

# DEVENSIAN AND FLANDRIAN FOSSILIFEROUS DEPOSITS IN THE NENE VALLEY, CENTRAL ENGLAND

by

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## Summary

Devensian and Flandrian deposits at and below the level of the floodplain of the River Nene (central England) are described. At Little Houghton fossiliferous deposits of Middle Devensian age underlay fluvial gravels. Fossiliferous silts or muds within fluvial gravel sequences at Titchmarsh and Orton Longueville are shown to be of Late Devensian age. River channel infills overlying the gravels at Titchmarsh and Orton Longueville are of late-Flandrian (approximately Iron Age) age.

Fossil plants (pollen and macrofossils), molluscs and mammals are described from most of these deposits. Notable palaeobotanical records are of *Aphanes arvensis* from the Late Devensian and the following taxa from the late-Flandrian: cf. *Arabidopsis thaliana*, *Arenaria leptoclados*, *Butomus*, *Eleocharis palustris* subsp. *palustris*, *Epilobium* cf. *hirsutum*, *Filaginella uliginosa*, *Hydrocharis*, *Myosotis scorpioides*, *Nitella* cf. *translucens*, *Scutellaria*, *Teucrium scordium*, *Tolypella nidifica* and *Veronica anagallis-aquatica*. Notable records of Mollusca include a single shell of *Carychium minimum* apparently from a Late Devensian deposit, and late Flandrian records of: *Viviparus contectus*, *Planorbarius corneus*, *Unio tumidus*, *Pseudanodonta complanata* and *Pisidium supinum*.

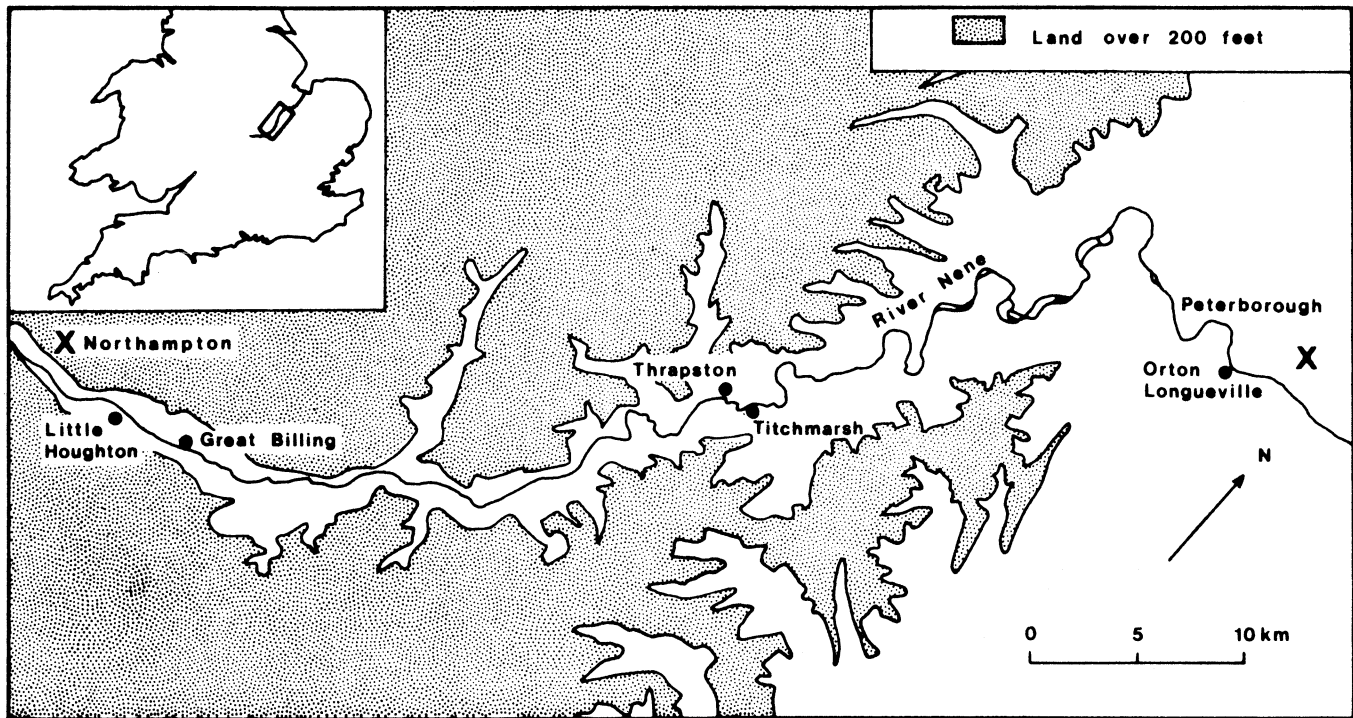
A limb bone of the giant deer *Megaceros giganteus* was found in the Late Devensian deposits at Orton Longueville. This species apparently became extinct in the Late Devensian and there are only two other records from England in this substage.

## 1. Introduction

Gravel quarries in the Nene Valley between Northampton and Peterborough have exposed fossiliferous Late Pleistocene sediments at numerous locations. Morgan (1969) described Middle Devensian fossil assemblages (principally insects, with some plants, molluscs and mammals) from Great Billing and Bell (1968) investigated Devensian plant fossils from near Thrapston. Visits to gravel quarries in the region between 1980 and 1982 revealed further fossiliferous Devensian deposits overlying the gravels. The results of studies on samples of these materials are reported here. These consist principally of analyses of pollen, plant macrofossils and Mollusca, with a few records of fossil mammals. Several records of both plants and Mollusca represent additions to the biota known from British Devensian or Flandrian deposits, or provide the first records from a clear stratigraphical context. The palaeo-environmental information from the fossil assemblages is also helpful in interpretation of the stratigraphy of the deposits at and near floodplain level (cf. Castleden, 1976, 1980a, 1980b).

The present study considers information from three separate gravel quarries, at Little Houghton (Northamptonshire), Titchmarsh (Northamptonshire) and Orton Longueville (Cambridgeshire). The location of these sites is shown in text-fig. 1. Following a brief summary of the methods used in studying the plant and molluscan material, each of these sites is considered in turn, concluding with a general discussion of the stratigraphy of deposits at and near floodplain level.

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Text-Fig.1 Location of sites in Nene Valley.

## 2. Methods

Pollen samples were prepared using a standard chemical method (West, 1977), modified to include use of sodium pyrophosphate to disperse clay (Bates, Coxon and Gibbard, 1978). The pollen and spores were identified to the type categories of Andrew (1970), with some more detailed identifications following Moore and Webb (1978) or the *Northwest European Pollen Flora*. Results are expressed as percentages of a pollen sum (tP) comprising total land pollen + pteridophyte spores + unidentified (i.e. excluding pollen of aquatic taxa and any reworked pre-Pleistocene palynomorphs). In the tables the percentages for those taxa excluded from the pollen sum are listed in parentheses.

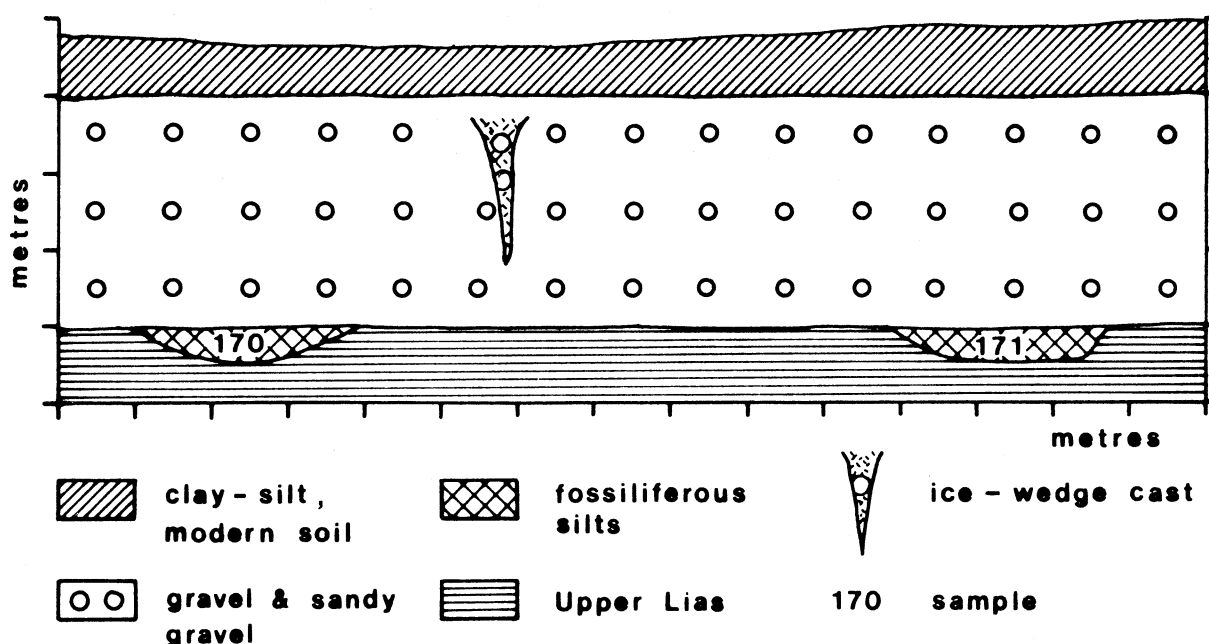
Samples for study of plant macrofossils were gently dispersed in water to which a little calgon was added, or in 5% nitric acid, and wet-sieved to 0.5 mm mesh. A large subsample of the material passing the 0.5 mm mesh was then wet-sieved to 0.2 mm. All identifiable plant macrofossils were picked from the residues in shallow water in a petri dish using a low-power stereomicroscope. Some specimens were encrusted with calcium carbonate which was removed with dilute hydrochloric acid. The material identified has been preserved in fluid or on microscope slides. Following Dickson (1973) the best preserved fragment of each fossil moss was noted according to its length (mm) and condition (vg very good, g good, b bad, vb very bad). The nomenclature of plants throughout follows *Flora Europaea* for vascular plants and Smith (1978) for mosses.

Samples for study of Mollusca were dispersed using calgon solution or hydrogen peroxide and then wet-sieved to 0.5 mm mesh. The residue was then dried and all of the following shell material was extracted: apices of gastropod shells, large fragments of gastropods, shell mouths of certain gastropods (Pupillidae, Vertiginidae), hinge-fragments of bivalves. Counts are of apices of gastropod shells (or mouths if the total number was greater than of apices) and of valves (i.e. fragments with cardinal teeth) of bivalves. The numbers given for shell valves of the bivalves are halved in the totals. Nomenclature follows Kerney (1976a) (freshwater species) and Kerney and Cameron (1979) (terrestrial species) throughout.

