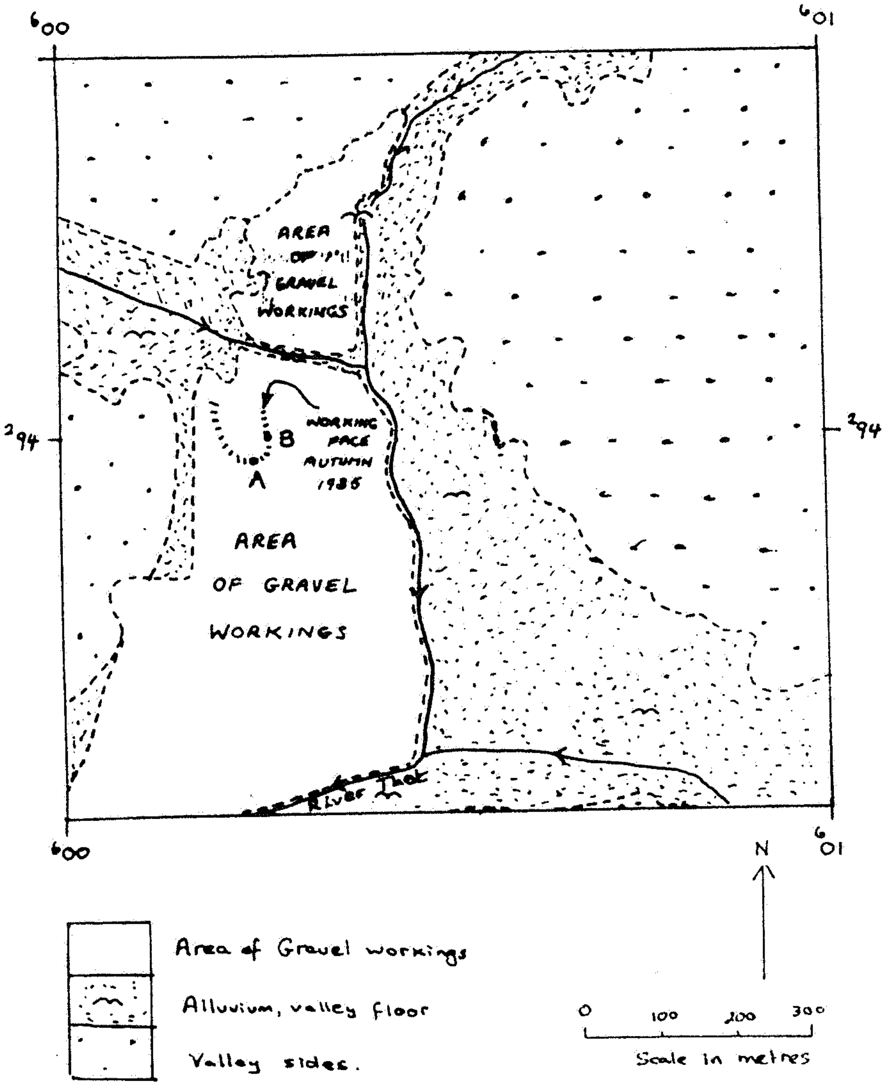
4.4 RIVER TERRACE DEPOSITS

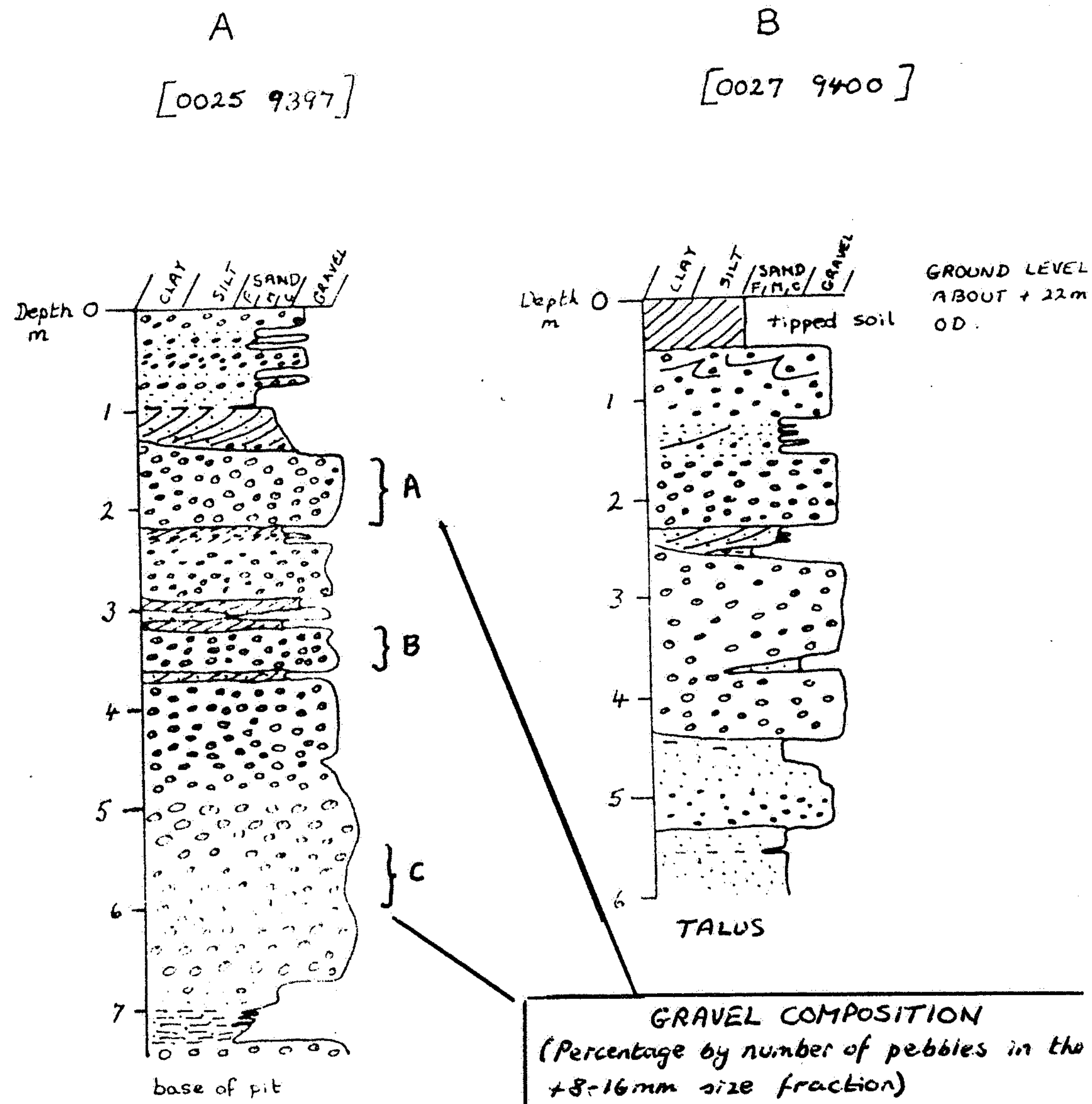
Two levels of River Terrace Deposits have been mapped in the valleys of the western part of the area. The drainage of this area is westwards into the River Thet.

The higher and older Second Terrace has a top surface 5-8 m above the level of the adjacent floodplain. This terrace is only developed at and around East Harling [TL 995 865].

The lower and younger First Terrace has a top surface 1-3 m above the level of the floodplain and occurs throughout much of the western part of the area.

FIG. 6 Location, graphic lithological logs and gravel composition of measured sections at Minn's gravel pit, west of Attleborough. Illustrating the lithology of the gravels beneath Alluvium on the floor of the Thet valley.





GRAVEL COMPOSITION
(Percentage by number of pebbles in the +8-16mm size fraction)

SAMPLE	A	B	C
% FLINT	97·5	94·3	96·3
% QUARTZ	0·7	0·8	1·7
% QUARTZITE	0·7	2·5	1·1
% CHALK	–	1·3	0·2
% OTHERS	1·1	1·1	0·7
NUMBER PEBBLES COUNTED	404	476	458

The terrace deposits comprise flint-rich sands and gravels; there are no exposures.

