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INTERGLACIAL DEPOSITS AT ILFORD, ESSEX

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CONTENTS

At Ilford, Essex, organic sediments have been found beneath the brickearth, long famous for its rich mammalian fauna. Pollen analysis shows that these organic sediments and the lower part of the overlying brickearth were deposited during the Ipswichian (Last) Interglacial. The pollen diagrams show the vegetational succession typical of the first half of the interglacial, with pollen zones *b*, *c*, *d*, *e* and *f*, which cover the early treeless part of the interglacial and the change to forested conditions with *Pinus* and *Quercus*. The rich flora of macroscopic plant remains indicates that a climate with summers warmer than now obtain in the area prevailed probably in zone *c* and more certainly in the later zones.

Analyses of the macroscopic plant remains and the non-marine Mollusca demonstrate that the organic deposits were formed in a large pond or a small stream, tributary to the Thames at that time. A rising base level, probably resulting from the rise in sea-level known to occur in zone *f* of the interglacial, caused the Thames floodplain to extend over the organic deposits, and brickearth was deposited up to a height of 42 ft. o.d. at least. The surface of the brickearth was contorted by cryoturbation during the Weichselian (Last) Glaciation.

The Ilford temperate deposits are correlated with temperate fossiliferous deposits at Little Thurrock (Grays), and more tentatively, with temperate fossiliferous deposits at Erith, Crayford and Ebbsfleet. The consequences of the dating of the Ilford brickearth to the Ipswichian Interglacial for the terrace succession of the lower Thames valley are considered.

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1. Introduction

In the spring of 1959 Mr Higginbottom, of the Central Laboratory of George Wimpey and Co. Ltd., brought to our notice an organic horizon which had been discovered under the Ilford brickearth* during a site investigation next to Seven Kings Station, Ilford (figures 1 and 2). Preliminary analyses of samples from the organic horizon disclosed the presence of pollen, abundant fruits and seeds, and Mollusca. Wimpey's, through the good offices of

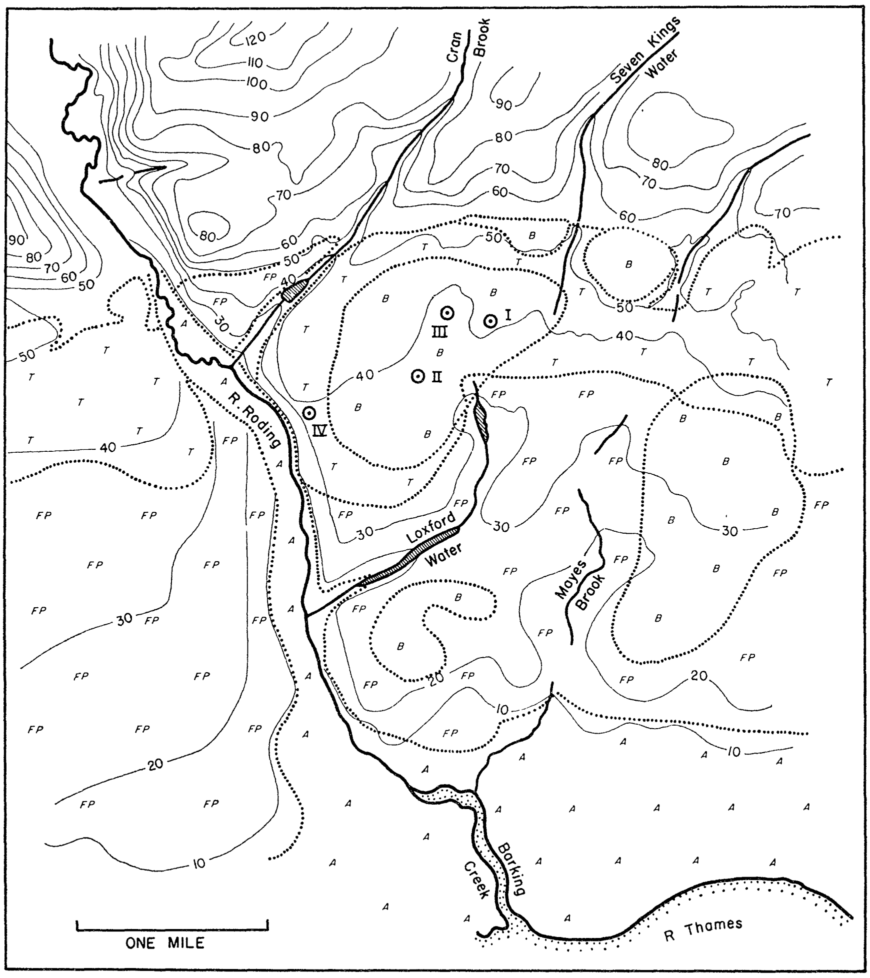


Figure 1. Relief, terrace deposits, and fossiliferous sites at Ilford. I, Seven Kings site; II, Gordon Road section; III, High Road pits; IV, Uphall pit. *T*, Taplow gravel; *FP*, Floodplain gravel; *B*, brickearth; *A*, alluvium; all according to the 1 in. Geological Survey Map, Sheet (drift) 257.

Mr Higginbottom, offered to put down a new borehole to obtain a continuous core through the organic deposits, and this borehole was made in April 1959. Analyses of the non-marine Mollusca and plant remains were made and these are described here. The Quaternary stratigraphy at the site is also described, and an attempt is made to relate the stratigraphy to the classic Ilford brickearth sections, the nearest of which is only two or three hundred yards to the west. The location of these old sites, and also sections described more recently by Rolfe (1958), are shown in figure 1.

* Although brickearth is strictly a bad lithological term, it is useful as a broad collective term describing a wide variety of fine inorganic sediments.

We make no detailed comparisons with the many other Pleistocene sites in the Ilford region, and we do not refer in detail to the descriptions of the previous sections or to the famous Ilford fauna. Rolfe (1958) gives a bibliography of the Ilford brickearth and its fauna. It is clear that much further work requires to be done on the exact provenance of the fauna in relation to the deposits described here.

We also attempt to describe the evidence for Thames terraces at Ilford, but we do not make detailed correlations of these with those of other parts of the Thames valley. Again, much further careful stratigraphical work is required on the lithology, floras and faunas of the different terraces before such correlations can be usefully made.

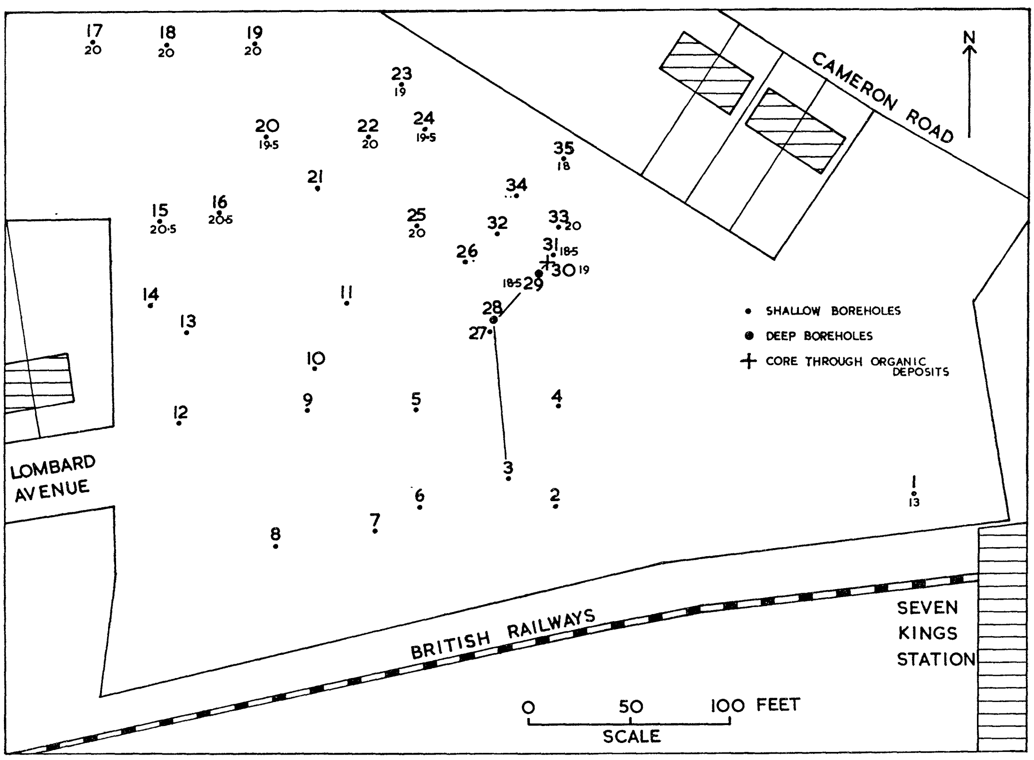


FIGURE 2. The Seven Kings site. The line shows the line of section in figure 3. The small figures by certain boreholes about 20 ft. deep indicate the depth at which the organic horizon was proved.

2. STRATIGRAPHY

Figure 2 shows the area where thirty-four boreholes were put down for site investigation and one (no. 30) for the purposes of the present investigation. Two deep percussion boreholes, nos. 28 and 29, reached the London Clay. Three auger holes, nos. 10, 21 and 34, only penetrated 10 ft. into the brickearth. One auger hole, no. 27, penetrated 25 ft. but did not find the organic muds. The remainder of the site investigation boreholes were auger holes to a depth of about 20 ft. Certain of these proved the organic muds at depths shown in small figures by the boreholes in figure 2. No figure is added where no muds were proved down to this depth. The borehole no. 30 made for the present investigation was augered to 18·5 ft. and then four 4 in. percussion cores were taken to a depth of 24·5 ft., through the organic muds to sand. The detailed stratigraphy of this borehole is given in Appendix 1.