### 3. Little Houghton

#### (a) Location and stratigraphy

These extensive gravel workings were located on the south side of the River Nene just over 2 km north-west of Little Houghton church (c. TQ 7960). The stratigraphy observed is summarised in text-fig. 2. The floor of the quarry exposed grey clay (Upper Lias) locally. This clay bedrock mostly had an even planar surface, into which several channels infilled with silt had been cut. Sample 170 was from a channel infill of blackish organic-rich silts, whereas sample 171 was from grey silt. Both of the channel forms were 2-3 m in width and no more than 0.5 m in depth. The channels lay beneath about 3 m of gravel that was being quarried. These gravels were composed mostly of ironstone, quartzite, sandstone, flint and shelly limestones. Within the gravel succession were both sandy matrix-supported units and clast-supported units, as well as small laterally impersistent beds of sand. Occurrence of these units gave evidence of fluvial sorting of the materials, but study of the gravel succession was made difficult by the lack of steep weathered quarry faces. An ice-wedge cast with an infill of brown silt and pebbly sand descended from near the top of the gravels to around 2 m depth. At the edges of the quarry the gravels were capped by up to 1 m of brown clay-silt in which the modern soil was developed.



Text-Fig.2 Summary of stratigraphy at Little Houghton.

#### (b) Plant fossils

Pollen counts from samples 170 and 171 are listed in table 1. The pollen was mostly well preserved, so it is unlikely that the pollen degradation evident from the occurrence of small percentages of unidentified grains seriously affects the relative frequencies of the different pollen taxa. The high frequencies of Jurassic spores present suggest that erosion of the Jurassic clay bedrock was occurring; the colour and texture of the silt matrix suggest that much of it may consist of reworked local Upper Lias material.

The two pollen spectra are essentially similar, so they will be discussed together. Pollen of trees is so scarce that the few grains of *Pinus* recorded can reasonably be attributed to long-distance transport of pollen, such as occurs in unwooded regions at the present day (Birks, 1973; West *et al.*, 1974). Herbaceous pollen types are dominant, principally pollen of Cyperaceae. In addition there are varied herbs of unshaded habitats, including plentiful pollen of Caryophyllaceae and Cruciferae. Shrubs are represented only by pollen of *Salix*, with both dwarf willows (*S. herbacea* type) and other larger willows represented. Aquatic plants are represented by low frequencies of *Potamogeton* pollen.

**Table 1 Pollen spectra from Little Houghton.**

Pollen sum (tP)	Sample			Sample	
	170	171		170	171
	512	498			
<b>Trees:</b>			<i>Potentilla</i> type	3.0	2.4
<i>Pinus</i>	2.3	1.7	<i>Ranunculus</i> type	-	0.2
<b>Shrubs:</b>			Rosaceae undiff.	-	0.4
<i>Salix viminalis</i> L. type	1.2	0.6	<i>Rumex acetosella</i> L. type	1.5	6.0
<b>Herbs:</b>			<i>Salix herbacea</i> L. type	3.0	1.4
<i>Armeria</i>	0.5	0.2	<b>Pteridophytes:</b>		
Caryophyllaceae	6.2	0.4	Filicales (monolete)	-	0.6
Compositae-Liguliflorae	-	0.8	<i>Huperzia selago</i> (L.) Bernh.	-	0.2
Cruciferae	-	2.4	<b>Aquatic:</b>		
Cyperaceae	61.0	64.2	<i>Potamogeton</i>	(4.4)	(2.7)
Gramineae	11.2	14.5	<b>Unidentified</b>	10.2	4.0
			<b>Pre-Pleistocene palynomorphs</b>	(47.6)	(27.4)

The pollen evidence thus shows open treeless vegetation, with sedges, herbs and willows. The plant macrofossils (table 2) allow a much fuller study of the composition of this vegetation. Trees are unrecorded, and shrubs are represented by buds and leaf fragments of larger *Salix* sp. in addition to parts of dwarf willows (*S. herbacea* and perhaps also *S. polaris* or hybrids with the latter species).

**Table 2 Plant macrofossils from Little Houghton.**

Approx. dry weight (kg)	Sample	
	170	171
	2.5	2.5
<b>Shrubs:</b>		
<i>Salix herbacea</i> L.	1	10
<i>Salix herbacea</i> L. or <i>polaris</i> Wahlenb.	twf	-
	twf + b	1
<i>Salix</i> cf. <i>polaris</i> Wahlenb.	1	1
<i>Salix</i> sp.	b	4
	1f	8
		2
<b>Herbs:</b>		
<i>Arenaria ciliata</i> L.	s	5
<i>Arenaria ciliata</i> L. agg.	s	4
<i>Armeria maritima</i> (Mill.) Willd.	s	1
<i>Campanula rotundifolia</i> L.	s	-
Caryophyllaceae (cf. <i>Arenaria</i> )	fl	1
Caryophyllaceae undet.	s	1
<i>Cochlearia</i> sp.	cpvf	2
Cruciferae	s	-
<i>Dryopteris</i> type	sp	1
<i>Juncus</i> sp.	s	3
<i>Luzula</i> sp.	s	1
cf. <i>Luzula</i> sp.	s	-
<i>Potentilla anserina</i> L.	a	-
	af	-
<i>Potentilla</i> sp.	a	1
<i>Rumex acetosella</i> L. agg.	n	-
<i>Saxifraga</i> cf. <i>hypnoides</i> L.	s	1
<i>Silene vulgaris</i> (Moench) Garcke agg.	sf	2
<i>Silene</i> sp.	sf	-
<i>Taraxacum officinale</i> Weber agg.	a	1
<i>Viola lutea</i> Huds./ <i>tricolor</i> L. type	s	-

**Helophytes:**

<i>Carex nigra</i> (L.) Reichard/ <i>bigelowii</i> Torr. type	n	6	-
<i>Carex</i> sp.	bn	8	1
	tn	1	3
Cyperaceae	bn	2	10
<i>Eleocharis palustris</i> (L.) Roem. & Schultes. group	bn	1	2
<i>Ranunculus hyperboreus</i> Rottb.	a	1	-
<i>Ranunculus</i> cf. <i>reptans</i> L.	a	1	-

**Unclassified:**

Gramineae	car	1	2
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**Aquatic:**

<i>Chara</i> sp.	oo	8	-
<i>Potamogeton filiformis</i> Pers.	en	2	-
<i>Potamogeton</i> cf. <i>filiformis</i> Pers.	en	-	1
<i>Potamogeton</i> sp.	en	2	-
	enf	-	1
<i>Ranunculus</i> sg. <i>Batrachium</i>	a	3	1
<i>Tolypella nidifica</i> (O. Müll.) A.Br.	oo	109	-
cf. <i>Tolypella nidifica</i> (O. Müll.) A.Br.	oo	-	1

**Mosses:**

<i>Bryum</i> sp.	1	3	-
<i>Distichium capillaceum</i> (Hedw.) Br. Eur.	ls	1	-
		(3mm, g)	
<i>Drepanocladus</i> sp.	ls	2	-
		(4mm, g)	
Musci undet.	ls	1	-
		(3mm, vb)	
cf. <i>Scorpidium scorpioides</i> (Hedw.) Limpr.	ls	1	-
		(3mm, b)	
<i>Tortula</i> sp.	1	2	-

**Notes**

a achene, af fragment of achene, b bud, bn biconvex nutlet, car caryopsis, cpvf fragment of capsule valve, en endocarp, enf fragment of endocarp, fl flower, l leaf, lf fragment of leaf, n nutlet, oo oospore, s seed, sf fragment of seed, sp sporangia, tn trigonal nutlet, twf fragment of twig.

The remainder of the material consists of parts of varied herbs, sedges, grasses, aquatic plants, ferns and mosses. A substantial proportion are plants of dry unshaded places (e.g. *Arenaria ciliata*, *Campanula rotundifolia*, *Cochlearia* sp., *Rumex acetosella* agg., *Tortula* sp.), several of them calcicoles (e.g. *Arenaria ciliata*), but with at least *Rumex acetosella* agg. (typically) being a calcifuge. The parts of these plants of dry habitats must be assumed to have been variously washed or blown into the stream channel in which silt deposition occurred. Other plants recorded require fens or other wet habitats (e.g. *Eleocharis palustris*, *Ranunculus hyperboreus*), or they are aquatic plants that grow submerged (*Chara* sp., *Potamogeton filiformis*, *Tolypella nidifica*).

Several of the plant species now have northern or montane distributions in the British Isles and are absent from the lowlands of central and southern England (*Salix herbacea*, *Arenaria ciliata*, *Saxifraga* cf. *hypnoides*, *Ranunculus* cf. *reptans*, *Distichium capillaceum*). Two species are no longer part of the flora of the British Isles (*Salix* cf. *polaris*, *Ranunculus hyperboreus*); both of these now have arctic and subarctic ranges that extend further south in Scandinavia only in the mountains. Occurrence of these northern plants, and the absence of plants with predominantly southern distributional patterns implies that the climate was cold during deposition of the silts.

A flora with similar northern affinities and with several species in common with the Little Houghton flora was reported from an analagous stratigraphical position about 4 km further downstream at Great Billing (F. Bell, in Morgan, 1969). A radiocarbon sample from Great Billing gave a Middle Devensian date of 28,225 ± 330 yr B.P. (Birm- 75) (Morgan, *op. cit.*).

**(c) Mollusca**

Sample 170 contained plentiful shells of freshwater Mollusca but sample 171 contained only three shells of the land snail *Pupilla muscorum* (table 3). The two commonest species in sample 170, *Lymnaea peregra* and *Pisidium casertanum*, both tolerate a wide range of aquatic habitats so that their presence provides little ecological information. The two shell valves of *Pisidium vincentianum* are also of rather uncertain ecological significance because this form is not known living at the present day (Ellis, 1978); close relatives are present in the Himalayas and the Mediterranean region (Kuiper, 1962) but it is not entirely certain that they are conspecific. The land-snail *Catinella arenaria* (only tentatively identified, sample 170) lives on unshaded calcareous mud in fens or dune slacks

(Baker, 1965; Coles and Colville, 1979). *Pupilla muscorum* lives in unshaded calcareous sites that typically have an incomplete cover of herbaceous vegetation.

**Table 3 Mollusca from Little Houghton.**

	Sample	
	170	171
Dry weight (kg)	2.5	12.5
<i>Lymnaea peregra</i> (Müller)	443	-
<i>Lymnaea</i> sp.	28	-
cf. <i>Catinella arenaria</i> (Bouchard-Chantreaux)	1	-
<i>Pupilla muscorum</i> (L.)	-	3
<i>Pisidium casertanum</i> (Poli)	64	-
<i>Pisidium vincentianum</i> Woodward	2	-
<i>Pisidium</i> sp.	9	-
Totals	510	3

All of these molluscan species have been recorded from Middle Devensian sites, some of them commonly (Holyoak, 1982) and such species-poor faunas are characteristic of this substage.