Beneath the Alluvium along the valley of the R Thet, sub-alluvial gravels are extensive and have been extracted as a source of aggregate. Only one pit - Minn's Pit - is extant and details of measured sections at this locality are shown in Figure 6. The sub-alluvial gravels are over seven metres thick at this point and consist of flint-rich coarse gravels. Near the base of Section A (Fig. 6) the deposits become black, and humic silts are intercalated with them. Mammaliferous bones have also been found extensively at this locality, although the level from which they derive has not been documented by the collectors. Clearly, further investigations are needed at this site to try and establish the age of the organic deposits and the source of the bones. The sub-alluvial gravels are probably Devensian in age and the organic deposits may prove to be Ipswichian.

The terraces and sub-alluvial gravels formed under conditions of greater river discharge than at the present-day. The terraces post-date the Anglian glaciation and probably aggraded during the subsequent cold phases.

4.5 ALLUVIUM

Alluvium has been mapped along the valley floors of some of the more substantial river courses in the west of the area, including the floodplain of the R Thet. The deposits are generally less than 3.0 m in thickness and comprise silts and clays which are locally humic and commonly sandy near their margins. These sediments may be interbedded with thin peaty layers. They are produced by the settling out of fine-grained material when the rivers overtop their channel banks and submerge the adjacent floodplain. The deposits relate to the latest phases of fluvial activity and are regarded as of Flandrian age (Table 1).

4.6 PEAT

Peat has accumulated along the floors of several of the poorly drained valleys and depressions within the area. The most notable developments are at Keninghall Fen [TM 040 875] and Old Buckenham Fen [TM 050 920]. The deposits at both sites are probably of the order of 10 m thick and probably include silts.

The Peat on Old Buckenham Fen is exposed in drainage ditches and commonly contains freshwater molluscs and thin layers of shell marl. The peat deposits within the area can be variably clayey and may pass transitionally into clays and silts (Alluvium). All have been mapped together rather than attempting intricate sub-division. The Peat is believed to be largely Holocene in age although in some of the deeper depressions older peat deposits might be encountered at depth.

5. REFERENCES

AUTON, C A 1982. The sand and gravel resources of the country around Redgrave, Suffolk. *Mineral Assessment Report, Institute of Geological Sciences No. 117,* 91 pp.

BADEN-POWELL, D F W 1948. The chalky boulder clays of Norfolk and Suffolk. *Geological Magazine 85,* 279-296.

BRIDGE, D McC and HOPSON, P M 1985. Fine gravel, heavy mineral and grain-size analyses of Mid-Pleistocene glacial deposits in the Lower Waveney valley, East Anglia. *Modern Geology, 9,* 129-144.

CLARKE, M R and AUTON, C A 1982. The Pleistocene depositional history of the Norfolk-Suffolk borderland. *Report Institute of Geological Sciences No. 82/1,* 23-29.

FUNNEL, B M, NORTON, P E P and WEST, R G 1979. The Crag at Bramerton, near Norwich, Norfolk. *Philosophical Transactions of the Royal Society of London B287,* 489-534.

MATHERS, S J, ZALASIEWICZ, J A, BLOODWORTH, A J and MORTON, A C 1987. The Banham Beds: a petrologically distinct suite of Anglian glacigenic deposits from central East Anglia. *Proceedings of the Geologists' Association 98,* 229-240.

MITCHELL, G F, PENNY, L F, SHOTTON, F W and WEST, R G 1973. A correlation of Quaternary deposits in the British Isles. *Geological Society of London Special Report 4,* 99 pp.

PEAKE, N B and HANCOCK, J M 1970. The Upper Cretaceous of Norfolk in *The Geology of Norfolk.* Eds Larwood, G P and Funnell, B M. *Norfolk Naturalists Society,* 293-340.

PERRIN, R M S, ROSE, J and DAVIES, H 1979. The distribution, variation and origins of Pre-Devensian tills in Eastern England. *Philosophical Transactions of the Royal Society of London B287,* 535-70.

SHOTTON, F W and WEST, R G 1969. Stratigraphical table of the British Quaternary *in Recommendations on stratigraphic usage. Proceedings Geological Society of London No. 1656,* 155-7.

WILCOX, C J and STANCZYSZYN, R 1983. The sand and gravel resources of the country around Diss, Norfolk. *Mineral Assessment Report, Institute of Geological Sciences No. 136,* 81 pp.