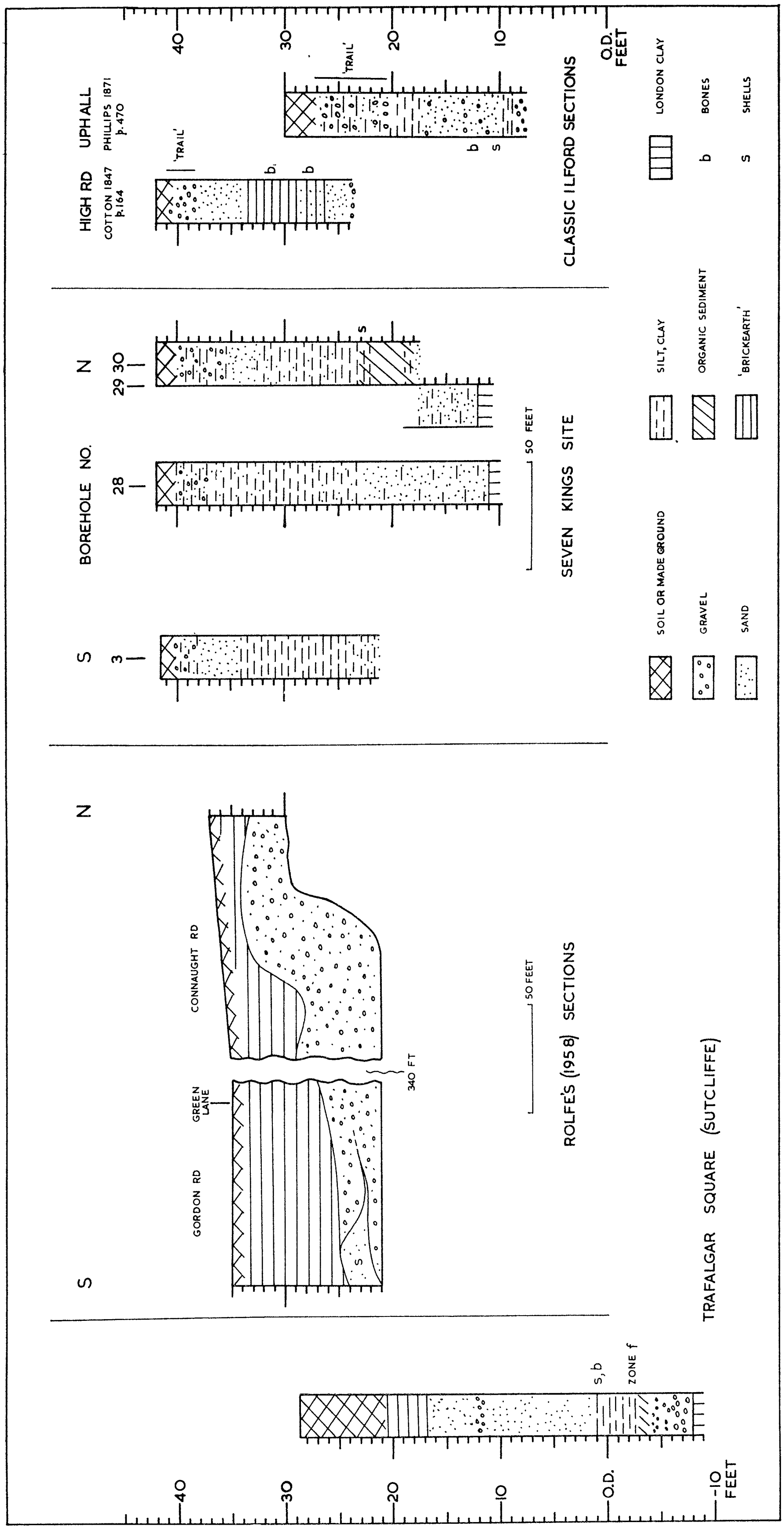


FIGURE 3. Sections at Ilford and Trafalgar Square, London.

The borings demonstrate:

(*a*) The occurrence of an organic horizon between basal sand and the overlying brickearth.

(*b*) That organic muds are found above 20 ft. below surface (*c*. 22 ft. O.D.) to the north and east of the site, but to the south the brickearth lies directly on the sand.

(*c*) The variability of the overlying brickearth, which varies from silty clay at the base to sandy gravel at the top (see also Hinton 1900).

(*d*) That the Pleistocene sequence rests on London Clay at about 10 ft. O.D.

Figure 3 shows the stratigraphy of the site. In boreholes no. 29 and no. 30 (see Appendix 1), a lower sand, lying on the London Clay, passes upwards through grey muddy silt to brown detritus mud. There is a gradual transition between this and the overlying brickearth at about 23 ft. O.D. The brickearth has varying proportions of clay, silt and sand. There is more sand, and gravel, towards the top. In borehole no. 28 the sand above the London Clay is overlaid by brickearth at 23 ft. O.D. Thus the organic deposits appear to lie in a channel or hollow in the lower sand.

The depositional history appears to be as follows. The organic deposits accumulated in a stream or pond, presumably a tributary to the River Thames of the time. A rise in the main river level resulted in the spreading of floodplain alluvium (brickearth) over the organic deposits of the tributary (see p. 205). The alluvium aggraded to a height of at least 42 ft. O.D. In the final stages of the aggradation coarser material was laid down. It is evident from the drawings of nearby sections in the brickearth given by Whitaker (1889) and Hinton (1900) that the gravelly deposits over the brickearth were later contorted by cryoturbation and frost wedges.

We now have to relate this sequence to the other sections in Ilford. The classic sections from the High Road and Uphall pits are shown in figure 3. There is no doubt that the brickearths of the High Road pits (see Hinton 1900) are of the same age as ours. They are at the same level and have similar lithology. With the Uphall pit (Whitaker 1889), there is some doubt because of the difference of heights, but the general lithology is similar and it seems reasonable to assume that the Uphall brickearths belong to the same stage of aggradation as our brickearth, but being close to the Roding Valley they have been truncated by erosion and solifluxion. The more recent sections described by Rolfe (1958) are also shown in figure 3. Here gravels underlie the brickearth. The temperate mollusc fauna of the sand associated with the gravel is discussed in §4. It appears that the sands and the gravels, in part at least, were formed in the main river during the same temperate period as the muds. Otherwise parts of the gravels may belong to an older stage of aggradation represented by the gravels (Taplow gravels) under the brickearth farther north and at a greater height (e.g. the gravels described by Holmes (1900)).

The other section shown in figure 3 is from excavations under Uganda House in Trafalgar Square. These details have been kindly supplied by Dr A. J. Sutcliffe of the British Museum (Natural History). Here sands and clays dated to zone *f* of the Ipswichian Interglacial (Franks 1960) are overlain by brickearth, with the junction at 17 ft. O.D. We shall demonstrate that the organic muds at Seven Kings also belong to the Ipswichian Interglacial. Aggradation of brickearths seems to have started at both sites at about the same heights in the middle of the interglacial.

3. Palaeobotany

(*a*) *Introduction*

The four 4 in. percussion cores of borehole no. 30 were split in half vertically and samples for pollen analysis were taken at close intervals from the centre of the core. The vertical halves of the cores were then divided horizontally into bulk samples at the levels shown in table 1. The basal sample of each core is the sediment in the shoe of the coring tool, about 5 cm in thickness. A few bulk auger samples above the organic deposit were also taken. The bulk samples were washed down for Mollusca and macroscopic plant remains. The relationship between the cored samples and the rest of the borehole is shown on the left of figures 4 to 6.

(*b*) *Pollen diagrams and zonation*

Tree pollen (*AP*) and non-tree pollen (*NAP*) diagrams are given in figures 4 and 5 respectively. The *AP* diagram also shows the proportions, in terms of the total pollen, of pollen of trees, shrubs, open ground herbs, Gramineae, Cyperaceae, other herbs, and aquatics.

The *AP* and *NAP* diagrams resemble diagrams from the Ipswichian (Last) Interglacial at Selsey, Sussex (West & Sparks 1960) and from Bobbitshole, Ipswich (West 1957). They are unlike the pollen diagrams from the two known interglacial stages older than the Ipswichian, the Hoxnian (West 1956) and Cromerian Interglacials (Duigan 1963). The following comparison of the Ilford pollen diagrams with those of the three known interglacials of the Upper and Middle Pleistocene, the Ipswichian, Hoxnian and Cromerian Interglacials, is based on sites in the south and east of England:

1. The late-glacial pollen spectra of zone *b* at Ilford, like those from the Ipswichian deposits at Bobbitshole and Selsey, show high *NAP* frequencies, with *Betula*, *Pinus* and *Juniperus* pollen prominent amongst the tree and shrub pollen. There is none of the *Hippophaë* pollen so abundant in the late-glacial of the Hoxnian. The late-glacial of the Cromerian is as yet little studied.

2. The rapid rise of the *Corylus* pollen curve, near the beginning of the mixed oak forest phase, is characteristic of the Ipswichian Interglacial and is also found at Ilford. In the Hoxnian and Cromerian the rise is much slower and the maximum is reached at a later stage in the forest development.

3. The stages of forest history at Ilford are similar to those of the first part of the Ipswichian. *Pinus*, *Quercus* and *Corylus* become the predominant pollen types of the forest, with *Carpinus* appearing later. In the Hoxnian *Ulmus*, *Tilia* and *Alnus* are frequent in the mixed oak forest zone before the appearance of *Carpinus*, and thus the mixed oak forest is more diverse than in the Ipswichian. The Cromerian mixed oak forest zone is characterized by high values of *Ulmus*, and so is unlike those of the Ipswichian and Hoxnian.

4. The substantial *Tilia* frequencies of the Hoxnian and Cromerian Interglacials have not been found in the Ipswichian Interglacial or at Ilford.

5. Low frequencies of *Alnus* pollen are found in the forested phase of the Ipswichian Interglacial, except in the zone *f* deposit at Wretton, Norfolk, now under investigation. Here, higher frequencies of *Alnus* pollen are found together with macroscopic remains of *Alnus*. In the Hoxnian and Cromerian Interglacials *Alnus* pollen frequencies are consistently high in the forested phase.

TABLE 1. LIST OF MACROSCOPIC PLANT REMAINS

zone		...	f	f	f	f	f	f	f	f	f	f	f	f	e	d/e	c	c/b	b	b	b	b	b	b
						core 1 (18 ft. 6 in. to 20 ft. 0 in.)					core 2 (20 ft. 0 in. to 21 ft. 6 in.)					core 3 (21 ft. 0 in. to 23 ft. 0 in.)						core 4 (23 ft. 0 in. to 24 ft. 6 in.)		
	type of remains	depth 17 ft. 9 in.	18 ft. 0 in.	18 ft. 6 in.	18 ft. 9 in.	29–36 cm	20–29 cm	10–20 cm	0–10 cm	Base	20–28 cm	10–20 cm	2–10 cm	0–2 cm	Base	35–42 cm	29–35 cm	20–29 cm	10–20 cm	0–10 cm	Base	30–39 cm	20–30 cm	12–20 cm
Alisma plantago-aquatica L.	*f*	.	2	3	31	36	90	80	78	29	29	22	42	14	1	–	1	1	–	5	4	1	4	1
Aphanes arvensis s.l.	*a*	.	.	.	.	.	2	6	6	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.
Arenaria cf. *serpyllifolia* L.	*s*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	3	.	.	.	.
Atriplex hastata L. or *patula* L.	*s*	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.
cf. *Atriplex* sp.	*s*	.	.	.	.	.	.	.	1	1	.	2	.	.	.	.	.	.	.	.	.	.	.	.
Berula erecta (Huds.) Coville	*f*	.	.	.	.	.	.	.	1	1	.	1	.	4	2	.	1	.	.	1	.	.	.	.
Betula sp. (tree)	*f*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
Butomus umbellatus L.	*f*	.	.	.	.	2	4	2	1	1	1	.	.	.	1	.	.	.	.	.	.	.	.	.
Callitriche sp.	*f*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
Capsella bursa-pastoris (L.) Medic.	*s*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	1	.
Carex appropinquata Schumach or *paniculata* L.	*n+u*	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.
C. riparia Curt.	*n+u*	.	.	.	.	.	2	2	2	7	.	.	2	.	.	.	.	.	.	.	.	.	.	.
C. rostrata Stokes.	*n+u*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
C. strigosa Huds.	*n+u*	.	.	.	.	.	.	.	3	.	17	9	22	16	2	.	.	.	.	.	.	.	.	.
Carex spp.	*n*	1	.	.	.	27	104	39	89	84	113	85	126	52	16	15	9	.	.	.	7	5	8	.
Caryophyllaceae	*s*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
cf. *Cerastium* sp.	*s*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.
Ceratophyllum demersum L.	*f*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	2	1	.
Chenopodium cf. *album* L.	*s*	.	.	.	.	.	.	.	.	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.
Chenopodium section *Pseudoblitum*	*s*	.	.	.	.	1	.	.	1	2	15	8	8	.	.	.	.	.	.	.	.	.	.	.
Cirsium arvense (L.) Scop. or *palustre* (L.) Scop.	*a*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	3	.	.	2
Cirsium sp. or *Carduus* sp.	*a*	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1	.	1	.
Cruciferae	*s*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.
Cucubalus baccifer L.	*s*	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.
Cyperaceae	*n*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	3	.	.	.	.
Eleocharis palustris (L.) Roem. & Schult.	*n*	.	.	.	.	9	8	2	10	2	.	.	.	.	.	.	.	.	1	7	14	.	14	13
E. palustris agg.	*n*	.	.	.	.	.	.	.	.	1	.	1	.	.	.	.	.	1	.	.	.	.	.	.
E. uniglumis (Link.) Schult.	*n*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.
Epilobium parviflorum Schreb.	*s*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	3	.
Eupatorium cannabinum L.	*a*	.	.	.	.	.	1	2	3	13	4	1	3	2	1	.	.	.	.	.	.	.	.	.
Groenlandia densa (L.) Fourr.	*fst*	.	.	.	.	1	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	1	.	.
Herniaria sp.	*s*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1
Hippuris vulgaris L.	*fst*	.	.	.	.	1	5	4	10	10	2	.	.	.	.	.	.	.	.	.	.	.	1	.
Hydrocharis morsus-ranae L.	*s*	.	.	.	.	1	.	2	2	.	.	4	3	2	9	2	4	.	.	.	.	.	.	.
Hypericum tetrapterum Fr.	*s*	.	.	.	.	.	1	1	.	3	.	2	1	.	.	.	.	.	.	.	.	.	.	.
Juncus sp.	*s*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.
Lemna cf. *minor* L.	*s*	.	.	.	.	.	.	2	.	2	17	16	19	7	.	.	.	.	.	.	.	.	.	.
cf. *Leontodon* sp.	*a*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.
Linum anglicum Mill.	*s*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.
Lycopus europaeus L.	*n*	.	.	.	.	.	14	5	13	13	7	10	16	11	3	2	19	10	5	21	32	21	16	.
Mentha aquatica L. or *arvensis* L.	*n*	.	.	.	.	2	10	8	10	14	1	5	10	16	24	44	2	1	.	.	2	.	2	.
Moehringia trinervia (L.) Clairv.	*s*	.	.	.	.	.	.	.	.	.	1	2	.	.	.	.	.	.	.	.	.	.	.	.
Myriophyllum spicatum L. or *verticillatum* L.	*n*	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	9	2	29	22	8	14	1