**(d) Mammals**

Sample 171 contained an incisor tooth and several limb bones from a small vole, *Microtus* sp. A molar of *Mammuthus primigenius* (Blumenbach) was collected by workmen from a screen in the gravel-sorting plant. If this molar was contemporary with the gravels it would provide further evidence of a Middle Devensian age as there are no British records from the Late Devensian (other than from Barnwell Station, for which the dating evidence may be doubted; Stuart, 1982, p. 159).

The gravels at Great Billing also produced remains of *Mammuthus primigenius*, along with woolly rhinoceros *Coelodonta antiquitatis* Blumenbach and reindeer *Rangifer tarandus* L. (Morgan, *op. cit.*). Elsewhere in the valley the low-lying gravels have produced remains of an extinct bison *Bison priscus* Bojanus, musk ox *Ovibos moschatus* Zimmerman and horse *Equus ferus* Boddaert (Castleden, 1976).

**(e) Discussion**

The palaeobotanical evidence shows the silts were deposited during a period with open tree-less vegetation. Presence of several plants with northern or montane modern ranges and the absence of plants of restricted southern distribution suggest the climate was cold. The molluscan fauna is composed of a few, cold-tolerant species. The similarity of the fossil flora and the similar stratigraphical setting to those of the deposits at Great Billing suggest they are also of Middle Devensian age. Occurrence of a mammoth's molar, if it was not derived from an older deposit, is also consistent with this correlation. The presence of an ice-wedge cast within the gravels overlying the fossiliferous silts provides evidence of sustained subaerial exposure of the gravel surface in an environment with regional continuous permafrost (cf. Washburn, 1979). However, the permafrost in which this ice-wedge developed could have been present during the Middle Devensian, parts of the Late Devensian, or both.

**4. Titchmarsh**

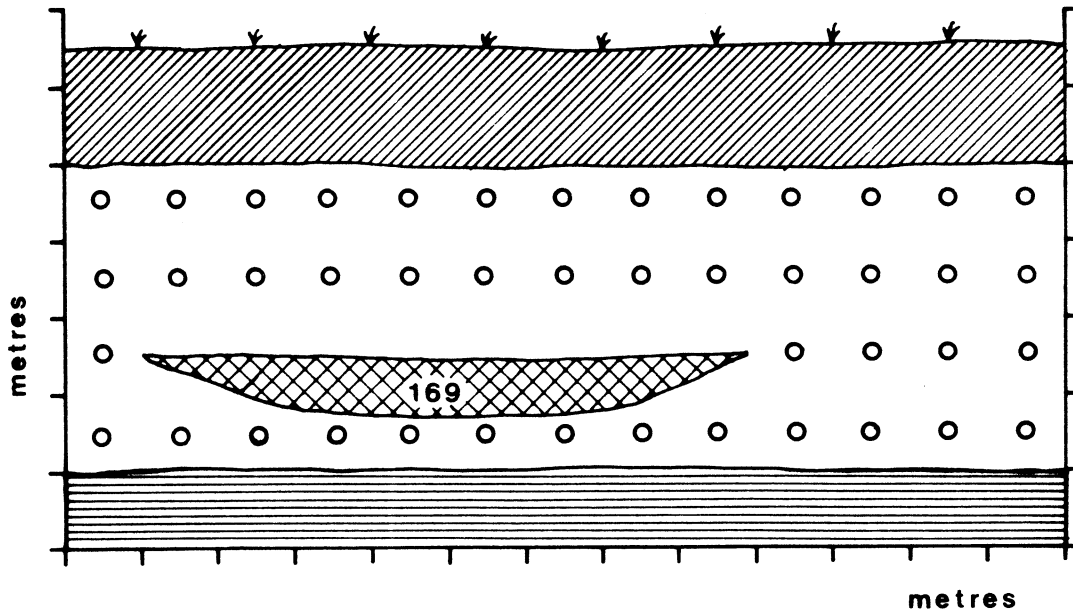
**(a) Location and stratigraphy**

Extensive gravel quarries on the Nene floodplain to the west of Titchmarsh were visited in June 1980. The stratigraphy observed then is summarised schematically in text-fig. 3. Up to 4 m of gravels were exposed, with water at the base preventing extensive exposure of the Jurassic clay (Upper Lias) bedrock. The gravels were generally similar in their lithological composition and fluvial bedding structures to those at Little Houghton. However, no ice-wedge casts were seen along the extensive exposures that were available and involutions and other evidence of post-depositional frost action was apparently absent.

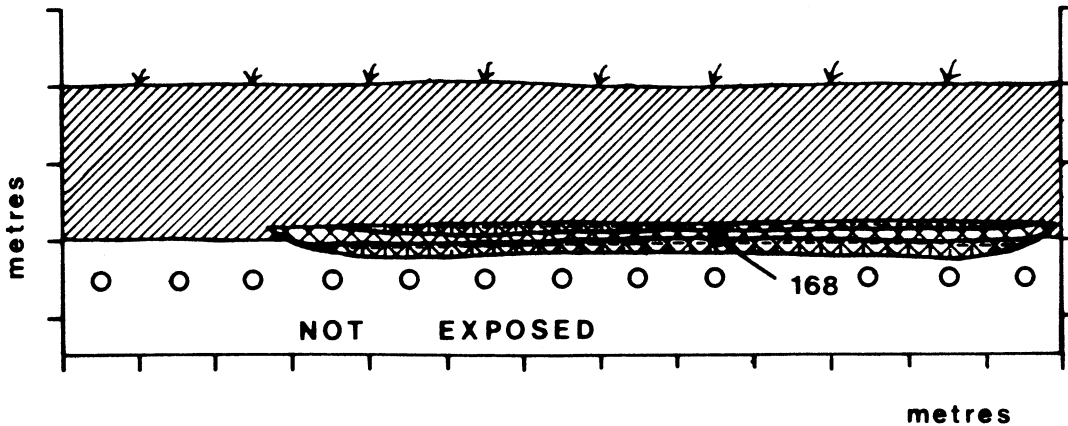
At around TL 010808 a channel infill of grey, organic-rich, silty-clay was found exposed beneath c. 2.5 m of gravel. This 'Lower Channel' provided sample 169.

At TL 009809 interbedded detritus muds and silts were exposed in a palaeochannel up to 20 m in width and 0.5 m in depth that cut through the less organic-rich clays and silts that overlay the gravels and into the uppermost gravel. Sample 168 was obtained from this 'Upper Channel' and numerous shells and bones were picked from the exposed sediment.

Lower Channel (TL 010808)



Upper Channel (TL 009809)



Text-Fig.3 Schematic summary of stratigraphy at Titchmarsh, June 1980.

The brown alluvial clays and silts capping the gravels were up to about 1.5-2 m in thickness at the edge of the quarry, but much of this thickness had been scraped away prior to gravel extraction elsewhere.

(b) Plant Fossils

Plant fossils were studied by pollen analyses of samples from the Lower Channel and the Upper Channel. The sample from the Lower Channel (table 4) contained an abundance of well-preserved pollen and spores. The vegetation of an open tree-less environment is evident from the high frequencies of Cyperaceae, Gramineae and herb pollen. The frequencies of *Pinus* and *Betula* pollen are too low to imply the presence of these trees locally, so these grains can probably be attributed to long distance transport of pollen. The abundance of pollen of such herbs as *Ranunculus*-type and *Filipendula* suggest the occurrence of herb-rich grassland, whilst the Cyperaceae pollen may have been from fen or waterside vegetation. Aquatic plants are represented by pollen of *Potamogeton*

and *Alisma*. The open tree-less vegetation shown by the pollen spectrum implies that the silts were deposited prior to the beginning of the Flandrian. However, it is not usually possible to distinguish Middle Devensian from Late Devensian deposits on the basis of pollen if there is no appreciable representation of tree pollen.

**Table 4 Pollen spectra from Titchmarsh.**

	Sample			Sample	
	169 Lower Channel	168 Upper Channel		169 Lower Channel	168 Upper Channel
Pollen sum (tP)	641	326			
<b>Trees:</b>			Gramineae	30.6	19.0
<i>Alnus</i>	-	8.0	Gramineae, cereals	-	0.6
<i>Betula</i>	1.4	-	<i>Lythrum</i>	-	0.6
<i>Carpinus</i>	-	0.3	<i>Plantago lanceolata</i> L.	-	0.9
<i>Fagus</i>	-	0.3	<i>Ranunculus</i> type	4.7	1.5
<i>Fraxinus</i>	-	0.3	Rosaceae undiff.	1.1	1.2
<i>Pinus</i>	1.8	-	Rubiaceae	0.2	0.6
<i>Quercus</i>	-	4.3	<i>Scutellaria</i>	-	0.6
<b>Shrubs:</b>			Umbelliferae	1.2	0.9
<i>Cornus sanguinea</i> L.	-	0.3	<i>Urtica</i>	-	0.3
<i>Corylus</i>	-	4.9	<b>Pteridophytes:</b>		
<i>Ilex aquifolium</i> L.	-	0.6	<i>Equisetum</i>	-	0.6
<i>Salix viminalis</i> L. type	2.1	1.8	Filicales (monoete)	1.0	6.4
<b>Herbs:</b>			<i>Polypodium vulgare</i> L. agg.	-	0.3
Boraginaceae	-	0.3	<i>Pteridium aquilinum</i> (L.) Kuhn	-	0.9
Caryophyllaceae	1.4	0.3	<b>Aquatic:</b>		
Chenopodiaceae	-	0.6	<i>Alisma</i>	(0.2)	(0.3)
Compositae, <i>Senecio</i> type	-	0.6	<i>Butomus</i>	-	(0.6)
Compositae-Liguliflorae	1.3	5.5	<i>Hydrocharis</i>	-	(0.3)
Cruciferae	1.4	-	<i>Nymphaea</i>	-	(0.6)
Cyperaceae	42.9	17.2	<i>Potamogeton</i>	(1.1)	(2.1)
<i>Epilobium</i> type	0.2	-	<b>Unidentified</b>	2.6	19.9
<i>Filipendula</i>	6.1	0.6	<b>Pre-Pleistocene palynomorphs</b>	(6.4)	(2.1)

A sample of detritus mud from 0.2 m above the base of the infill of the Upper Channel was also examined for pollen (table 4). The rather high proportion of unidentified pollen (19.9%) consisted mainly of corroded and crumpled grains, many of them probably of Cyperaceae and Gramineae. Nonetheless, much of the remaining pollen is well preserved so that differential loss of pollen is unlikely to bias the spectrum counted.

The spectrum as a whole implies predominantly unwooded conditions in the region (13.2% tree pollen, cf. 50.9% pollen of herbs). Grassland was probably extensive, to judge from the high frequency of Gramineae pollen (19.0%) and presence of pollen of *Plantago lanceolata* suggests pastureland was present. Evidence of cultivation of arable land is much less clear, with only 0.6% of pollen clearly identifiable as that of cereals (rather than other grasses) and only Chenopodiaceae pollen (0.6%) from probable weeds of cultivation. Other pollen types recorded are likely to have come from vegetation fringing the channel (e.g. Cyperaceae, *Filipendula*, *Lythrum*, *Scutellaria*) or growing in the channel ('Aquatic' group).

The presence amongst the tree pollen of single grains of *Carpinus*, *Fagus* and *Fraxinus* along with *Alnus* (8.0%) and *Quercus* (4.3%) points to an age in the latter half of the Flandrian, and the presence of cereal pollen implies a Neolithic or later age. The generally unwooded vegetation with evidence of extensive grassland on or about the river floodplain is most likely to indicate an Iron Age or later age (cf. Godwin, 1975), but the absence of detailed pollen diagrams from the region prevents a more precise correlation.

Few palynological studies have examined muds from this type of late-Flandrian deposit, from large slow-flowing rivers in south-eastern England. This probably accounts for the scarcity of other records from the British Flandrian of some of the pollen types found (cf. Godwin, *op. cit.*):

*Butomus* (flowering rush) two grains; previously recorded from the Flandrian (zone VIIb) only at Plantation Farm, Cambs. (Godwin and Clifford, 1938);

*Scutellaria* (skullcap) two grains; apparently not previously recorded from the Flandrian in Britain;

*Hydrocharis* (frog-bit) one grain; not previously recorded from the Flandrian in Britain; several interglacial records are of fruit not pollen.

(c) **Mollusca**

Shells were scarce in the silty-clay of the Lower Channel (table 5). The total of 29 shells recovered from a large sample (12.2 kg dry weight) includes 9 aquatic and 5 terrestrial species. Three of the aquatic species tolerate a wide range of different water bodies (*Lymnaea truncatula*, *L. peregra*, *Pisidium casertanum*) so that they provide little ecological information. However, *L. truncatula*, *Anisus leucostoma* and *Pisidium obtusale* typically occur in small and often impermanent or muddy pools (Sparks (1961) lists these as members of his 'Slum' group). On the other hand, *Bithynia tentaculata* and *Pisidium nitidum* prefer moving water and avoid small or temporary pools, and *Armiger crista* and *Pisidium milium* typically live in permanent waters where aquatic vegetation is plentiful.

The terrestrial species include *Pupilla muscorum*, which requires unshaded grassy or herb-rich sites, often with sparse vegetation; *Vallonia costata* typically occurs in grassland, but it will tolerate shading; *Carychium minimum* and *Punctum pygmaeum* tolerate a wide range of habitats including grasslands, fens and woods, and *Oxyloma pfeifferi* usually lives on waterside mud or amongst fen vegetation. Thus the only species giving unambiguous environmental information imply the occurrence of unshaded grassland or herb-dominated associations, and of fens or waterside habitats.

The presence of these indicators of open habitats, the composition of the molluscan assemblage, the pollen evidence and the location of the deposit within a river gravel sequence c. 2.5 m from its top all imply a Devensian rather than a Flandrian age. Several of the molluscan species recorded are scarce in Middle Devensian deposits in eastern England (*Armiger crista*, *Vallonia costata*, *Punctum pygmaeum*, *Pisidium milium*) so it would be surprising to find all of them together in a deposit of that age (cf. Holyoak, 1982). However, all of the species recorded except for *Carychium minimum* occur in deposits from the latter half of the Late Devensian.

*Carychium minimum* has rarely been reported from the Late Devensian in Britain and its presence is often taken to distinguish early Flandrian from Late Devensian deposits (cf. Kerney, 1977; Kerney, Preece and Turner, 1980). At Titchmarsh there were no fossiliferous Flandrian deposits exposed anywhere near to the Lower Channel, so the shell of *C. minimum* is most unlikely to be a contaminant. It thus appears to have been part of the Late Devensian fauna, although there remains the rather unlikely possibility of the shell having been reworked from an interglacial deposit. *Carychium minimum* was recorded from a deposit within gravels of the Thames floodplain of apparent Late Devensian age near Abingdon (Briggs, 1973; Gilbertson, 1976; Briggs and Gilbertson, 1980.)

Shells were abundant in most of the muds and silts infilling the Upper Channel (table 5). A sample of detritus mud of only 0.1 kg dry weight provided sufficient shells to give an indication of the relative abundance of the commoner species. Additional specimens of large-shelled species were picked out in the field, or taken from another sample of 1.0 kg dry weight.

The great majority of these shells are of freshwater species. Some species now occur mostly or entirely in well-oxygenated water of hard-water rivers and canals (*Theodoxus fluviatilis*, *Unio* spp., *Pseudanodonta complanata*, *Pisidium supinum*, *P. moitessierianum*). Others prefer well-vegetated sites with little or no flow (e.g. *Anisus vortex*, *Armiger crista*, *Planorbarius corneus*, *Acroloxus lacustris*, *Pisidium milium*). The diversity of this assemblage of shells of freshwater molluscs (32 species) as well as the presence of species with southern modern ranges (e.g. *Viviparus contectus*, *Unio* spp.) shows that a Flandrian rather than a Devensian fauna is involved. In the British Pleistocene the robust and distinctive shells of *Theodoxus fluviatilis* are known only from deposits of the Flandrian (Ellis, 1969).

There have been few modern studies of the Flandrian Mollusca of the larger lowland rivers of England, although Holyoak (1980) described assemblages from the Loddon and Kennet, and Preece and Robinson (1982) described assemblages from the Thames near Staines. Several of the Mollusca recorded from the Upper Channel at Titchmarsh have few other records from British Flandrian deposits. Most of these other records are old and poorly dated, and only scanty stratigraphical detail has been recorded:

*Viviparus contectus* Kennard and Woodward (1922) list 'Holocene' records from Bromham (near Bedford), near Ely (Cambs.), St. Ives (Huntingdonshire), Hardley Cross (Norfolk) and Knettishall (Suffolk).

*Planorbarius corneus* Kennard and Woodward (1922) list 'Holocene' records from Upware near Wicken (Cambs.), St. Ives (Huntingdonshire), Hardley Cross (Norfolk), Thorpe near Norwich (Norfolk) and Knettishall (Suffolk). It is also recorded from 'Holocene' deposits of the River Lea at Waltham Cross by Kennard (1943) and from late-Flandrian (pollen zones VIIb and VIII) deposits of the River Loddon at Swallowfield By-Pass (Berks.) (Holyoak, 1980).

*Unio tumidus* (Plate 19, G-L) Kennard and Woodward (1908) record it from 'Holocene' alluvium at Wallingford (Berks.) from a bed that also yielded 'remains of ox, horse, and probably sheep' and from Thames alluvium at Dagenham (Essex) 'at a depth of 20 feet'. Kennard and Woodward (1922) also record it from 'Holocene' deposits at St. Ives (Huntingdonshire) and Alderford (Norfolk).

**Table 5 Mollusca from Titchmarsh.**

(Additional shells from the Upper Channel that were picked out in the field, or taken from another sample of 1.0 kg dry weight are listed in parentheses).

	Sample		
	169 Lower Channel	168 Upper Channel	
Dry weight (kg)	12.2	0.1	
<i>Theodoxus fluviatilis</i> (L.)	-	12	
<i>Viviparus contectus</i> (Millet)	-	-	(5)
<i>Valvata cristata</i> Müller	-	22	
<i>Valvata piscinalis</i> (Müller)	-	10	
<i>Bithynia tentaculata</i> (L.) shells	2	20	
opercula	-	15	
<i>Bithynia leachii</i> (Sheppard) shells	-	6	
opercula	-	2	
<i>Bithynia</i> sp. shells	-	14	
opercula	-	16	
<i>Carychium minimum</i> Müller	1	2	
<i>Carychium</i> sp.	-	1	
<i>Lymnaea truncatula</i> (Müller)	2	7	
<i>Lymnaea palustris</i> (Müller)	-	1	
<i>Lymnaea stagnalis</i> (L.)	-	1	(1)
<i>Lymnaea auricularia</i> (L.)	-	-	(7)
<i>Lymnaea peregra</i> (Müller)	1	5	
<i>Planorbis planorbis</i> (L.)	-	1	
<i>Planorbis carinatus</i> Müller	-	1	
<i>Anisus leucostoma</i> (Millet)	3	-	
<i>Anisus vortex</i> (L.)	-	1	
<i>Gyraulus albus</i> (Müller)	-	14	
<i>Armiger crista</i> (L.)	2	5	
<i>Planorbarius corneus</i> (L.)	-	-	(1)
<i>Ancylus fluviatilis</i> Müller	-	1	
<i>Acroloxus lacustris</i> (L.)	-	18	
<i>Oxyloma</i> cf. <i>pfeifferi</i> (Rossmässler)	5	4	
cf. <i>Succinea putris</i> (L.)	-	1	
<i>Cochlicopa lubrica</i> (Müller)	-	1	
<i>Pupilla muscorum</i> (L.)	5	-	
<i>Vallonia costata</i> (Müller)	3	1	
<i>Vallonia pulchella</i> (Müller)	-	-	(1)
<i>Vallonia</i> sp.	1	1	
<i>Punctum pygmaeum</i> (Draparnaud)	1	1	
<i>Deroceras</i> sp.	-	1	
<i>Trichia striolata</i> (C. Pfeiffer)	-	1	
<i>Unio tumidus</i> Philipsson	-	-	(23)
<i>Unio pictorum</i> (L.)	-	-	(6)
<i>Pseudanodonta complanata</i> (Rossmässler)	-	-	(25)
<i>Sphaerium corneum</i> (L.)	-	8	
<i>Pisidium amnicum</i> (Müller)	-	5	
<i>Pisidium casertanum</i> (Poli)	1	30	
<i>Pisidium obtusale</i> (Lamarck)	1	-	
<i>Pisidium milium</i> Held	1	2	
<i>Pisidium subtruncatum</i> Malm	-	32	
<i>Pisidium supinum</i> A. Schmidt	-	1	
<i>Pisidium henslowanum</i> (Sheppard)	-	22	
<i>Pisidium nitidum</i> Jenyns	2	58	
<i>Pisidium hibernicum</i> Westerlund	-	1	
<i>Pisidium moitessierianum</i> Paladilhe	-	2	
Totals	29	267	

*Pseudanodonta complanata* (Plate 19, A-F). There are apparently no previous records from stratified Flandrian deposits in Britain (cf. Kennard, Salisbury and Woodward, 1925; Ellis, 1978).