TABLE 1 (*cont*).

	zone ...	*f*													*e*	*d/e*	*c*	*c/b*	*b*					
						core 1 (18 ft. 6 in. to 20 ft. 0 in.)					core 2 (20 ft. 0 in. to 21 ft. 6 in.)					core 3 (21 ft. 6 in. to 23 ft. 0 in.)						core 4 (23 ft. 0 in. to 24 ft. 6 in.		
	type of remains	depth 17 ft. 9 in.	18 ft. 0 in.	18 ft. 6 in.	18 ft. 9 in.	29–36 cm	20–29 cm	10–20 cm	0–10 cm	Base	20–28 cm	10–20 cm	2–10 cm	0–2 cm	Base	35–42 cm	29–35 cm	20–29 cm	10–20 cm	0–10 cm	Base	30–39 cm	20–30 cm	12–20 cm
Oenanthe aquatica (L.) Poir.	*f*	.	.	.	2	27	25	16	17	10	12	17	22	15	4	.	.	.	.	.	.	.	.	.
Plantago major L.	*s*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	3	.	.	.	3	.
Polygonum aviculare L. s.l.	*n*	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	2	.
P. convolvulus L.	*n*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
P. lapathifolium L. or *nodosum* Pers.	*n*	.	.	.	.	1	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.
Polygonum sp.	*n*	.	.	.	.	.	1	.	1	.	1	1	.	.	.	.	.	.	.	.	.	.	.	1
Potamogeton berchtoldii Fieb.	*fst*	.	.	.	.	.	1	2	.	6	21	33	6	.	.	.	4	9	.	.	2	.	4	1
P. crispus L.	*fst*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4	4	.	21	7	7	3
P. pectinatus L.	*fst*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.
P. trichoides Cham. & Schlecht or *acutifolius* Link.	*fst*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	2	1	.	.
Potamogeton spp.	*fst*	.	.	.	.	.	.	2	2	1	1	4	3	2	.	1	1	1	.	3	2	2	4	.
Potentilla anserina L.	*a*	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
P. cf. *argentea* L.	*a*	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	1	.	.	.	.
P. crantzii (Crantz) G. Beck ex Fritsch. or *P. tabernaemontani* Aschers.	*a*	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1	.	.	3	1	3	2	.
Potentilla sp.	*a*	.	.	.	.	1	8	3	.	1	3	1	4	2	.	.	.	.	.	.	.	.	.	.
Ranunculus cf. *acris* L.	*a*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.
R. lingua L.	*a*	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.
R. repens L.	*a*	.	.	.	.	3	.	2	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.
R. sardous Crantz.	*a*	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
R. sceleratus L.	*a*	.	.	.	4	38	75	91	89	73	55	51	55	23	53	15	3	1	2	1	.	.	.	.
Ranunculus sp.	*a*	.	.	.	.	3	1	1	1	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.
Ranunculus-Batrachium spp.	*a*	.	.	.	5	25	8	8	11	7	19	16	15	9	3	2	1	1	3	2	2	.	3	.
Rorippa microphylla (Boenn.) Hyland.	*s*	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.
Rubus sp.	*fst*	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Rumex hydrolapathum Huds.	*n+p*	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
R. maritimus L.	*n+p*	.	.	.	.	4	.	3	3	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Rumex sp.	*n*	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1	.	1	2	.	.	.
Sagittaria sagittifolia L.	*f*	.	.	8	6	4	4	9	6	.	4	2	7	.	.	.	.	.	.	.	.	.	.	2
Salix sp.	*b*	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	2	.	.
Sambucus nigra L.	*s*	.	.	.	.	.	.	.	.	.	1	4	1	1	1	.	.	.	.	.	.	.	.	.
Scirpus lacustris L.	*n*	.	.	.	.	1	.	2	.	.	4	5	9	18	95	30	39	40	10	82	81	195	143	.
Scirpus sp.	*n*	.	.	.	.	.	4	.	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Scleranthus cf. *annuus* L. s.l.	*f*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.
Solanum dulcamara L.	*s*	.	.	.	.	.	.	1	1	2	.	.	1	.	.	.	.	.	.	.	.	.	.	.
Sparganium erectum L.	*fst*	.	.	.	2	2	12	13	18	16	15	17	18	11	6	.	1	1	.	1	1	.	1	.
Stachys cf. *arvensis* (L.) L.	*n*	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.
Stellaria media (L.) Vill.	*s*	.	.	1	.	1	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.
Teucrium scordium L.	*n*	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
cf. *Thalictrum* sp.	*a*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.
Typha sp.	*s*	.	.	.	.	1	2	2	2	6	21	49	63	46	112	71	72	2	.	3	4	1	3	.
Urtica dioica L.	*f*	.	.	.	.	1	3	2	.	8	6	10	8	2	3	.	.	.	.	.	.	.	.	.
Viola palustris L.	*s*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
Zannichellia palustris L.	*a*	.	.	.	.	3	4	6	18	24	70	29	39	.	3	.	.	.	.	.	.	.	.	.
	total	1	2	12	50	197	390	323	305	342	447	413	513	265	339	182	162	91	35	171	208	254	246	25

abbreviations: *a*, achene; *b*, budscale; *f*, fruit; *fst*, fruit-stone; *n*, nutlet; *p*, perianth; *s*, seed; *u*, utricle.

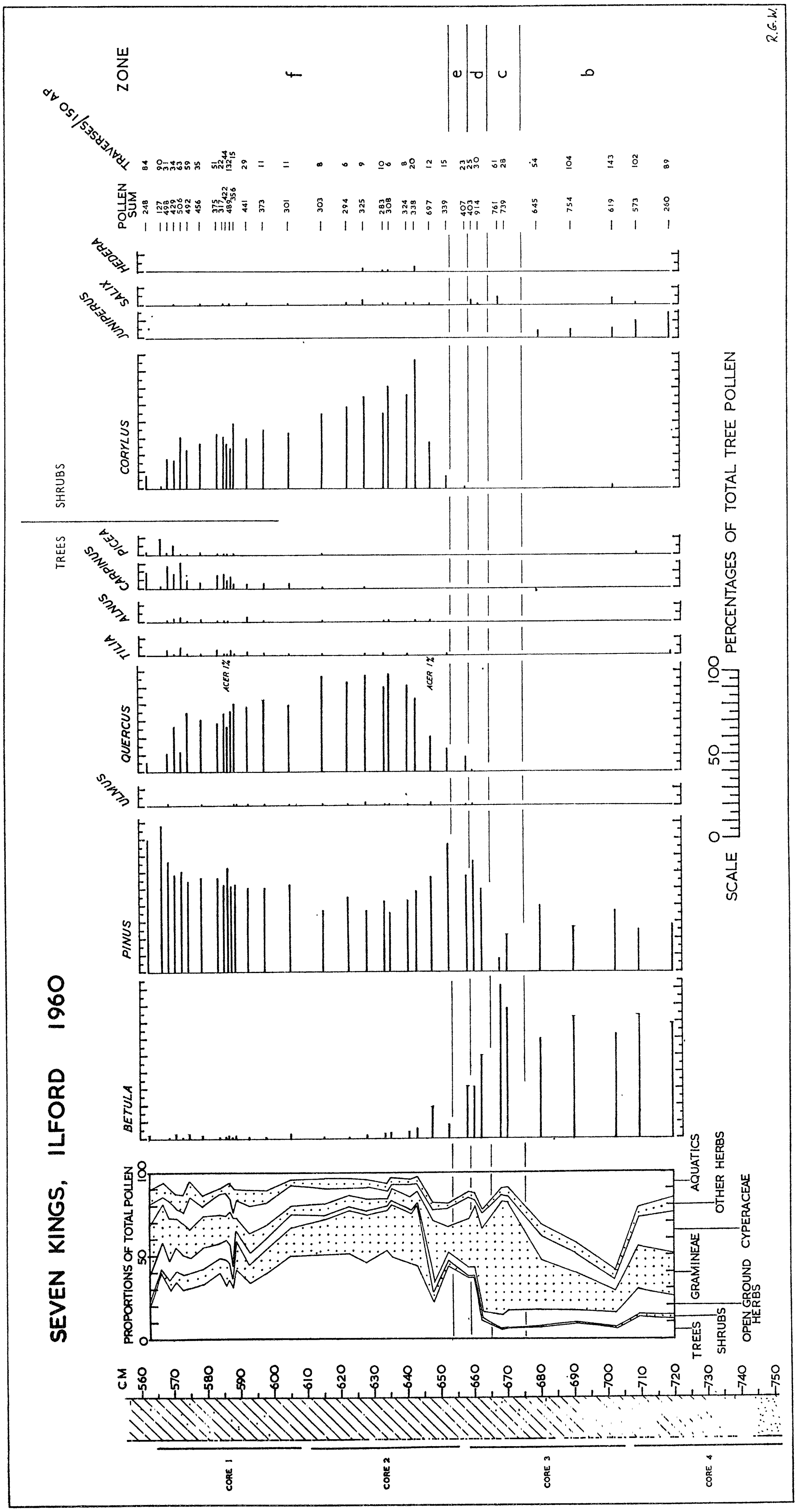


FIGURE 4. Tree pollen diagram from borehole no. 30. Sediment symbols as in figure 3.

6. *Acer* pollen is frequent in zone *f* of the Ipswichian at Trafalgar Square (Franks 1960), Bobbitshole (West 1957) and Stone (West & Sparks 1960). It is very rare at Ilford, as it is in the Hoxnian and Cromerian Interglacials. *Acer* is insect-pollinated and it is highly likely that the pollen rain of the tree is very local. The irregular appearance of high *Alnus* pollen frequencies in the Ipswichian referred to above may also be explained by a local distribution of the *Alnus*. The behaviour of *Acer* and *Alnus* in the Ipswichian Interglacial has been discussed in more detail elsewhere (West 1964).

7. The substantial *Carpinus* pollen frequencies in the upper part of the Ilford diagram and the low frequencies of *Picea* pollen are both characteristic of the latter part of the Ipswichian Interglacial. In the Hoxnian low *Carpinus* pollen frequencies appear first long after the appearance of a continuous pollen curve for *Picea*. In the Cromerian, as far as is now known, *Carpinus* is very rare and *Picea* is common throughout the forested phase.