*Pisidium supinum* Listed from 'Holocene' deposits at St. Ives (Huntingdonshire) by Kennard and Woodward (1922) and as a Holocene fossil by Kennard (1924). Also recorded from late-Flandrian (pollen zones VIIb, VIII) deposits of the River Loddon at Swallowfield By-Pass (Holyoak, 1980).

Records of the large freshwater mussels of the genera *Unio* and *Pseudanodonta* are of particular interest because they shed light on their former (natural) ranges. The modern ranges (Kerney, 1976b) of these mussels in Britain have probably been extended by introduction of the parasitic larval stages from one river catchment to another with introductions of coarse fish, possibly by introductions of the adult mussels, and in some cases by dispersal along canals (cf. Boycott, 1936).

All of the British Flandrian fossil records of these genera are from river catchments bordering the eastern English Channel or the southern North Sea. Wheeler (1977) proposed that all the indigenous primary freshwater fishes entered England "during existence of a land bridge connected to continental Europe which was severed probably at the end of the Boreal period, at about 7500 years B.P. Their wide distribution outside these areas is due directly or indirectly to anthropogenic factors". The known distribution of fossil *Unio* spp. fits with this interpretation (and so also, apparently, does that of *Pseudanodonta* and *Anodonta* spp.) as would be expected with the glochidia larvae being dispersed by freshwater fish. However, more studies of fossil Mollusca in deposits of rivers of other parts of the British Isles are needed to test this hypothesis, as well as records of *Unio* from south-eastern England from earlier in the Flandrian.

Shells of land Mollusca form only a small fraction of the assemblage from the Upper Channel at Titchmarsh. The eight taxa recorded include a grassland (or grassy-fen) species (*Vallonia pulchella*), two species characteristic of fens or wet sites near water (*Oxyloma* cf. *pfeifferi*, cf. *Succinea putris*) and five others that occur in a wider range of terrestrial habitats that may be either shaded by trees or open.

#### (d) Mammals

A number of bones and teeth were collected from the silts and muds infilling the Upper Channel. Dr. A. J. Stuart has identified these as: cattle *Bos* sp., horse *Equus* sp., red deer *Cervus elaphus* L. and roe deer *Capreolus capreolus* (L.). The cattle and horse remains, in view of their late-Flandrian age, were presumably from domestic animals. Red deer and roe deer occurred throughout the latter part of the Flandrian in Britain (Stuart, 1982), remaining common in England until Mediaeval times. Both species then declined markedly, with roe deer becoming extinct over much of England by the late eighteenth century; subsequent expansion of their ranges in England has mostly been based on introductions by man (Corbet and Southern, 1977).

#### (e) Discussion

The pollen spectrum from the Lower Channel provides clear evidence of open tree-less environments, implying a Devensian rather than a Flandrian age. The Mollusca strongly suggest that this channel fill is of Late Devensian rather than Middle Devensian age.

Two radiocarbon dates have been reported from organic materials within the gravels of the Nene at Thrapston, less than 2 km upstream from Titchmarsh. A sample of twigs from c. 5 m depth at SP 988895 gave an age estimate of  $25,780 \pm 870$  yr B.P. (Birm-113). This Middle Devensian date was associated with an assemblage of fossil Coleoptera suggesting a cold tundra environment (G. R. Coope, in Shotton, Blundell and Williams, 1970). Plant remains from an erratic of *Carex* peat within the gravels at SP 995802 gave  $8920 \pm 160$  yr B.P. (Birm-87)(Shotton, Blundell and Williams, 1969) although the plant remains were thought to be of Late Devensian age so that the date may be somewhat too young (cf. Bell, 1968). The 'Lower Channel' at Titchmarsh thus provides further evidence for the occurrence of Late Devensian as well as Middle Devensian materials beneath the floodplain of the River Nene.

The silty and clayey alluvium covering the floodplain gravels of a tributary of the River Nene near Northampton (SP 80686214) has been shown to be of late Flandrian age: wood from 'felted plant materials' near the base of the alluvium there gave an apparent age of  $3870 \pm 55$  yr B.P. (SRR-143) (Harkness and Wilson, 1974). This date falls within the Early Bronze Age, so it implies that deposition of the main thickness of silt and clay occurred either later in the Bronze Age, or during and since the Iron Age.

The Upper Channel at Titchmarsh is stratigraphically lower than most of the thickness of silt and clay alluvium (text-fig. 3). The fossil assemblages from the channel infill imply presence of a predominantly unwooded environment on and near the river floodplain during the infilling of the channel. Grassland was extensive and apparently grazed at least by cattle and horses. Presence of some cereal pollen shows that cultivation of arable land was occurring in the region. Such extensive forest clearance had not occurred over much of East Anglia until

the Late Bronze Age or Iron Age (Godwin, 1975). Thus the main thickness of the silt and clay alluvium overlying the Upper Channel at Titchmarsh must also date from the late Flandrian, probably from deposition during or since the Iron Age.

## 5. Orton Longueville

### (a) Location and stratigraphy

The gravel quarry at Orton Longueville (c. TL 165971) provided exposures of the sediments that infilled a former ox-bow lake on the floodplain on the south side of the River Nene. In addition, the floodplain gravels and associated silt beds were exposed. The sequence recorded in January 1982 is shown in text-fig. 4, the following beds being recognised at the site with the ox-bow lake infill:

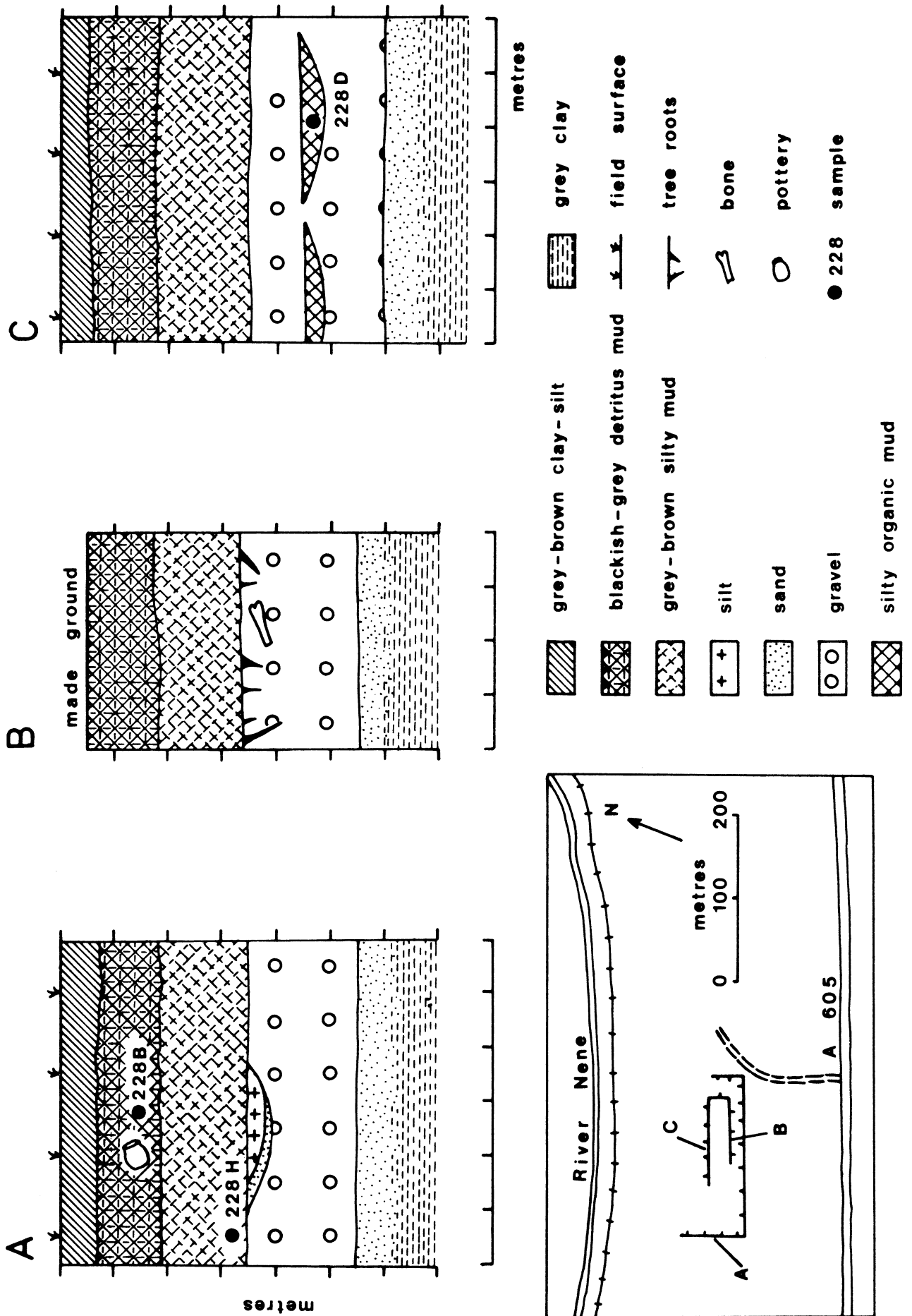
	Description	Thickness (m)
(7)	Grey-brown silty-clay with sticky texture (modern soil developed at its surface); no fossil shells evident;	0.7
(6)	Blackish-grey detritus mud with many shells of freshwater Mollusca; a large fragment of pottery was found with its base 0.3 m above the bottom of this unit; sample 228B was from the same level as the pottery;	1.2
(5)	Grey-brown silty mud with many shells of freshwater Mollusca; sample 228H was from 0.3 m above the base of this unit;	1.6
(4)	A small channel infill (c. 2.5 m in width, 0.5 m in depth) was cut into the top of unit (3) at one point;	0.5
(3)	Flat-bedded gravels; (lithology: flint with much limestone and a few pebbles of quartzite, sandstone, etc); fluvial bedding structures (sand beds, imbricated gravel, alternation of matrix-supported and clast-supported gravel units) well preserved; no involutions or ice-wedge casts were seen; one of several channel infills of silty organic mud at around mid-height provided sample 228D; woody tree roots (up to 60 mm in thickness, 0.4 m in depth) descending from the top of the gravel were visible along a length of about 30 m of section, these roots evidently having been truncated by erosion at the upper surface of the gravels;	2.0
(2)	Whitish medium-sand (not well exposed);	0.7
(1)	Grey clay with platy fracture (presumably this was a Jurassic clay forming the local bedrock, but this unit was not well exposed and no fossils were seen).	>1.0

### (b) Pottery from bed (6)

The pottery from low in bed (6) consisted of several large pieces which together formed the base of a pot. Dr. M. Fulford (Department of Archaeology, University of Reading) commented that the lack of any pattern on the fragments and of rim sherds made precise identification difficult. The pot had been formed by hand, not thrown on a wheel. He commented that pottery of this type was typical of the Iron Age; it was unlikely to have been made before 500 B.C. or after 400 A.D.

### (c) Plant fossils

Fossil plants were studied from both pollen (table 6) and macrofossils (table 7).



Text-Fig.4 Stratigraphy recorded at Orton Longueville in January 1982.

**Table 6 Pollen spectra from Orton Longueville.**

	Sample		
	228D	228H	228B
Pollen sum (tP)	252	211	159
<b>Trees:</b>			
<i>Alnus</i>	-	5.2	-
<i>Betula</i>	0.4	-	-
<i>Fraxinus</i>	-	0.9	-
<i>Picea</i>	-	0.5	-
<i>Pinus</i>	1.6	0.5	0.6
<i>Quercus</i>	-	0.5	1.3
<b>Shrubs:</b>			
<i>Betula nana</i> L. type	0.4	-	-
<i>Corylus</i>	-	3.8	-
<i>Juniperus</i>	2.0	-	-
<i>Salix</i>	0.8	-	-
<b>Herbs:</b>			
<i>Artemisia</i>	0.8	-	-
Caryophyllaceae	0.8	-	-
<i>Centaurea nigra</i> L.	-	-	0.6
<i>Cirsium</i> type	-	0.9	0.6
Compositae, Liguliflorae	1.6	1.4	5.7
Compositae, <i>Senecio</i> type	-	-	0.6
Cruciferae	-	-	0.6
Cyperaceae	44.8	13.3	11.9
<i>Epilobium</i> type	-	0.9	-
<i>Filipendula</i>	1.6	0.9	1.3
Gramineae	7.1	27.0	34.0
Gramineae, cereals	-	6.6	6.9
Labiatae, <i>Mentha</i> type	-	-	1.3
Leguminosae	0.8	-	-
<i>Plantago lanceolata</i> L.	-	2.8	1.3
<i>Plantago major</i> L. / <i>media</i> L. type	0.8	1.9	-
<i>Potentilla</i> type	0.4	0.9	-
<i>Ranunculus</i> type	1.2	2.8	1.3
Rosaceae undiff.	4.0	2.4	1.9
Rubiaceae	0.4	0.5	0.6
<i>Rumex obtusifolius</i> L. type	-	1.9	1.3
<i>Rumex</i> undiff.	1.6	-	-
Scrophulariaceae	-	0.9	0.6
<i>Thalictrum</i>	0.8	-	-
Umbelliferae	2.4	0.9	2.5
<i>Urtica dioica</i> L.	-	1.9	6.3
<b>Pteridophytes:</b>			
<i>Equisetum</i>	1.6	-	1.3
Filicales (monolete)	2.4	7.1	3.8
Lycopodiaceae undiff.	1.6	-	-
<i>Pteridium</i>	-	1.4	2.5
<b>Aquatic:</b>			
<i>Alisma</i>	(1.2)	(2.4)	(1.9)
<i>Callitriche</i>	-	-	(0.6)
<i>Lemna</i>	-	(1.9)	(1.3)
<i>Nuphar</i>	-	(0.5)	-
<i>Nymphaea</i>	-	(1.4)	-
<i>Potamogeton</i>	(2.8)	(4.7)	(1.3)
<i>Sagittaria</i>	-	(1.9)	(0.6)
<i>Sparganium erectum</i> L. type	-	(1.4)	(0.6)
<i>Sparganium</i> undiff.	(0.4)	-	-
<i>Typha latifolia</i> L.	-	(0.5)	(1.3)
<b>Unidentified</b>	20.2	11.8	12.6
<b>Pre-Pleistocene palynomorphs</b>	(4.4)	-	-

**Table 7 Plant macrofossils from Orton Longueville.**

(Additional material obtained from mollusc samples is listed in parentheses).

		Sample		
		228D	228H	228B
Approx. dry weight (kg)		1.2	0.5	0.5
<b>Trees:</b>				
<i>Quercus petraea</i> (Matt.) Liebl. or <i>Q. robur</i> L.	cu	-	-	1(1)
	ff	-	-	-(1)
<b>Shrubs:</b>				
<i>Rubus fruticosus</i> L. agg.	fs	-	-(1)	2
<i>Salix</i> sp. (not <i>S. herbacea</i> L. type)	bf	10+	-	-
	lf	13+	-	-
	s	-	-	1
	tw	9	-	-
<i>Sambucus</i> sp.	fs	-	-	1
<b>Herbs of dry land:</b>				
<i>Aphanes arvensis</i> L.	a	1	-	-
<i>Aphanes microcarpa</i> (Boiss. & Reut.) Rothm.	a	-	1	-
cf. <i>Arabidopsis thaliana</i> (DC.) Heynh.	s	-	-	1
<i>Arenaria leptoclados</i> (Rchb.) Guss.	s	-	-	1
<i>Artemisia</i> sp.	a	-	1	-
<i>Campanula rotundifolia</i> L.	s	1	-	-
Caryophyllaceae undet.	s	-	1	-
<i>Cerastium fontanum</i> Baumg.	s	-	1	-
cf. <i>Cerastium</i> sp.	s	-	1	-
<i>Chenopodium album</i> L.	s	-	6	-(1)
<i>Chenopodium</i> sp.	s	-	1	-
<i>Cirsium</i> cf. <i>arvense</i> (L.) Scop.	a	-	1	-
Compositae undet.	af	-	2	-
<i>Filaginella uliginosa</i> (L.) Opiz	a	-	6	-
cf. <i>Filaginella uliginosa</i> (L.) Opiz.	a	-	-	1
<i>Filaginella</i> or <i>Filago</i>	a	-	14	-
<i>Plantago lanceolata</i> L.	s	-	4	4
<i>Plantago major</i> L.	cl	-	-	1
<i>Polygonum persicaria</i> L.	n	-	2(3)	1
<i>Polygonum</i> sp.	bn	-	-(1)	-
<i>Potentilla anserina</i> L.	a	11	-	-(1)
	af	-	-(2)	-
<i>Potentilla</i> sp.	a	-	-	1
<i>Ranunculus parviflorus</i> L.	a	-	-	1
<i>Ranunculus</i> cf. <i>repens</i> L.	a	-	-	4
<i>Ranunculus</i> subg. <i>Ranunculus</i>	a	-	1(3)	-(1)
<i>Rumex conglomeratus</i> Murr.	n	-	-	1
<i>Rumex</i> cf. <i>crispus</i> L.	ps	-	1	-
<i>Rumex obtusifolius</i> L.	n+p	-	1(1)	-
<i>Rumex</i> cf. <i>obtusifolius</i> L.	n	-	1(2)	1
<i>Rumex</i> sp.	n	-	-(1)	-
<i>Senecio aquaticus</i> Hill or <i>jacobaea</i> L. type	a	-	3	-
<i>Silene dioica</i> (L.) Clairv.	s	-	1	-
<i>Solanum dulcamara</i> L.	s	-	-	1
<i>Sonchus asper</i> (L.) Hill	a	-	1	-
<i>Stellaria media</i> (L.) Vill.	s	-	1	-
<i>Urtica dioica</i> L.	a	-	5	4
<b>Helophytes:</b>				
<i>Apium cf. inundatum</i> (L.) Rchb. f.	f	-	-	1
<i>Apium nodiflorum</i> (L.) Lag.	f	-	-	3
cf. <i>Apium</i> sp.	f	-	-	1
<i>Caltha palustris</i> L.	fo	-	-	1
<i>Carex</i> cf. <i>riparia</i> Curt.	uf	-	-	1
<i>Carex</i> sp.	bn	2	1	-
	tn	1	-	-

Cyperaceae	bn	-	-	6(2)
	lf		6+	-
	nf		3	-
<i>Eleocharis palustris</i> (L.) Roem. & Schult., ssp. <i>palustris</i>	n	-	1	4(1)
<i>Epilobium</i> cf. <i>hirsutum</i> L.	s	-	-	1
<i>Juncus articulatus</i> L. type	s	-	-	4
<i>Juncus bufonius</i> L. group	s	-	48	9
<i>Juncus bulbosus</i> L.	s	-	13	-
<i>Juncus effusus</i> L. type	s	-	7	3
<i>Juncus</i> sp.	s	1	25	14
<i>Lysimachia</i> cf. <i>vulgaris</i> L.	s	-	5	-
<i>Myosotis scorpioides</i> L.	s	-	-	7
<i>Nasturtium officinale</i> R.Br.	s	-	-	14
<i>Ranunculus sceleratus</i> L.	a	-	-	2
<i>Rumex maritimus</i> L.	n	-	11(1)	1
	n+p	-	8(1)	-
	p	-	2	-
<i>Scirpus lacustris</i> L. ssp. <i>lacustris</i>	if+n	-	-	1
	n	-	8(28)	17(14)
<i>Scirpus lacustris</i> L. cf. ssp. <i>tabernaemontani</i> (C.C. Gmel.) Syme	n	-	-(2)	-
<i>Scirpus setaceus</i> L.	n	-	-	2
<i>Teucrium scordium</i> L.	n	-	1	-
<i>Typha</i> cf. <i>angustifolia</i> L.	s	-	-	2
<i>Typha</i> cf. <i>latifolia</i> L.	s	-	-	6
<i>Typha</i> sp.	s	-	-	4
<i>Veronica anagallis-aquatica</i> L.	s	-	-	1
<b>Aquatic:</b>				
<i>Alisma plantago-aquatica</i> L.	f	-	-	32
<i>Alisma</i> sp.	em	-	2	7
<i>Callitriche</i> sp.	ff	-	-	1
	s	-	-	4
<i>Chara</i> spp.	oo	4	126	108
<i>Hippuris vulgaris</i> L.	f	-	-	3
<i>Lemna</i> sp.	s	-	-	1
<i>Nitella</i> cf. <i>translucens</i> (Pers.) Ag.	oo	-	-	3
<i>Nuphar lutea</i> (L.) Sm.	s	-	-(1)	1
<i>Ranunculus</i> subg. <i>Batrachium</i>	a	-	3(2)	14
<i>Sagittaria sagittifolia</i> L.	em	-	2	-
	f	-	1	-
	ff	-	2	-
<i>Tolypella nidifica</i> (O. Müll.) A. Br.	oo	-	-	14
<i>Zannichellia palustris</i> L.	f	-	13	17
	lfr	-	-	1
<b>Unclassified:</b>				
<i>Epilobium</i> sp.	s	-	2	2
Gramineae	ca	-	-	3
	lf	4+	-	-
<i>Mentha aquatica</i> L. or <i>arvensis</i> L.	n	-	2	38(1)
Monocotyledones undet.	lf	-	X	X
	stf	-	X	X
<i>Rumex</i> sp.	in	-	5	-
	nf	-	1	1
	pf	-	3	-
<b>Mosses:</b>				
Brachytheciaceae undet.	1	-	-	1
<i>Cratoneuron filicinum</i> (Hedw.) Spruce	ls	-	2	-(4 mm, g)
cf. <i>Cratoneuron filicinum</i> (Hedw.) Spruce	ls	-	3	-(6 mm, b)
<i>Drepanocladus</i> cf. <i>aduncus</i> (Hedw.) Warnst.	ls	-	1	-(7 mm, g)
cf. <i>Drepanocladus</i> sp.	ls	-	1	-(3 mm, g)
Musci undet.	ls	-	1	-(2 mm, b)

## Notes

a achene, af achene fragment, bf bark fragment from twig, bn biconvex nutlet, ca caryopsis, cl lid of capsule, cupule from fruit, em embryo, f fruit, ff fragment of fruit, fo follicle, fs fruit-stone, if fragment of inflorescence, in immature nutlet, l leaf, lf leaf fragment, lfr lid from fruit, ls leafy stem, n nutlet, nf fragment of nutlet, oo oospore, p perianth, pf fragment of perianth, s seed, stf fragment of stem, tn trigonal nutlet, tw twig, uf fragment of utricle, X many, + more present in sample than were picked and counted.