This comparison strongly indicates that the Ilford organic deposit is of Ipswichian age. The diagrams can, in fact, be zoned according to the scheme of Jessen & Milthers (1928) for the Last (≡ Ipswichian) Interglacial deposits of Denmark and north-west Germany, as were the diagrams of Bobbitshole and Selsey. Zones *b*, *c*, *d*, *e* and *f* can be distinguished. The characteristics of these zones and their demarcation are as follows:

Zone *f*. 563–653 cm. Zone of *Quercus*, *Pinus* and *Corylus*. The base of the zone is where *Corylus* begins to rise to high values.

Zone *e*. 653–660 cm. Zone of *Pinus*, *Betula* and *Quercus*. The base of the zone is where the *Quercus* curve starts to rise.

Zone *d*. 660–665 cm. Zone of *Pinus* and *Betula*. The base of the zone is where *Pinus* starts to rise and *Betula* declines.

Zone *c*. 665–675 cm. Zone of *Betula* and *Pinus*. High *NAP* frequencies, mainly composed of Gramineae pollen.

Zone *b*. 675–720 cm. Zone of high frequency of *NAP*, with variety of *NAP* types, *Betula*, *Pinus* and *Juniperus*.

Zones *c*, *d* and *e* are very compressed in these pollen diagrams and occupy 22 cm of sediment. At Selsey they are also compressed (30 cm) but at Ipswich they are more clearly developed (130 cm). Although *Carpinus* occurs towards the top in the Ilford diagram, zone *g*, the *Carpinus* zone, has not been demarcated. This zone properly shows far greater frequencies of *Carpinus* pollen, as at Histon Road, Cambridge (Sparks & West 1959) and in a site under investigation at Wretton, Norfolk, where the end part of zone *f* has similar low frequencies of *Carpinus*.

(*c*) *Macroscopic plant remains*

The macroscopic plant remains identified and the numbers found are recorded in table 1. The nomenclature follows Dandy (1958). Frequencies of the most common species are shown in figure 6.

(*d*) *Vegetational and environmental history*

Zone *b* (grey muddy silt). Open vegetational conditions in this zone are indicated by the high *NAP* frequencies, mostly over 90% of the total pollen. *Betula* and *Pinus* pollen are both present throughout the zone, but in very low frequencies. These two genera, and *Juniperus*, represented by a low continuous pollen curve, must have been scarce in the region. One fruit of a tree *Betula* was found in the zone. Perhaps all the *Pinus* pollen is distantly derived.

The herbaceous pollen is divided into various categories in the pollen diagram. Apart from the aquatics the pollen of Gramineae and Cyperaceae is the most common of the herbaceous pollen types. Of the open-ground herbs there are substantial frequencies of pollen of *Artemisia*, Chenopodiaceae and Compositae. In this category is also recorded the pollen of *Helianthemum*, *Plantago maritima*, *P. major/media*, *Polygonum aviculare*, *P. convolvulus* and *Linum catharticum*. Of the other herbs, which might be members of the marsh or terrestrial floras, pollen of Caryophyllaceae, *Ranunculus*, *Thalictrum* and Umbelliferae is well represented. Amongst the aquatics, pollen of *Alisma*, *Caltha*, *Myriophyllum alterniflorum* and *Typha latifolia* is infrequent and that of *Myriophyllum spicatum/verticillatum* and *Sparganium*-type abundant.

The sediments of zone *b* contained a rich flora of macroscopic plant remains. Apart from the single tree *Betula* fruit and two bud-scales of *Salix*, the remains were of terrestrial herbs, helophytes and hydrophytes. The terrestrial herbs include *Arenaria* cf. *serpyllifolia*, *Capsella bursa-pastoris*, cf. *Cerastium* sp., *Herniaria* sp., *Linum anglicum*, *Plantago major*, *Polygonum aviculare*, *Polygonum convolvulus*, *Potentilla anserina*, *Potentilla* cf. *argentea*, *Potentilla crantzii/tabernaemontani*, *Ranunculus acris* and *Scleranthus* cf. *annuus*. Many of these plants are characteristic of waste places, others of dry and sandy habitats. The helophytes include *Alisma plantago-aquatica*, *Berula erecta*, *Carex rostrata*, *Eleocharis palustris*, *E. uniglumis*, *Epilobium parviflorum*, *Lycopus europaeus*, *Ranunculus repens*, *R. sceleratus*, cf. *Thalictrum* and *Viola palustris*. The hydrophytes include *Callitriche* sp., *Ceratophyllum demersum*, *Groenlandia densa*, *Hippuris vulgaris*, *Myriophyllum spicatum/verticillatum*, *Potamogeton berchtoldii*, *P. crispus*, *P. acutifolius/trichoides*, *Sagittaria sagittifolia*, *Scirpus lacustris*, *Sparganium erectum* and *Typha* sp. (*T. latifolia* pollen is present). The frequency of the most common of these species is graphed in figure 6.

The pollen and macroscopic analyses show that during zone *b* times a rich aquatic and marsh flora grew in and around the water body, probably a small pond or a slowly flowing river. In the surrounding region grew open herbaceous vegetation with few trees or shrubs. Presumably the dry sandy soils indicated by many of the terrestrial plants formed on the surface of the Taplow and Boyn Hill gravels mapped in the region. The calcicolous plants recorded, *Helianthemum* and *Linum*, may have grown on the nearby Chalk.

Of the 32 species identified by macroscopic remains from zone *b*, 17 are wide ranging throughout Scandinavia and 27 throughout the British Isles. Certain of the species have a southern or continental type of distribution in Britain or in Scandinavia. These include *Berula erecta*, *Groenlandia densa*, *Herniaria* sp., *Lycopus europaeus*, *Potamogeton crispus* and *P. acutifolius/trichoides*. Taken as a whole, the flora of zone *b* seems to indicate more temperate conditions than now obtain in the Arctic or Sub-arctic, despite the paucity of trees. The southern species mentioned above, together with the substantial frequencies of *Artemisia* pollen, indicate a continental type of climate. The same general conditions of vegetation and flora were also found in zone *b* at Selsey and seem to be a feature characteristic of the beginning of this temperate stage. At Bobbitshole, Ipswich, a silt resembling water-laid loess occurred immediately under the zone *b* organic deposit, again suggesting continental climatic conditions at this time.

The treelessness of this zone is not necessarily climatically controlled. Indeed, the southern species mentioned above, and the absence of true steppe species, suggest it was not. It may then be caused by two other factors, singly or in combination. First, the presence of fresh unleached soils formed by solifluxion and other periglacial activities

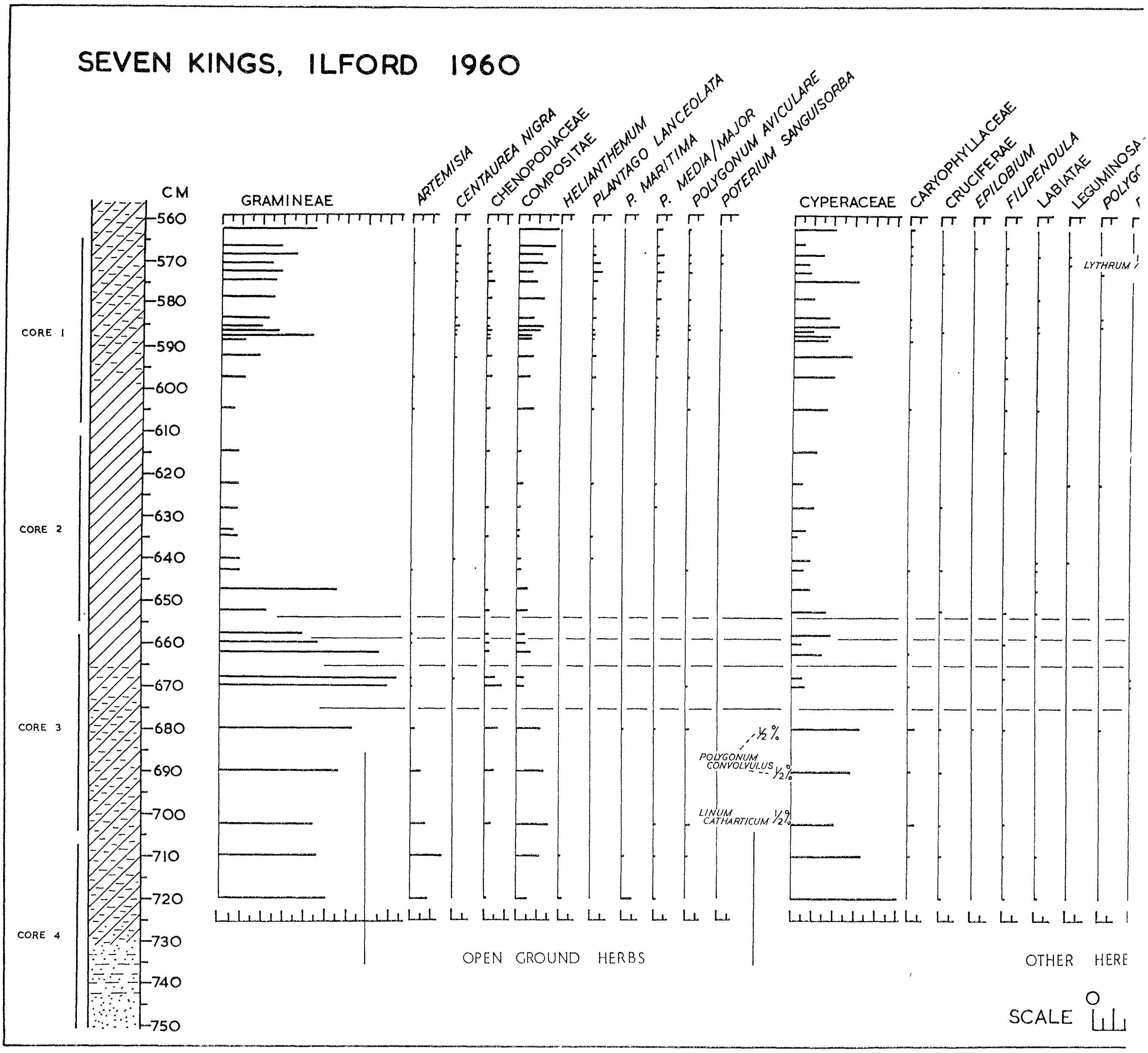
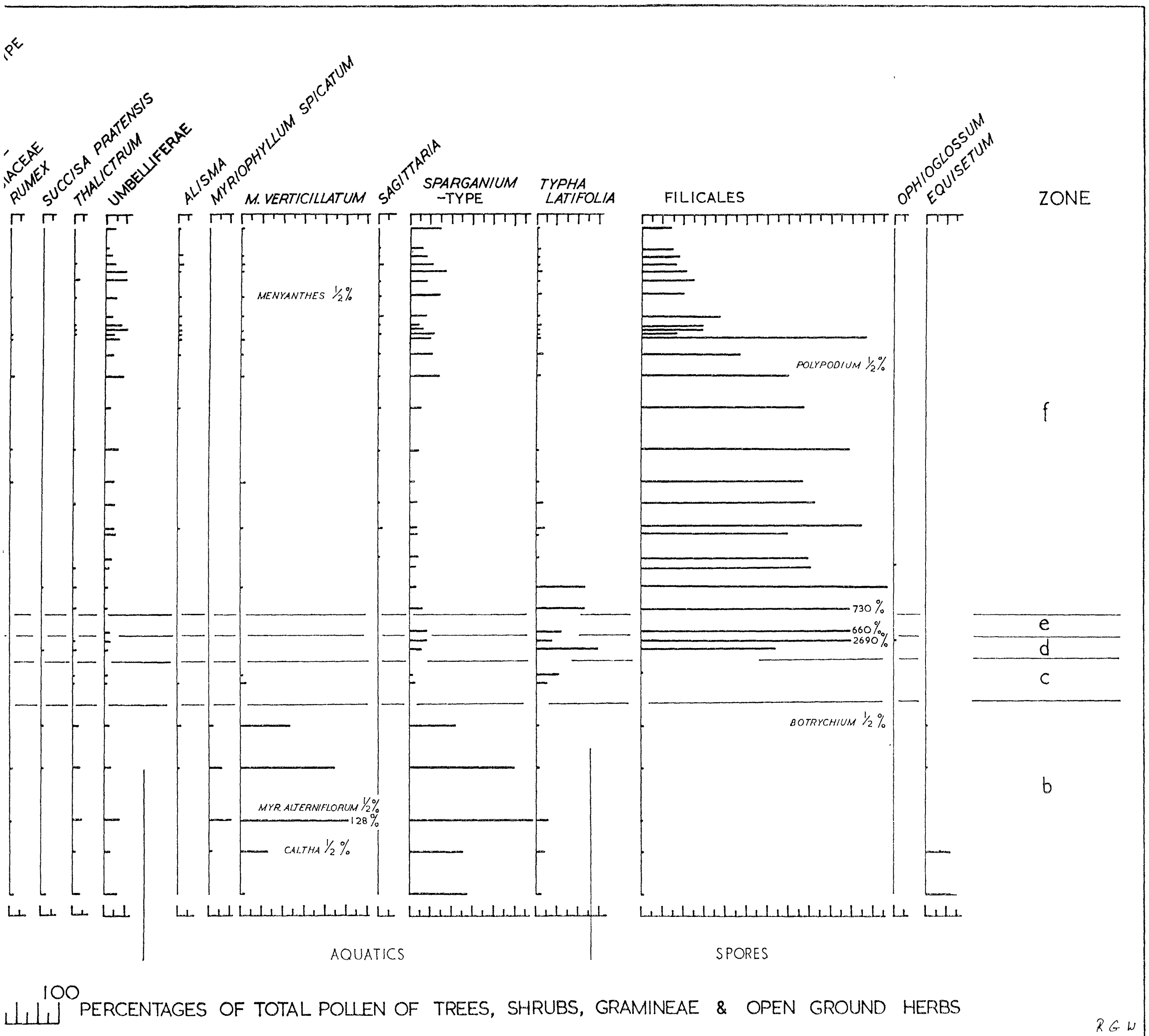