The silty organic mud infilling channels within the gravels of bed (3) (sample 228D) yielded a pollen spectrum with many degraded grains (20.2% unidentified). However, such fragile pollen types as those of *Juniperus* and Cyperaceae were represented, so pollen degradation may not have drastically biased the spectrum. Pollen of herbs (69.0%) predominated over low frequencies of tree (2.0%) and shrub pollen (3.2%). The few grains of *Pinus* and *Betula* pollen recorded might therefore be attributable to long-distance transport of pollen. The great scarcity of tree pollen and the absence of any pollen of thermophilous trees imply that the silty mud dates from the Devensian rather than the Flandrian stage.

Shrubs are represented by few grains, of *Betula nana* type, *Juniperus* and *Salix*. The herb pollen is dominated by Cyperaceae (44.8%) with lesser amounts of Gramineae pollen (7.1%) and varied herbs. Many of the herbs and pteridophytes recorded from pollen or spores are plants of open habitats, including Lycopodiaceae, *Plantago major/media* type, *Rumex*, *Thalictrum*, *Artemisia* and *Ranunculus* type. A few of the taxa present are characteristically common in Devensian deposits (e.g. *Artemisia*) and two of these no longer occur in the Peterborough region (*Betula nana*, Lycopodiaceae). Aquatic plants are represented by pollen of *Potamogeton*, *Alisma* and *Sparganium*. Occurrence of Jurassic palynomorphs (4.4%) may give evidence of reworking of Jurassic clays within the catchment.

Plant macrofossils from the silty mud of channel infills in bed (3) are listed in table 7 (sample 228D). These remains were scarce and of restricted variety, but they amplify the pollen evidence for tree-less vegetation, with occurrence of shrubs (*Salix* sp.), herbs of open habitats (*Potentilla anserina*, *Aphanes arvensis*, *Campanula rotundifolia*, Gramineae), sedges (*Carex* sp.), rushes (*Juncus* sp.) and the aquatic charophytes (*Chara* sp.). The record of the small herb *Aphanes arvensis* (parsley piert) is noteworthy as the only published record from the Devensian is from the apparently Early Devensian deposits at Sidgwick Avenue, Cambridge (Lambert, Pearson and Sparks, 1963).

The pollen spectra from the detritus mud (bed 6; sample 228B) and the silty mud (bed 5; sample 228H) were generally similar (table 6). Hence, they will be discussed together with a comment at the end about the minor differences between them. Both spectra had mainly well-preserved pollen, with small proportions of unidentified grains, most of which were corroded.

Presence of significant amounts of pollen of cereals (6.6, 6.9%) shows the spectra are from late in the Flandrian, and the high proportions of herb pollen (68.2, 78.0%) and low proportions of tree pollen (7.6, 1.9%) show that the regional forests had mostly been cleared. Thus the silty mud of bed 5 is unlikely to be much older than the approximately Iron Age date inferred from the pottery stratified low in the overlying detritus mud.

Pollen of Gramineae (27.0, 34.0%) was plentiful, and accompanied by pollen of a variety of herbs. Occurrence of *Plantago lanceolata* pollen suggests pastureland was present, while pollen of *Plantago major/media* type is (at this site) most likely to be from *P. major* growing in trampled places. Other herbs represented by pollen or spores are mostly plants of waysides and waste-ground, notably *Pteridium*, *Centaurea nigra*, *Rumex obtusifolius* type, *Urtica dioica* and Umbelliferae.

A wide variety of aquatic plants was represented. These included emergent plants of shallow margins of water (*Alisma*, *Sparganium erectum* type, *Typha latifolia*), plants with floating leaves that grow rooted in river or lake bottoms (*Nuphar*, *Nymphaea*, *Sagittaria*), a minute floating plant (*Lemna*), and genera that may have both submerged and floating leaves in different species or under different conditions (*Callitriche*, *Potamogeton*). The abundance of Cyperaceae pollen (13.3, 11.9%) presumably reflects a waterside vegetation with many sedges.

The change of sediment type from the silty mud of bed (5) to the detritus mud of bed (6) occurred mainly because of a great reduction in the input of silt-sized mineral grains. This probably occurred when the ox-bow lake became isolated from the main flow of the river. Because pollen may be transported with the silt load in rivers, differences between the pollen spectra in beds (5) and (6) may thus reflect differing origins of the pollen instead of, or in addition to, differences in the regional and local vegetation. The marked reduction in frequency of tree and shrub pollen (11.4 to 1.9%) between samples 228H and 228B is therefore difficult to interpret. A

change towards reduced representation of the regional vegetation (with trees and shrubs present) by pollen as against the local vegetation (of herbs) may however, be more likely to account for this difference than the almost complete deforestation that might at first sight seem to be implied by sample 228B.

The detritus mud (bed 6; sample 228B) and silty mud (bed 5; sample 228H) contained richly varied assemblages of well preserved plant macrofossils (table 7). Remains of trees and shrubs were very scarce, whereas parts of herbs of dry land, helophytes and aquatic plants were plentiful. The two samples were generally similar in their fossil contents, so they are discussed together.

The herbs of dry land that were represented are varied, including small plants of open sites (*Aphanes microcarpa*, cf. *Arabidopsis thaliana*, *Arenaria leptoclados*, *Filaginella uliginosa*) along with tall plants characteristic of rank vegetation in waste places (*Rumex conglomeratus*, *R. cf. crispus*, *R. obtusifolius*, *Urtica dioica*). Several are familiar weeds of cultivated ground (e.g. *Chenopodium album*, *Stellaria media*), whereas *Plantago lanceolata* grows mainly in pastures and hayfields and *P. major* grows mainly on trampled ground such as in gateways or beside pathways.

Marsh and waterside plants were well represented, with *Carex cf. riparia*, *Scirpus lacustris*, other sedges, and varied herbs (e.g. *Epilobium cf. hirsutum*, *Lysimachia cf. vulgaris*, *Myosotis scorpioides*, *Teucrium scordium*). Several rush species that were represented (*Juncus articulatus* type, *J. bulbosus*, *J. effusus* type) are most likely to have grown in open marshy places such as wet pastures, but the *J. bufonius* group are ruderals that mostly grow on moist or wet mud or sand.

A rich aquatic flora was evident from remains of emergent plants of shallow edges (e.g. *Typha* spp., *Veronica anagallis-aquatica*, *Alisma plantago-aquatica*, *Hippuris vulgaris*, *Apium* spp.), of submerged aquatic plants (*Callitriche* sp., *Chara* spp., *Nitella cf. translucens*, *Tolypella nidifica*, *Zannichellia palustris*), of rooted plants with floating leaves (*Nuphar lutea*, *Sagittaria sagittifolia*) and of a small floating plant (*Lemna*).

Several of the plants are the first records from the British Flandrian (marked\*) or from the British Pleistocene as a whole (marked\*\*): cf. *Arabidopsis thaliana*\*\*\*, *Arenaria leptoclados*\*, *Eleocharis palustris* subsp. *palustris*\*, *Epilobium cf. hirsutum*\*, *Filaginella uliginosa*\*\*, *Myosotis scorpioides*\*\* (previous records were tentative), *Nitella cf. translucens*\*\*, *Tolypella nidifica*\* and *Veronica anagallis-aquatica*\*. The absence of other records of several of these plants probably reflects the scarcity of studies of small seeds from Flandrian deposits and the general scarcity of studies of oospores of charophytes. Another interesting palaeobotanical record is of *Teucrium scordium* (water germander), which is now rare in Britain; the only other Flandrian record is from the early Flandrian near Nazeing, Herts. (Allison, Godwin & Warren, 1952).

#### (d) Mollusca

Shells were scarce in the channel infills of silty organic mud within the gravels (unit 3). The sample of 7.2 kg (228D) yielded a total of only 26 shells, representing 8 aquatic and 4 terrestrial species (table 8). The aquatic species include *Bithynia tentaculata* and *Pisidium nitidum* which require substantial bodies of moving water, *Valvata cristata*, *Armiger crista* and *Planorbis* sp. which prefer sites with plentiful aquatic vegetation, and three tolerant species which typically occur in shallow or muddy pools, often those that dry in summer or are shaded by vegetation (*Lymnaea truncatula*, *L. palustris*, *Anisus leucostoma*). In view of the differing habitat preferences of some of these species it is more likely that their shells were accumulated by flow in river channels than that they were all living together. The terrestrial species represented include two that require unshaded habitats: *Pupilla muscorum* prefers dry ground with open grass or herb cover, whereas *Vallonia pulchella* prefers damp grassland but also occurs in drier places. *Oxyloma pfeifferi* lives in muddy places or among waterside herbs and *Trichia hispida* is a rather tolerant species that can live in grassland, fens or woodland.

Several of these Mollusca are uncommon in Middle Devensian deposits in eastern England (*Valvata cristata*, *Planorbis* sp., *Vallonia pulchella*) so that their occurrence together would be unlikely in a Middle Devensian deposit (cf. Holyoak, 1982). However, the presence of these species in an assemblage that lacks the many woodland species that characterise Flandrian deposits implies a Late Devensian age.

The silty mud (sample 228H) and detritus mud (samples 228B and 228E) both had abundant shells of freshwater Mollusca (table 8). Both of these assemblages of freshwater molluscs were similar to the living faunas of the richer, slow-flowing rivers of south-eastern England at the present day, except that species known to be modern introductions to Britain (*Potamopyrgus jenkinsi* (E. A. Smith), *Dreissena polymorpha* (Pallas)) were of course lacking.