FIGURE 5. Non-tree pollen diagram fro

would favour open pioneer vegetation (note the number of species of waste and open ground recorded in zone *b*). Secondly, the trees, particularly the more thermophilous ones, may not have had time to spread in the area from the regions they were confined to during the rigours of the previous glaciation.

Zone c (fine detritus mud with laminations of grey clay and silt).

High *NAP* frequencies in this zone indicate the continuation of open vegetational conditions. The main change is the expansion of the *Betula* curve, and the absence of *Juniperus* pollen. Amongst the *NAP* types, Gramineae reach high values, but Cyperaceae pollen and



no. 30. Sediment symbols as in figure 3.

pollen of the open-ground herbs falls away in frequency. *Typha latifolia* pollen becomes much more frequent, and that of *Myriophyllum spicatum*, *M. verticillatum* and *Sparganium*-type much less. The reduction in the frequency and variety of the open-ground herbs is possibly related to the increase of *Betula*, with the high Gramineae values being a local effect. Such a regional change took place at Selsey at the transition from zone *b* to zone *c*.

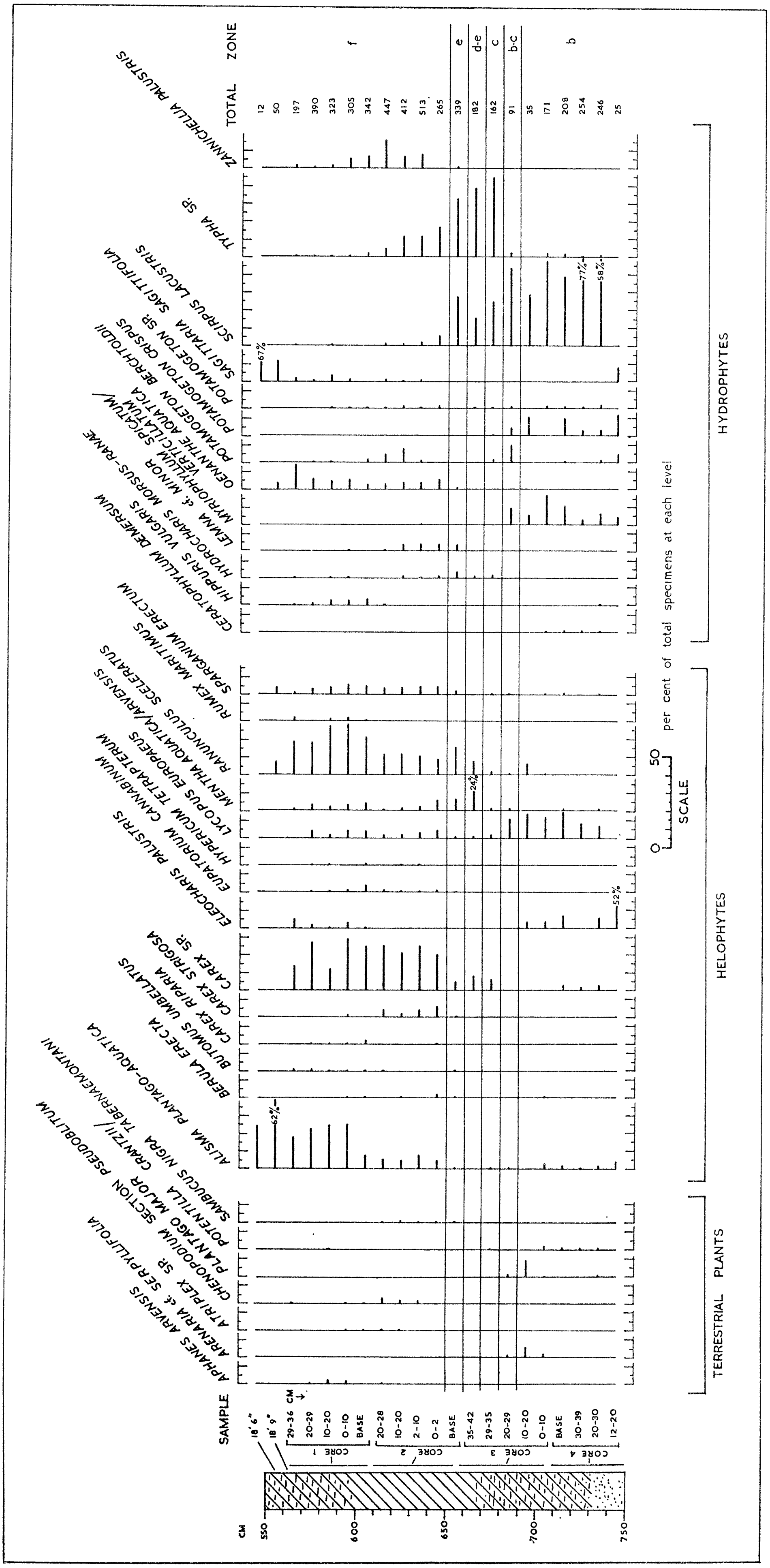


FIGURE 6. Frequencies of macroscopic plant remains in borehole no. 30. Sediment symbols as in figure 3.

The macrofossil frequency changes seen in figure 6 indicate the restriction of the aquatic flora and the spread of the reed swamp vegetation during zone *c*. There is a steep rise in the frequency of *Typha* seeds, in part at least *Typha latifolia* as indicated by the pollen record. At the same time there is a decrease of the aquatics *Myriophyllum*, *Potamogeton crispus*, and also of *Scirpus lacustris*. The sediment of this zone, alternating organic and inorganic layers, suggests fluctuating conditions of water supply, and such might also favour the spread of the reedswamp.

Zone *c* covers only 10 cm of sediment and the macroscopic flora is much poorer than zone *b*, only 11 species being recorded in zone *c* proper. The terrestrial species are much rarer but the helophytes and hydrophytes remain well represented. Two additions to the hydrophytes are *Hydrocharis morsus-ranae* and *Potamogeton pectinatus*. The former rarely if ever fruits in this country now, and the presence of its seeds in zone *c* suggests a considerable summer warmth, more so than in the region at present.

Zone d (detritus mud).

At the beginning of this zone the sediment becomes predominantly organic. The *NAP* frequency declines to values (*ca.* 60%) remaining more or less the same throughout the rest of the section. In this zone *Pinus* pollen is more frequent than *Betula*. The zone represents a short-lived phase, before the spread of deciduous thermophilous trees, in which *Pinus* and *Betula* became more widely distributed at the expense of the open herbaceous vegetation. Amongst the herbaceous pollen the frequency of Gramineae remains high, and pollen of Cyperaceae, Chenopodiaceae, Compositae and *Typha latifolia* is well represented. There is a great rise of frequency of Filicales spores during the zone.

There is no record of terrestrial species in the macroscopic list from this zone. The same helophyte and hydrophyte species occur as in zone *c*, except that the *Potamogeton* species are not found. The macrofossil frequency curves of figure 6 show the further decline of *Potamogeton* and *Scirpus lacustris*, and also of *Lycopus europaeus*, perhaps confined by the growth of the reedswamp with *Typha*. Seeds of *Mentha*, *Ranunculus sceleratus*, *Scirpus lacustris* and *Typha* are the most common macrofossils in this zone.

There is no indication of change in climatic conditions since the previous zone, apart from the amelioration perhaps suggested by the fall in *NAP* and rise of *Pinus* and *Betula*. The warmth of zone *c* already mentioned makes it more likely that the changes are successional.

Zone e (detritus mud)

Quercus spreads in this zone and contributes a low proportion of the total tree pollen. *Pinus* pollen frequencies remain high, but *Betula* declines in frequency. The *NAP* frequency is still substantial. Gramineae and Cyperaceae remain the most common *NAP* types, with *Sparganium*-type and *Typha latifolia* the only aquatics. The macrofossil list again lacks terrestrial species, apart from *Sambucus nigra* and *Urtica dioica*. The helophytes and hydrophytes remain much as in the previous zone, except for the addition of *Eupatorium cannabinum*, *Carex strigosa* and *Zannichellia palustris*. Both the former species have a southern type of distribution. There is no clear indication of climatic change since the previous zones.

Zone f (detritus mud, then transition to clay-mud)

Near the beginning of this zone the herbaceous pollen falls to its lowest values in the section (*ca*. 20%). Forest became widespread in the region, with *Pinus*, *Quercus* and *Corylus* the most important constituents. Of the other trees, *Betula*, *Ulmus*, *Tilia* and *Alnus* are scarcely represented by pollen throughout the zone, whereas *Carpinus* and *Picea* pollen frequencies rise in the latter half of the zone. By the end of the zone, *Quercus* and *Corylus* pollen frequencies have declined considerably, but *Pinus* has risen. The considerable frequencies of *Pinus* pollen throughout the zone may result from this tree being favoured by the dry soils formed on the neighbouring spreads of sand and gravel.

In the middle of the zone the herbaceous pollen frequencies begin to rise again, and by the end of the zone reach some 60% of the total pollen. The variety of herbaceous pollen also increases in the upper part of the zone. It includes many open ground herbs—*Artemisia*, *Centaurea nigra*, Chenopodiaceae, *Plantago lanceolata*, *P. media/major*, *Polygonum aviculare*, and *Poterium sanguisorba*. The variety of pollen of aquatics also increases in this zone; *Alisma*, *Myriophyllum verticillatum*, *Menyanthes*, *Sagittaria*, *Sparganium*-type and *Typha latifolia* pollen are all present.

The macrofossil list for the zone comprises some 40 species. Shrubs are represented by *Salix* and *Sambucus nigra*. There are 15 species of terrestrial herbs, many characteristic of waste places; they include *Aphanes arvensis* agg., *Chenopodium* cf. *album*, *Polygonum aviculare*, *P. lapathifolium/nodosum*, *Potentilla anserina*, *Potentilla* cf. *argentea*, *P. crantzii/tabernaemontani*, *Ranunculus sardous*, *Solanum dulcamara*, cf. *Sonchus asper*, *Stachys* cf. *arvensis* and *Stellaria media*. There are 14 species of helophytes and 11 of hydrophytes. Most of them are the same as in the previous zones; newcomers are *Carex riparia*, *Hypericum tetrapterum*, *Lemna* cf. *minor*, *Rorippa microphylla*, *Rumex hydrolapathum*, *Rumex maritimus* and *Butomus umbellatus*.

In terms of the sediment, pollen and macroscopic remains, zone *f* is divisible into two parts. An early part with the deposition of the detritus mud, low herbaceous pollen frequencies, and a macroscopic flora rich in aquatics and an upper part, with clay-mud, *Carpinus* in the forest, higher frequencies of herbaceous pollen and a restricted marsh flora. The change from the lower to the upper part follows the flooding of the organic deposits by the clay-muds.

In the lower part of the zone, as illustrated in figure 6, the aquatics include *Potamogeton berchtoldii*, *Zannichellia palustris*, *Lemna* cf. *minor* and *Hydrocharis morsus-ranae*. There is also a continuing decline of *Typha* seeds. These changes may be the result of a raising of the water level. This phase also shows the presence of several herbs which are often maritime in distribution, e.g. *Chenopodium* section *Pseudoblitum*, *Atriplex hastata/patula*, and *Rumex maritimus*. There is an indication of neighbouring maritime conditions in this assemblage and it is reasonable to explain the rise in water-level and the subsequent flooding to the rise in sea-level which is known to take place in zone *f* of this interglacial (West & Sparks 1960). The flooding of the organic deposits and the deposition of the clay-mud and then brickearth is associated with a rise in the frequency of seeds of *Alisma plantago-aquatica*, *Ranunculus sceleratus* and *Sagittaria sagittifolia*, and a decline of the aquatics. This assemblage in the clay-muds is such as would be found today in shallow muddy water.

The variety of the open-ground herbs found both as pollen and macroscopic plant remains, especially in the upper part of the zone, suggests much open vegetation in the neighbourhood. The many plants indicative of waste places are probably associated with disturbed ground on and marginal to the floodplain. The large mammals found fossilized in the brickearth must have affected the vegetation and produced suitable habitats for these plants.

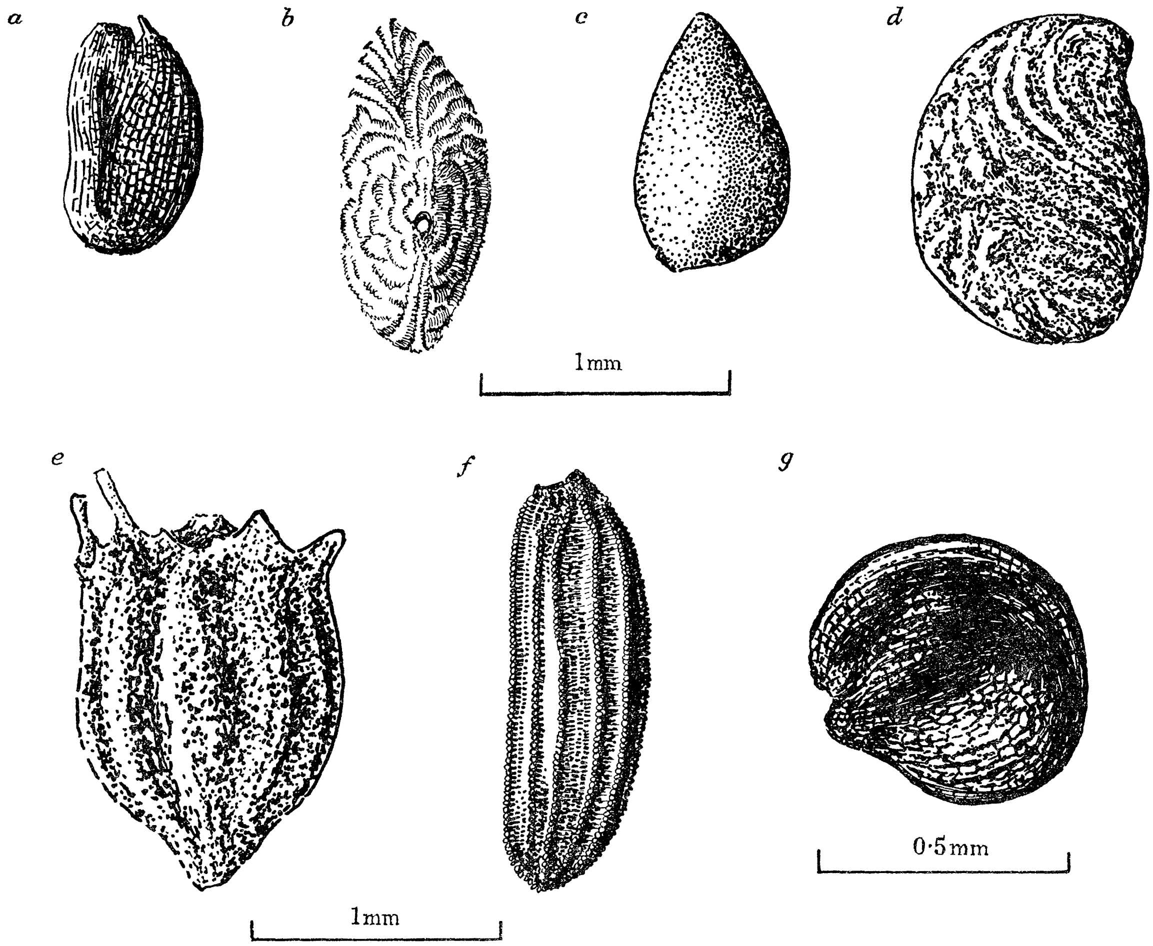


Figure 7. Macroscopic plant remains from borehole no. 30. *a*, *Capsella bursa-pastoris* (L.) Medic.; *b*, *Plantago major* L.; *c*, *Aphanes arvensis* L. s.l.; *d*, *Potentilla crantzii* (Crantz) G. Beck or *P. tabernaemontani* Aschers; *e*, *Scleranthus* cf. *annuus* L. s.l.; *f*, *Butomus umbellatus* L.; *g*, *Herniaria* sp.

From the climatic point of view, there is little to add from the flora and vegetation of zone *f*. There is an increase in the number of the more thermophilous plants, e.g. *Aphanes arvensis* agg., *Carpinus betulus*, *Carex riparia*, *Cucubalus baccifer*, *Hedera*, *Lemna* cf. *minor*, *Ranunculus sardous*, *Rumex maritimus*, *Teucrium scordium*, *Stachys* cf. *arvensis*, but there is no evidence that the climate was distinctly different from the previous zone, or that it was distinctly more oceanic or continental than the present climate in the area.

(*e*) *Notes on species*

Aphanes arvensis L. s.l. (figure 7, *c*).

The seventeen achenes which were found range from 0·85 to 1·2 mm in length; the achene is biconvex, ovate with a sub-acute apex and asymmetrical basal point of attachment. The slightly rough surface is often worn away in the fossil leaving a fine network of very small cells with raised margins. These achenes compare exactly with those of *Aphanes arvensis* s.l. including within their range small achenes comparable with those of *A. microcarpa* (Boiss. & Reut.), Rothm.

Butomus umbellatus L. (figure 7, *f*)

Several black seeds of this species were found, they are about 1·6 mm long and 0·5 mm wide. They have 9 to 13 longitudinal ribs one of which is extended in a keel-like manner. These seeds are distinguished from the achenes of the Compositae by the presence of bead-like cells on the tops of the ribs.

Capsella bursa-pastoris (L.) Medic. (figure 7, *a*)

Three black seeds of a crucifer type were recovered, one of them being well preserved and 0·95 mm long. The oval seeds have a pointed radicle and clear rectangular cells, with raised margins, longitudinally orientated. Recent seeds of *Capsella bursa-pastoris*, though brown, exactly match the fossils in other characters. Seeds of *C. bursa-pastoris* have previously only tentatively been recorded from Upton Warren, Worcs. (Coope, Shotton & Strachan 1961), a Late-Pleistocene deposit of the Last Glaciation.

Carex strigosa Huds.

Numerous nutlets, enclosed in utricles, of a *Carex* species were recovered. The nutlets are about 1·5 mm long and narrowly trigonous with flattened sides. The utricles, *ca.* 3 to 3·5 mm long, are rather thin-walled, scarcely inflated and taper to the unforked apices (they are usually damaged at the bases). The 14 to 18 ribs are clearly defined; the cells are regularly polygonal with raised margins. Carices having fruits of similar dimensions and appearances were compared with the fossils. *C. pseudo-cyperus* L. has similar nutlets but the ribs of the utricles are much broader. *C. acutiformis* Ehrh. has more numerous ribs on the utricles. The utricles of *C. pendula* Huds. have narrow cells with sinuous margins. *C. binervis* Sm. and *C. laevigata* Sm. both have larger broader nutlets and the utricles have forked apices. *C. strigosa* Huds. has exactly similar nutlets to the fossils and the utricles, *ca.* 2·7 to 4·0 mm long, are fusiform, thin and closely fit the sides of the nutlets. A character of this species is the rather tapered base of the utricle, unfortunately usually lost in the fossil; in all other points, however, the fossils agree with *C. strigosa*.

Cucubalus baccifer L.

One black shiny seed, 1·5 mm in diameter was found. Though now damaged, and flattened, it appears to have been broadly reniform. The cells are only very slightly raised and have finely interdigitating margins; they are small and squarish near the hilum, larger and more or less radially elongated on the sides, becoming round or oval opposite the hilum. Although a similar shape and cell pattern are characteristic of many of the seeds of the Caryophyllaceae most of these have a clearly raised or tuberculate surface; the only species in Britain with seeds of a comparable size, similar surface and matching cell pattern to the fossil is *Cucubalus baccifer*. This record is of particular interest since *C. baccifer* has long been thought to have been introduced into this country and it is only recently that its native status in eastern England has been seriously considered (Lousley 1961). Its main distribution in Europe is central and eastern with its northern limit in Holland. This is the first Quaternary record for *C. baccifer* in England.

Herniaria sp. (figure 7, *g*).

Two shiny black lenticular seeds, diameter 0·5 and 0·6 mm, were recovered. The seeds are slightly keeled and have polygonal surface cells which are very slightly raised though rather indistinct. They can be referred with certainty to the genus *Herniaria*; and resemble the seeds of the British species. Of the two native species *H. glabra* L. has seeds of 0·5 to 0·7 mm diameter, those of *H. ciliolata* Meld. can range from 0·55 to 0·8 mm. *H. hirsuta* L., a central and southern European species now naturalized in Britain, has seeds of 0·5 to 0·8 mm diameter. This is the first published record of a *Herniaria* species and is of particular interest since the genus is rare and local in this country at the present time.

Linum anglicum Mill.