Comparison of the assemblages from the silty mud (sample 228H) and the detritus mud (samples 228B/E) revealed that the silty mud had:

Table 8 Mollusca from Orton Longueville.

	Sample			
	228D	228H	228B	228E
Dry weight (kg)	7.2	0.85	0.24	
<i>Theodoxus fluviatilis</i> (L.)	-	1	-	
<i>Valvata cristata</i> Müller	2	11	140	(1)
<i>Valvata piscinalis</i> (Müller)	-	152	19	
<i>Bithynia tentaculata</i> (L.) shells	2	12	80	(4)
opercula	2	15	149	
<i>Bithynia leachii</i> (Sheppard) shells	-	3	30	
opercula	-	2	33	
<i>Bithynia</i> sp. shells	-	25	169	
opercula	-	2	109	
<i>Lymnaea truncatula</i> (Müller)	1	9	150	
<i>Lymnaea palustris</i> (Müller)	5	-	5	(2)
<i>Lymnaea stagnalis</i> (L.)	-	1	1	(1)
<i>Lymnaea auricularia</i> (L.)	-	-	-	(4)
<i>Lymnaea peregra</i> (Müller)	-	16	57	(8)
<i>Lymnaea</i> sp.	4	3	14	
<i>Planorbis planorbis</i> (L.)	-	-	47	
<i>Planorbis carinatus</i> Müller	-	15	3	(1)
<i>Planorbis</i> sp.	1	26	87	
<i>Anisus leucostoma</i> (Millet)	3	-	-	
<i>Anisus vortex</i> (L.)	-	-	73	(1)
<i>Bathyomphalus contortus</i> (L.)	-	1	-	
<i>Gyraulus albus</i> (Müller)	-	33	37	
<i>Armiger crista</i> (L.)	1	6	73	(1)
<i>Hippeutis complanatus</i> (L.)	-	1	3	
<i>Planorbarius corneus</i> (L.)	-	-	-	(6)
<i>Acroloxus lacustris</i> (L.)	-	3	1	
<i>Oxyloma</i> cf. <i>pfeifferi</i> (Rossmässler)	2	3	9	
Succineidae sp.	-	4	11	
<i>Pupilla muscorum</i> (L.)	1	1	-	
<i>Vallonia pulchella</i> (Müller)	1	-	1	
<i>Vallonia excentrica</i> Sterki	-	2	-	
<i>Vallonia</i> sp.	1	2	9	
<i>Deroceras</i> sp.	-	-	7	
<i>Trichia hispida</i> (L.)	1	-	1	
<i>Trichia</i> sp.	-	-	1	
<i>Anodonta</i> sp.	-	-	f	(X)
<i>Pisidium amnicum</i> (Müller)	-	1	1	(2)
<i>Pisidium casertanum</i> (Poli)	-	83	157	
<i>Pisidium obtusale</i> (Lamarck)	-	-	16	
<i>Pisidium milium</i> Held	-	2	31	
<i>Pisidium subtruncatum</i> Malm	-	12	10	
<i>Pisidium supinum</i> A. Schmidt	-	1	-	
<i>Pisidium henslowanum</i> (Sheppard)	-	7	2	
<i>Pisidium nitidum</i> Jenys	1	1	13	
<i>Pisidium moitessierianum</i> Paladilhe	-	27	1	
Totals	26	403	1218	

Notes f = fragment; X = many.

- (a) Many fewer shells per unit volume of sediment, which probably implies that this unit accumulated much more rapidly than the detritus mud;
- (b) Higher relative proportions of shells of species requiring or preferring moving water in rivers (*Theodoxus fluviatilis*, *Valvata piscinalis*, *Planorbis carinatus*, *Pisidium subtruncatum*, *P. supinum*, *P. henslowanum*, *P. moitessierianum*);
- (c) Much lower relative proportions of shells of species requiring or preferring plentiful vegetation in slow-flowing or standing water (*Valvata cristata*, *Planorbis planorbis*, *Anisus vortex*, *Armiger crista*, *Hippeutis complanatus*, *Pisidium milium*, *P. obtusale*).

Hence the assemblages of freshwater Mollusca provide clear indications that the sedimentological change from deposition of silty mud to deposition of detritus mud was accompanied by reduction in the rate of flow (or even cessation of flow) and increased abundance of aquatic vegetation.

Comments on Flandrian records of *Planorbis corneus* and *Pisidium supinum* in England are given above in section 4(c).

Shells of land molluscs are relatively scarce in both the silty mud and the detritus mud. However, the taxa recorded provide indications of the habitat conditions on land that reinforce the palaeobotanical evidence. Dry unshaded sites with open cover of grass or herbs are implied by presence of *Pupilla muscorum* and *Vallonia excentrica*, (probably) damp grassland by *Vallonia pulchella*, and wet mud or waterside herbs by *Oxyloma pfeifferi*. Slugs of the genus *Deroceras* and the snail *Trichia hispida* both tolerate a wide range of terrestrial habitats, including sites disturbed by man such as waysides and other waste ground.

**(e) Mammals**

A large limb bone found stratified within the gravels (unit 3) 0.3m from their top edge was the only mammalian fossil recovered. Dr. A. Lister identified the bone as giant deer *Megaceros giganteus* Blumenbach. This species became extinct in the Late Devensian and there are only two other records from England in this substage (Stuart, 1982, p.155).

**(f) Discussion**

Poor exposures and lack of evidence from fossils prevented any satisfactory interpretation of the basal clay (unit 1) and the overlying whitish sand (unit 2). Channel infills of silty organic mud within the fluvial gravels (unit 3) provided a pollen spectrum showing open treeless vegetation and macrofossils of plants of unshaded habitats. Although few shells were available the molluscan assemblage from these muds implied a Late Devensian rather than a Middle Devensian age.

A marked unconformity existed between the Late Devensian gravels of unit (3) and the overlying silty-mud deposits of late Flandrian age (unit 5). The localised infill of a small palaeochannel cut into the top of the gravels (forming unit 4) was not fossiliferous, so that its precise age was uncertain. However, subaerial exposure of the top of the gravels (unit 3) was evident locally from the presence there of truncated tree roots. These were presumably of Flandrian age and they were truncated by fluvial erosion prior to onset of deposition of the silty mud of unit (5).

The silty mud (unit 5) and overlying detritus mud (unit 6) accumulated underwater in a river channel. The change of sediment type between these units involved a great reduction in the input of silt-sized mineral particles, and it is argued above that the silty mud may have been deposited much more rapidly than the detritus mud. The sedimentological evidence of marked reduction or cessation of flow in the channel is accompanied by evidence from the molluscan assemblages of reduced flow and increased growth of aquatic vegetation. However, the palaeobotanical study showed little change between these units (in composition of either the pollen spectra or macrofossil assemblages), presumably because the increase in abundance of aquatic vegetation involved plant species that were already present at and near the site.

The silty clay (unit 7) extended laterally beyond the confines of the palaeochannel containing units (5) and (6). In view of this distribution and its texture it is interpreted as resulting from overbank deposition subsequent to the infilling of the palaeochannel. Soil development within this unit has led to its general decalcification and the oxidation of most of the plant remains that may have been present originally.

## Conclusions

Although based on studies at only three sites, the present investigation allows a number of tentative conclusions about the depositional history in the Nene Valley during the Late Pleistocene.

Middle Devensian fluvial deposits at or near modern floodplain level were previously known at Great Billing (Morgan, 1969), Thrapston (G. R. Coope, in Shotton, Blundell and Williams, 1970) and apparently elsewhere (Castleden, 1976, 1980a). The deposits at Little Houghton described above thus provide a further example of deposition at or near modern floodplain level during the Middle Devensian.

Late Devensian deposits beneath the floodplain of the River Nene at Thrapston were tentatively identified by Bell (1968); a radiocarbon date suggesting an early Flandrian age for these was thought to be too young. In the present study secure evidence of Late Devensian deposition of silts and muds within fluvial gravel sequences is provided from Titchmarsh and Orton Longueville. At both of these sites palynological data show tree-less conditions that must ante-date the early Flandrian, while the molluscan assemblages include a number of species that imply a Late Devensian rather than a Middle Devensian age.

Castleden (1980a) provided a model of river terrace formation in the Nene Valley. He attributed the entire sequence of terraces to the Devensian, but this was based on the unsupported assumption that 'During the previous two cold stages the Nene basin was engulfed by ice-sheets' (*op. cit.*, p.143). In that study the 1st Terrace/floodplain gravels were regarded as having aggraded between approximately 41-14 k yr B.P., followed by possible vertical incision between approximately 14-11 k yr B.P. and formation of the 1st Terrace surface between approximately 11-10 k yr B.P. This chronology is, however, inadequately supported by the evidence available as no deposits in the region have been reliably dated to between approximately 25 and 10 k yr B.P.

The Late Devensian deposits reported here cannot be reliably assigned to any particular part of the substage, although the presence of various of the molluscs may suggest the warmer conditions that developed elsewhere in England after about 15 k yr B.P. (cf. Coope, 1977). In addition, it may be noteworthy that the gravels at both Titchmarsh and Orton Longueville had well-preserved sedimentary structures with none of the evidence of ice-wedge casts noted at Little Houghton and Great Billing (Morgan, *op. cit.*), nor involutions and other post-depositional disturbance. This may suggest that deposition of the gravels during the Late Devensian was not followed by prolonged subaerial exposure in an environment with regional continuous permafrost, as evidently happened to the Middle Devensian deposits. Hence the undisturbed nature of the gravels at Titchmarsh and Orton Longueville may provide further support for an age in the younger half of the Late Devensian.

The oldest dated material overlying gravels of the River Nene floodplain appears to be wood from the base of alluvial clay at TL 08159960 which gave a radiocarbon date of  $9420 \pm 70$  yr B.P. (SRR-283) (Harkness and Wilson, 1979). This shows that movement of the floodplain gravels at that locality had ceased before or during the early Flandrian. The same may have occurred more generally on the Nene floodplain, but there is a dearth of information from deposits of early Flandrian age in the region.

At two locations river channel infills show that regional forest clearance had occurred by the time that deposition of the extensive silty-clay alluvium on the floodplain had begun. Around Orton Longueville this forest clearance was largely complete by the Iron Age. There can be little doubt that deposition of this alluvium of silt and clay resulted from extensive soil erosion caused by forest clearance followed by ploughing for early agriculture. The clearance of forests over much of the catchment may also have led to more rapid run-off, causing flooding that resulted in the widespread overbank deposition of silt and clay.

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**Explanation of Plate 19**

Plate 19. Shells of freshwater mussels from Flandrian deposits at Titchmarsh. A-F *Pseudanodonta complanata*, G-L *Unio tumidus*.