Two seeds of a species of *Linum* were recovered; their lengths are 3·5 and 3·8 mm and they are identical with many other *Linum* seeds found associated with late- or full-glacial floras. These previous records of seeds named as *L. praecursor* Reid are now recognized as being indistinguishable from seeds of *L. anglicum* Mill. (Lambert, Pearson & Sparks 1963). *L. anglicum* is considered by some authorities to be a subspecies of *L. alpinum* Jacq., part of the very variable *L. perenne* aggregate which has a wide morphological and ecological range. This association with late- or full-glacial floras may suggest a biotype of *L. alpinum* more closely related to *L. anglicum* in form but since extinct.

Plantago major L. (figure 7, *b*)

Several rhomboidal flattened seeds, about 1·3 mm long, were found. They have low delicate papery ridges; on the upper surface these radiate irregularly from the hilum, and on the lower they are more or less parallel to the long axis. This ridged surface and prominent hilum seem peculiar to *Plantago major*, all other British species of *Plantago* having smooth surfaces. Seeds of *P. major* have only been found in the Hoxnian Interglacial hitherto. Pollen of *P. media/major* type was identified at similar levels to the seeds.

Potentilla crantzii (Crantz) G. Beck or *P. tabernaemontani* Aschers. (figure 7, *d*)

Eleven *Potentilla* achenes were found, 1·2 to 1·5 mm long and 0·8 to 1·1 mm wide; some are rather reniform with a narrow rather pointed apex, others have a straight or slightly keeled ventral edge. The remains of broad low dense ridges can be seen on some of them. Achenes of the British *Potentillas* of a similar size and shape were compared with the fossils. Those of *P. sterilis* (L.) Garcke have fine anastomosing ridges. Achenes of *P. erecta* (L.) Raüsch have clear, well raised, sinuous broken ridges. The size, shape and surface of achenes of *P. tabernaemontani* are rather variable; our reference material ranged from 1·3 to 1·9 mm long and 0·8 to 1·2 mm broad. Some achenes are rather slender and pointed, others small and broad and the surface may be nearly smooth or have clear but low ridges. *P. crantzii* also has variable achenes; those examined were 1·2 to 1·5 mm long and 0·9 to 1·2 mm broad. The achenes are usually small and broad with ridges varying in clarity from being just visible on the surface to clearly rugulose; the ridges appear rather denser than those of *P. tabernaemontani*. The fossils most resemble these latter two species; some, from the lower cores, have a much worn densely ridged surface and are therefore more like *P. crantzii* and one of these is figured. Others have no ridges but these may of course have worn off. It is quite possible, however, that both species are present.

Scleranthus cf. *annuus* L. s.l. (figure 7, *e*)

One thick-walled fruit with 10 furrows and the bases of 5 sepals was found; its length, excluding the sepals, is 1·4 mm. Fruits of *Scleranthus annuus* (incl. *S. polycarpos* L.) and *S. perennis* L. have a similar structure and were boiled in dilute NaOH to produce a comparable state to the fossils. In *S. perennis* the 5 sepals each have two well-developed lateral nerves parallel to a main nerve. The sepals of *S. annuus* have slighter main nerves with small and divergent lateral ones. Although the main nerves in the fossil fruits have broken off, the very small lateral nerves which remain suggest a tentative identification with *S. annuus*. *S. annuus* has previously been identified from the Upton Warren Late Pleistocene deposit (Coope, Shotton & Strachan 1961).

4. Non-marine Mollusca

Unfortunately, the non-marine Mollusca from the cores only just overlap that part rich in pollen, fruits and seeds. They start in the upper half of core 1 and continue up into the lowest 2 or 3 ft. of the brickearth, but all samples washed above a depth of about 16 ft. yielded no Mollusca. The Mollusca recovered are listed in table 2.

Table 2. Non-marine Mollusca from Ilford

(nomenclature according to Ellis 1951)

	core 1		18 ft. 9 in.	18 ft. 6 in.	18 ft. 0 in.	17 ft. 9 in.	17 ft. 6 in.	17 ft. 0 in.	16 ft. 6 in.	16 ft. 0 in.	total
	20·29	29·36									
Valvata cristata	25	11	1	15	6	5	6	17	5	5	96
Bithynia tentaculata	33	58	32	83	61	51	38	98	58	80	592
Lymnaea palustris	?2	.	?1	.	.	.	.	.	.	?3	6
Lymnaea sp.	2	1	.	3	3	4	4	6	2	.	25
Planorbis planorbis	.	1	.	.	.	.	.	.	.	.	1
P. (*Planorbis*) sp.	1	.	.	1	1	1	1	1	.	2	8
P. vorticulus	.	.	.	.	.	.	1	1	.	.	2
P. leucostoma	?2	.	.	.	.	.	.	1	.	.	3
P. crista	5	1	1	.	.	1	.	.	.	.	8
P. contortus	.	.	.	.	.	.	.	1	.	.	1
Segmentina nitida	1	2	2	2	3	4	1	6	1	3	25
Acroloxus lacustris	2	.	.	.	.	.	.	.	.	.	2
Succinea sp. (*putris* or *pfeifferi*)	4	3	.	.	.	.	.	.	.	1	8
Zonitoides nitidus	1	.	.	.	.	.	.	.	.	.	1
Agriolimax cf. *agrestis*	.	1	.	.	.	.	.	.	.	.	1
Agriolimax sp.	1	.	.	1	.	.	.	.	.	.	2
Sphaerium lacustre	.	.	.	.	.	1	.	1	?1	.	3
Pisidium obtusale	.	.	.	.	.	.	.	.	.	1	1
P. nitidum	1	.	.	.	.	.	.	.	.	.	1
Pisidium sp.	6	5	1	.	2	.	2	5	.	.	21
total	86	83	38	105	76	67	53	137	67	95	807

Most of the Mollusca are poorly preserved and many of them are in a fragmentary state. Compared with older lists from this deposit, the fauna is a distinctly poor one. There are no extinct species and no typical interglacial indicators such as have been found before, e.g. *Belgrandia marginata* in the Uphall pit (Kennard & Woodward 1900) and at Gordon Road (Kerney & Davis in Rolfe 1958), *Corbicula fluminalis* in both these sections and also at the High Road pit, *Discus ruderatus* at the Uphall Pit, *Potamida littoralis* at Gordon Road and *Pisidium clessini* (= *astartoides*) at the High Road pit and at Gordon Road. However, *Planorbis vorticulus*, *Segmentina nitida* and *Acroloxus lacustris* all fail to extend very far northwards in Scandinavia at the present day and so give a somewhat southern complexion to the Seven Kings fauna.

The fauna consists almost entirely of freshwater molluscs, the over-all proportion of land snails being only 1·5%. The freshwater species indicate a 'good' habitat especially the high proportion of *Bithynia tentaculata*, but the next most frequent species are probably more important. *Valvata cristata* likes mud and running water, and usually occurs with a dense plant cover (Boycott 1936), while *Segmentina nitida*, a rare species both now and in the past, is, according to the same authority, characteristic of the valley-side marshes associated with streams in their natural state. These facts suggest a small, sluggish, meandering stream or even a good-sized pond.

The faunas recorded from Gordon Road and from the Uphall and High Road pits are all very different in type, and are much more characteristically river faunas. A number of features suggest this conclusion: the presence of *Corbicula* and the large bivalves, *Unio* and *Potomida*; the *Pisidium* species combination of *amnicum*, *clessini*, *henslowanum* and *moitessierianum*, which is characteristically a moving-water group; the record of *Ancylus fluviatilis* at Uphall; the fact that at Uphall the Mollusca were mainly in gravel below the brickearth; and the much greater frequency of land snails, a feature typical of river deposits. This conclusion must remain slightly indefinite because so little is known about frequency of species at the old sites, although Woodward (1890) did mention that both *Helix*, which in those days included many land species, and *Corbicula* were extremely common and that *Unio* was not uncommon. At Gordon Road the moving-water species listed above were the most frequent. Compared with these the Seven Kings fauna is decidedly indicative of a much smaller stream. Even comparatively small East Anglian rivers such as the Stour, the Cam and the Wissey, had faunas in the Ipswichian Interglacial much more like the older Ilford records than the present one.

It seems reasonable from this to infer that the older Ilford faunas were deposited by the interglacial Thames and that the Seven Kings fauna was laid down by a minor tributary such as those which at present drain the area, e.g. the Seven Kings Water which passes close to the site (figure 1). Such a suggestion would help to explain the high altitude of the early part of the interglacial deposits, when one might have expected a low base-level. The interglacial deposits of this ancestor of the Seven Kings Water were later buried beneath the brickearth deposited by the aggrading Thames in the later part of the interglacial.

There are no brackish-water Mollusca in the present collection, but it should be noted that *Hydrobia ventrosa* was recorded from the Uphall Pit by Johnson (Kennard & Woodward 1900). This identification was later changed to *Paladilhia radigueli* Bourguignat, an extinct species originally described from deposits of the river Seine at Paris. The habitat of this species, thought at first to be fresh water, is unknown and, since closely related species may be either fresh water or brackish, it is better not to base ecological conclusions on its occurrence until further investigations have been made. However, the height of the shell bed in the Uphall pit appears to have been at about 15 ft. O.D. and there is nothing impossible in the occurrence of brackish conditions at about this level in the middle of the Ipswichian Interglacial.

5. Terraces at Ilford

The relief of the Ilford area is shown in relation to the fossiliferous sites and to certain drift deposits in figure 1. The 10 ft. interval contours on this map east of the River Roding have been based on plotting the many hundreds of bench marks listed by the Ordnance Survey. They are thought to represent a fairly accurate picture of the surface relief with slight errors due to modification of the surface by building and road construction. An attempt to contour at 5 ft. intervals had to be abandoned because of these effects. West of the Roding the contours have been sketched in from the 6 in. map.

The map clearly reveals certain salient features of the landscape. To the north lies a ridge cut into isolated blocks by the tributaries of the Thames and varying considerably in elevation from 70 to 120 ft. O.D. This is shown on the 1 in. Romford Geological Survey map as capped by Boyn Hill terrace gravels, which are thought to belong to an earlier interglacial than the Ilford deposits. A sharp break of slope separates the Boyn Hill terrace from the main terrace of the area, which lies between 45 and 20 ft. O.D. This in turn is separated from the modern floodplain by another break of slope indicated by the closeness of the 10 ft. and 20 ft. contours on figure 1. The fossiliferous sections at Ilford are all at the back of the main terrace near the 40 ft. contour.

As far as one can tell this terrace is a single feature, although both Taplow and Flood Plain terrace gravels have been mapped on it by the Geological Survey. However, the Romford memoir (Dines & Edmunds 1925) specifically states (p. 34) that the river deposits in this area merge into one another, that the boundaries are to some extent conjectural and that they indicate the levels at which the terraces concerned would be expected. It will be noted that all the fossiliferous sections are in that part of the gravels assigned to the Taplow terrace. Although it would seem that these Taplow and Flood Plain gravels are part of one aggradation forming the main terrace at Ilford, this is not necessarily so, for the aggradation could have covered irregular existing relief and incorporated patches of earlier gravel probably with some reworking so as to make the two virtually indistinguishable from each other.

Aggradation involving alluvial silts, often brickearths, seems to have been a characteristic feature of the second half of the Ipswichian Interglacial and comparisons with Grays, Erith and Crayford are suggested below. Comparable deposits of the same age are also known from Stutton in the Stour valley (Sparks & West 1964), while the silty marls of the Histon Road sections at Cambridge (Sparks & West 1959) are not greatly different from unoxidized brickearth. The vegetation seems to have been fairly open in the latter part of the Ipswichian Interglacial and one wonders whether such a surface was more open to erosion than the more fully wooded surface earlier in the interglacial, the eroded silt being deposited in the lower reaches of the river valleys.

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

The aggradation to 42 ft. O.D. of brickearth which sealed the Ilford organic deposit seems to have been in response to a rising base-level, which is known to have risen above present sea-level in zone *f* at Selsey and in parts of continental north-west Europe (West & Sparks 1960).

6. Further correlations and conclusions

(*a*) *Age of the Ilford brickearth in relation to other lower Thames terrace deposits*

Whitaker (1889) gave a historical survey of the views held concerning the age of the brickearth at Ilford and elsewhere in the lower Thames valley. At that time it was generally though that the brickearths at Ilford, Grays, Erith and Crayford were of much the same age and younger than the higher level Thames terrace gravels. An early view of Wood (1866) that the Ilford brickearth underlay the Thames gravel was later withdrawn by him (Woodward & Davies 1874). King & Oakley (1936) remark that the Ilford brickearths apparently emerge from below Middle Terrace gravel, referring to Wood's earlier statement. They placed the brickearth at a slightly later stage of the same aggradation that deposited the channel deposits at Clacton and at Little Thurrock (Grays). This conclusion they reached from the faunal studies of Hinton and Kennard. However, pollen analytical evidence dates the organic part of the Clacton channel filling to the Hoxnian Interglacial (Pike & Godwin 1953), while the Ilford brickearth was formed after the middle of the Ipswichian Interglacial. It is suggested later that the channel deposits at Little Thurrock are also of Ipswichian Interglacial age.

King & Oakley's (1936) Inter-Boyn Hill erosional stage, which they thought preceded the aggradation leading to the formation of the Clacton, Grays, Ilford and Late Boyn Hill deposits, thus requires much more substantiation before it can be accepted.

Previous correlations based on the faunas seem to assume that different mammalian species are characteristic of particular warm or cold episodes. But it is more probable that faunal changes occur within the episodes, parallel to the vegetational and climatic changes which are known to occur within them. The mammalian faunas need restudying in the light of the environmental changes which are known to take place in, for example, the interglacials.

(*b*) *Relation to other brickearth localities in the Lower Thames valley*

Grays Thurrock

The most detailed account of the fossiliferous channel deposits at Grays (Little Thurrock) was given by Tylor (1869). His section of these deposits is given in figure 8. There is a general similarity in height and disposition with the Ilford deposits. It seems reasonable to suppose that the filling of fossiliferous clays and sands is of Ipswichian age.

Crayford and Erith

These sections have been described by Tylor (1869), Dawkins (1867) and Kennard (1944). Figure 8 gives sections in the fossiliferous parts of the Crayford and Erith exposures, showing a shelly horizon between brickearths at about 30 to 45 ft. O.D. The presence of brickearths at Crayford and Erith containing temperate molluscan faunas with *Corbicula* at about the height of the comparable fauna at Ilford suggests that these deposits are approximately contemporaneous, especially in view of the proximity of the three sites.

Ebbsfleet

Figure 8 gives the section in the Ebbsfleet channel deposits described by Burchell (in Zeuner 1945). Again the disposition and height of the temperate bed suggests a correlation with the Ilford deposits and so with the Ipswichian.

(*c*) *Correlation of the lower Thames terrace sequence*

Correlations based on the dating of the organic deposits at Ilford are shown in table 3.

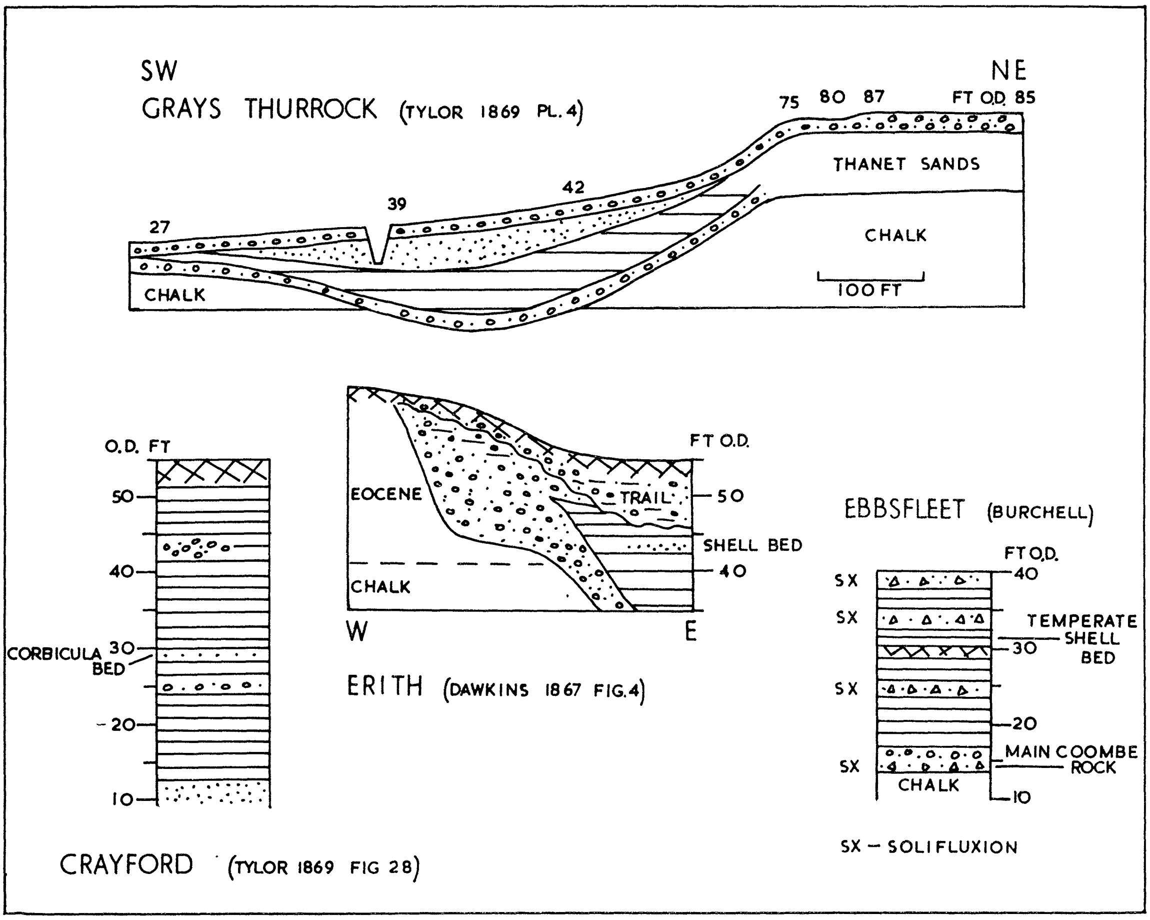


FIGURE 8. Sections through other brickearth sites in the lower Thames valley. Sediment symbols as in figure 3.

TABLE 3. CORRELATIONS RESULTING FROM THE DATING OF THE ILFORD BRICKEARTH

stage (West 1963)	deposit
Weichselian	Cryoturbation and 'trail' above the Ilford brickearth. Upper brickearth with cold faunas at Crayford and uppermost solifluxion horizons at Ebbsfleet
Ipswichian	Organic deposits at Ilford (and Trafalgar Square). Brickearth at Ilford formed in later part of this temperate stage, perhaps into Weichselian, aggrading to 42 ft. O.D. at least. Temperate fossiliferous brickearths at Grays, Crayford and Ebbsfleet
Gipping	'Taplow' gravels under the brickearth near Seven Kings. Main Coombe Rock

Appendix 1. Stratigraphy of borehole no. 30

feet	
0–2	Soil. Top at 42 ft. O.D.
2–7	Brown-red sandy clay and gravel
7–10	Brown sand, iron-stained
10–17	Brown-red sandy silt and clay
17–18·5	Brown red silty clay, muddy and shelly towards the base
18·5–20	Core 1
20–21·5	Core 2
21·5–23	Core 3
23–24·5	Core 4

Detailed stratigraphy of cores:

Core 1.	10–37 cm	Brown-grey clay-mud with shells
	3–10 cm	Transition
	0–3 cm Shoe (5 cm)	Brown detritus mud
Core 2.	0–28 cm Shoe (5 cm)	Brown detritus mud
Core 3.	34–42 cm	Brown detritus mud
	33–34 cm	Grey clayey very fine detritus mud
	31–33 cm	Brown fine detritus mud with grey clayey laminations
	29–31 cm	Transition with muddy laminae
	0–29 cm Shoe (5 cm)	Grey muddy silt
Core 4.	24–39 cm	Grey muddy silt
	23–24 cm	Transition
	15–23 cm	Grey sandy silt, slightly muddy
	5–15 cm	Grey sandy clay and sand, stratified
	0–5 cm	Yellow-greenish sand

Appendix 2. Bryophyta from Ilford

By J. H. Dickson

The following table shows the provenance of the small number of moss fragments recovered from the interglacial deposit:

zone …	*b*						*c*	*e*	*f*					
	core 4			core 3				core 2					core 1	
species / sample (cm)	12–20	20–30	30–39	Base	0–10	10–20	29–35	Base	0–2	2–10	10–20	20–28	Base	20–24
Amblystegium sp.	+	–	–	+	–	–	–	–	–	–	–	–	–	–
Barbula hornschuchiana Schultz	–	+	–	–	–	–	–	–	–	–	–	–	–	–
Brachythecium albicans (Hedw.) B., S. & G.	–	–	–	–	–	+	–	–	–	–	–	–	–	–
cf. *Brachythecium velutinum* (Hedw.) B., S. & G.	–	–	–	–	–	–	–	–	–	–	–	+	–	–
cf. *Dicranella* sp.	–	–	–	–	+	–	–	–	–	–	–	–	–	–
Drepanocladus cf. *exannulatus* (B., S. & G.) Warnst.	–	+	–	–	–	–	+	–	–	–	–	–	–	–
cf. *Drepanocladus* sp. or spp.	–	+	+	+	+	–	–	+	+	+	+	+	+	+

The material is very poor in quantity and quality. *Barbula hornschuchiana*, the two species of *Brachythecium* and *Dicranella* sp. are represented by one fragment each and the state of preservation of the fragments of *Drepanocladus* is very bad. In consequence, the identifications are tentative, especially those of *Dicranella* and *Drepanocladus*. However, there is much less doubt about *Barbula hornschuchiana* and *Brachythecium albicans*.

The species recovery from zone *b* may be taken to support the conclusion, drawn from the nature of the assemblage of spores, pollen and macroscopic fossils of angiosperms, that the vegetation was of an open nature. *Brachythecium albicans* is a species of sandy substrata (Watson 1955; Ducker & Swann 1960) which may be acid (Proctor 1956). *Barbula hornschuchiana* occurs on calcareous rocks and soil (Watson 1918) and on clayey soil (Burck 1947; Szafran 1957). Its habitat is described by Proctor (1956, p. 28) as 'bare sandy and chalky soil, commonly in grassland' and by Paton (1961, p. 47) as 'compacted sandy, gravelly or chalky soil, usually on open tracks and on roadsides'. Amman (1928) regards this species as a heliophile (i.e. a species preferring habitats exposed to direct sunlight).

Only one other record of British fossils of *Brachythecium albicans* has been made, namely that by Fergusson from the Late Weichselian deposit at Garvel Park, Renfrewshire (Robertson 1881; Godwin 1956). *B. albicans*, widespread in Europe (Podpera 1954), reaches 71° N in Scandinavia (Brotherus 1923).

There are no previous records of British fossils of *Barbula hornschuchiana*, a species which in north-western Europe reaches its northern limit in the southern lowlands of Scandinavia. Bryogeographers have classified this species as 'sub-oceanic' (Bizot 1937), 'mediterranean-atlantic' (Gaume 1953) and 'eurymediterranean' (Koppe 1955). Thus *B. hornschuchiana*, in company with various angiosperms from zone *b*, has a southern distribution in Europe.

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PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES