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Studies of the Post-Glacial History of British Vegetation. XIII. The Meare Pool Region of the Somerset Levels

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STUDIES OF THE POST-GLACIAL HISTORY OF BRITISH VEGETATION

XIII. THE MEARE POOL REGION OF THE SOMERSET LEVELS

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(with Appendices by W. A. Macfadyen)

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In continuation of researches into the physiographic and vegetational history of the Somerset Levels, investigations have been made of the Meare Pool region using methods of field-stratigraphy, palynology and foraminiferal analysis. The historic Meare Pool is shown to have originated by encroachment of the growth of raised bogs round it, especially in the Sub-atlantic period. A marine transgression in late Roman time filled the Axe valley with clay which reached the landward side of the lake but cannot have been concerned with its origin. The vegetational history of the region is outlined and related to the occupancy of the Glastonbury and Meare Lake Villages and to the agricultural activity within the area from the Neolithic period to late Roman time.

1. Introduction

In recent years sustained observations in the Somerset Levels have begun to yield an outline history of the region over the last eight or ten thousand years, and its physiographic evolution has been to some extent related to the course of land- and sea-level change, climatic and vegetational history and the record of archaeological occupation of the region.

During the last glacial period sea-level was 100 m or so lower than at present, and between the long ridges of the Mendips, the Poldens and the Quantocks deep valleys cut down far below present sea-level. In Boreal time the rapid eustatic recovery of ocean levels was practically completed, and borings in Swansea Bay, on the other side of the Bristol Channel, have yielded peats intercalated between marine clays, that prove upon pollen analysis that the last stages of the rise in sea-level were accomplished during the closing stages of the Boreal period. This rise of the sea flooded the valleys of the Somerset Levels and filled them with an estuarine clay whose surface now lies a few feet above mean sea-level. At places such as Witchey Bridge (Godwin 1943) thin fresh-water peats within the upper part of this clay also prove to have formed in Zone VI, and at many places pollen analyses of the surface layers of the clay have shown it to correspond with the boundary between Zones VI and VII, i.e. the Boreal/Atlantic transition.

The surface of the clay was impermeable and so nearly level that after a temporary phase of brackish marsh it gave place, in the Shapwick-Meare Heath region where most investigations have so far been made, to extensive reed-swamps and sedge fens, in some places open and in others bearing small thickets of fen carr. This phase apparently lasted through Zone VII*a*, but early in VII*b*, and almost certainly as a result of a change of climate, the fens became overgrown by fen carr dominated by birch, and upon this basis commenced the growth of ombrogenous mires, that is to say of raised bogs whose dominant vegetation of *Sphagnum* moss, *Calluna* and *Eriophorum* built up extensive domed masses of peat, acidic in reaction, poor in plant nutrients, and receiving water chiefly from direct precipitation.

In this region of the Somerset Levels such bogs persisted until two or three hundred years ago, but their history was varied. Through the Neolithic and the Bronze Ages the raised-bog surfaces appear to have grown slowly, to have carried a good deal of *Calluna* and *Eriophorum*, and to have been traversable on foot. Towards the end of the Bronze Age it seems clear that the bog surfaces became much wetter; this effect became very pronounced about the opening of Zone VIII, and thus the change may be taken to correspond with the climatic 'degeneration' of the Sub-atlantic period round about 500 B.C. It was expressed by the widespread establishment of *Cladium–Hypnum* fen with *Myrica* over the tops of all but the highest raised bogs, and this must imply increase in river flooding by calcareous water from the Mendips and the Poldens. It was the sudden flooding of these bog surfaces that induced the widespread construction of numerous and diversified wooden trackways in Late Bronze Age time across the valleys and between the low islands scattered about them. This first and severest flooding was followed by some resumption of active growth of *Sphagnum* peat, until, about A.D. 50, further flooding brought back *Cladium* and *Hypnum* sedge-fen over the bog surfaces. From then until late Roman time oligotrophic *Sphagnum* communities continued to build up fresh Regeneration–complex peat, and on Shapwick Heath many hoards of this date testify to the position of the contemporary surface. Surprisingly enough it appears, on Shapwick Heath at least, that bog growth now ceased, but no cause for cessation has yet been conjectured.

Meanwhile at the seaward end of the Somerset Levels about A.D. 250 the effects became apparent of a substantial marine transgression which brought marine and brackish-water clays far into the valleys. The seaward edges of the raised bogs were deeply eroded, and for a distance of 2 or 3 miles overlaid by thick clay deposits reaching nowadays to about +20 ft. O.D. These clay surfaces themselves were occupied within the Romano-British period. With this marine transgression, presumed to have been caused by eustatic rise in sea-level, our stratigraphic evidence for the post-glacial evolution of the Levels ends.

Having established the developmental history of this central area of the Somerset Levels by investigation of the complex of raised bogs which occupied the Polden–Wedmore valley, we seek now to find what further light can be shed on the history of the region by analysis of the deposits of contiguous areas where other types of mire were forming.

It is of particular interest to examine the former history of the area occupied until recent historic time by 'Meare Pool' on the banks of which the well-known 'Meare Lake Villages' were occupied during the Early Iron Age, and of the relation of this lake to the River Brue beside which the 'Glastonbury Lake Village', also of Early Iron Age date, was situated. We may expect to find evidence of the age and former extent of the lake and some reflexion in its deposits of the alternation of dry and wet periods that so markedly affected the raised bogs, and of the marine invasion of the late Romano-British period. It will clarify the position to discuss the latter phase first.

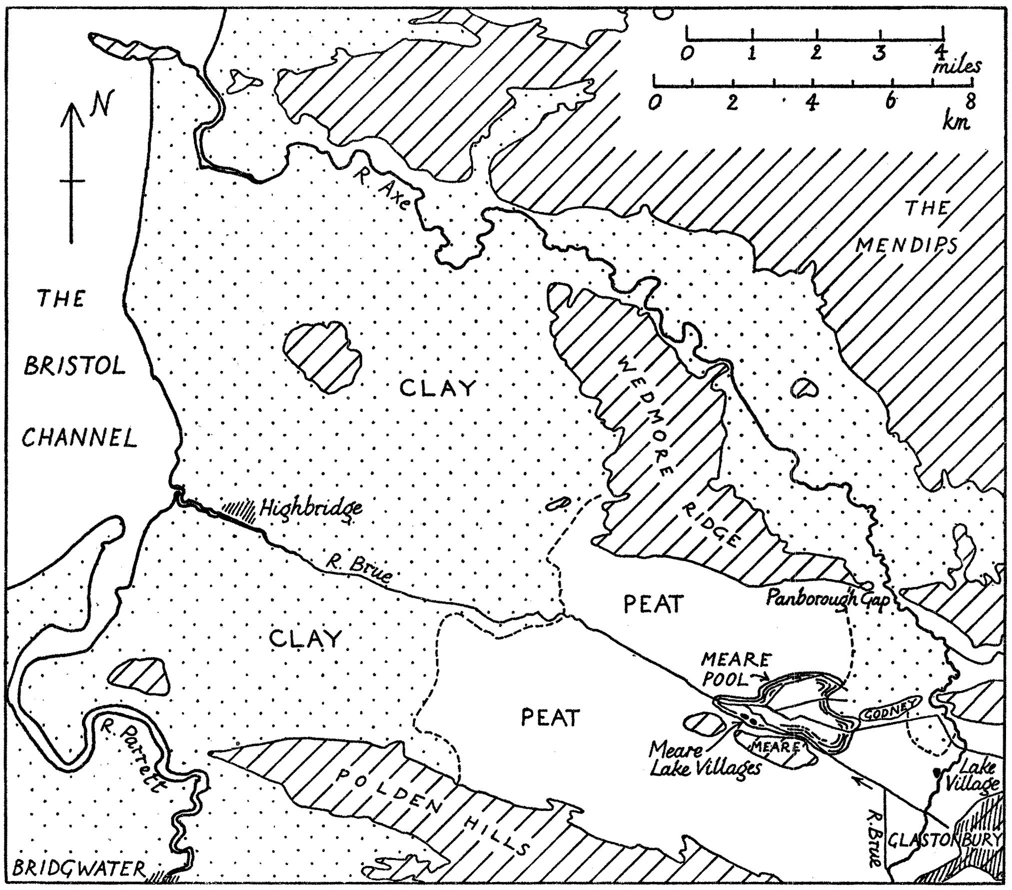

Figure 1. Sketch map of part of the Somerset Levels showing the distinction between the coastal clay belt, and the peat-bog covered hinterland in the valley between the Wedmore Ridge and the Polden Hills.

2. The Romano-British marine transgression

We have already demonstrated (Godwin 1941, 1943) that during late Romano-British time a marine transgression extended over the seawards part of the raised-bog system in the Polden–Wedmore valley and laid down the mass of clay which extends to the present surface at about +20 ft. O.D. Not only are Roman remains found at or near the surface of this coastal clay, but they occur deep in it and below it, as, for example, the Samian cup found on 2 February 1911 at Highbridge Brickworks, 26 ft. below the surface, and with the mark PRISCIUS (a second-century potter).

There appears at this time to have been no true estuary in this valley, so that the clays were laid down merely as a coastal belt 5 or 6 miles deep, to a line just reaching the islet of Edington Burtle; beyond this the raised-bog complex remained, no doubt with altered drainage relations, but there is no evidence that the marine clay extended inland here by any river system. This is not so in the great flats south of the Poldens and north of the Wedmore Ridge. Here respectively the great estuaries of the Parrett and Axe led the tidal water far inland, covering the pre-existing peat mires almost totally. The valley of the

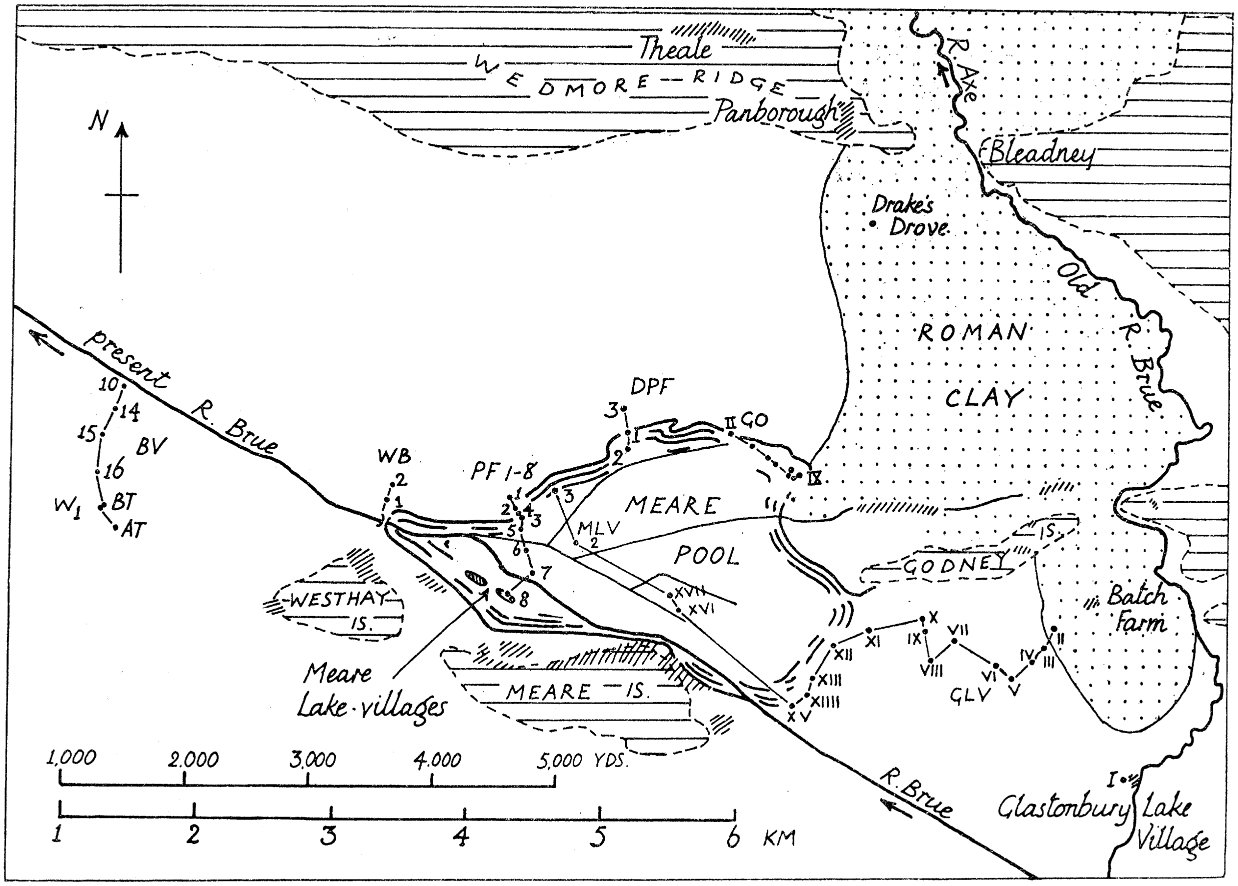

FIGURE 2. Sketch map of the Meare Pool region showing the approximate limits of the Romano-British estuarine clay intruding through the Panborough–Bleadney gap. Its presence is not established east of the course of the 'Old River Brue'. The outline of Meare Pool is that of early maps modified by observation on the ground. Letters and numbers refer to borings and transects mentioned in the text.

Axe was choked with this clay up to the Panborough–Bleadney gap through which it entered the Wedmore–Polden valley in its upper reaches. The first evidence we had of this was in vertical air photographs of the region which displayed a remarkable 'shark-skin' patterning south of the Panborough Gap. Field investigation showed this to be related to a clay layer just below the peat surface, and it became apparent that the clay extends south to Godney as a belt of arable ground vastly more productive than the surrounding acid peat. This area has since been mapped in the Soil Survey for the region.

Ditch sections and supplementary borings sufficed to establish the continuity of this clay with that in the Axe valley, and to show a tapering edge at its westwards margin and

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where it met the fresh-water Meare Pool beside Lower Godney. It could be further traced through the next ridge by the gap to the east of Godney Island, where it formed a last expansion coming to within 200 yards or so of the former Glastonbury Lake Village site. Faunistic analyses from several sites have shown it to be an estuarine clay (see appendices).

A reconstruction along these lines, emphasizing the absence of a main river draining the Wedmore–Polden valley to the sea, whilst according with historical evidence that the present river Brue from Pomparles Bridge, Glastonbury, is artificial, also obliges us to seek to reconstruct the natural (post-Roman) channel of the Brue. Here air photographs, old maps and the evidence of the parish boundaries force us to the view long previously advanced by Dr Bulleid, that the Brue formerly took a winding course to the west of Glastonbury, along the residual watercourse beside Glastonbury Lake Village and Crannel Farm, through the gap in the Godney ridge at Garslade Farm and thence to the Panborough–Bleadney gap, close before joining with the River Sheppey (figure 2). The meanders of the ancient channel suggest perfect continuity with those of the Axe beyond the Wedmore ridge, and one cannot escape the view that the whole river system to the sea is really that of the Brue. It would appear that the Wedmore–Polden flats were so choked with raised bog inland, and with the continuous clay belt coastally that the natural river exit during and since late-Roman time followed the remarkable course of the tidal channel now described.

That such was the situation in medieval time is confirmed by the nature of the first attempt to drain Meare Pool; this was the construction of a channel from its western end to reach not directly to the sea, but to the lower reaches of the Axe, skirting the western end of the Wedmore Ridge by way of Mark. In fact the Highbridge channel was not excavated until very much later.

3. Physiography of the Meare Pool region

If, as we think probable, the natural course of the River Brue from the valley above Glastonbury is by the Lake Village site, between the islands of Godney, and thence to the valley of the Axe by the Panborough gap in the Wedmore Ridge, then the original structure of Meare Pool was largely unrelated to the River Brue. Bulleid had already pointed out that alongside Meare Island the river is clearly in an artificial channel cut into hard Liassic rock, and at Westhay Bridge the Liassic bed is extremely shallow. It was clearly possible that no natural channel (or at least no large one) led westwards from Meare Pool towards the sea and that a natural barrier of rock or of raised bog near Westhay was the threshold to the natural lake. Two sets of borings substantiated this view. The first followed the road from Westhay Bridge to the Tollgate house, a distance of 2000 ft. (610 m). The first boring, 470 ft. (144 m) north of the present river channel met Lias clay at 60 cm (+9·8 ft. o.d.), the second boring (280 m north of the river) gave the following section:

WB 2

cm	
0–41	Mottled brown-grey clay with fresh-water shell fragments.
41–128	Detritus mud peat with abundant seeds of *Menyanthes* and hypnoid moss.
128–170	Highly humified *Eriophorum–Calluna* peat possibly in part reworked.
170–290	Fine detritus mud with *Cladium* and abundant *Phragmites* towards the base.
290–	Soft grey clay with abundant *Phragmites*.

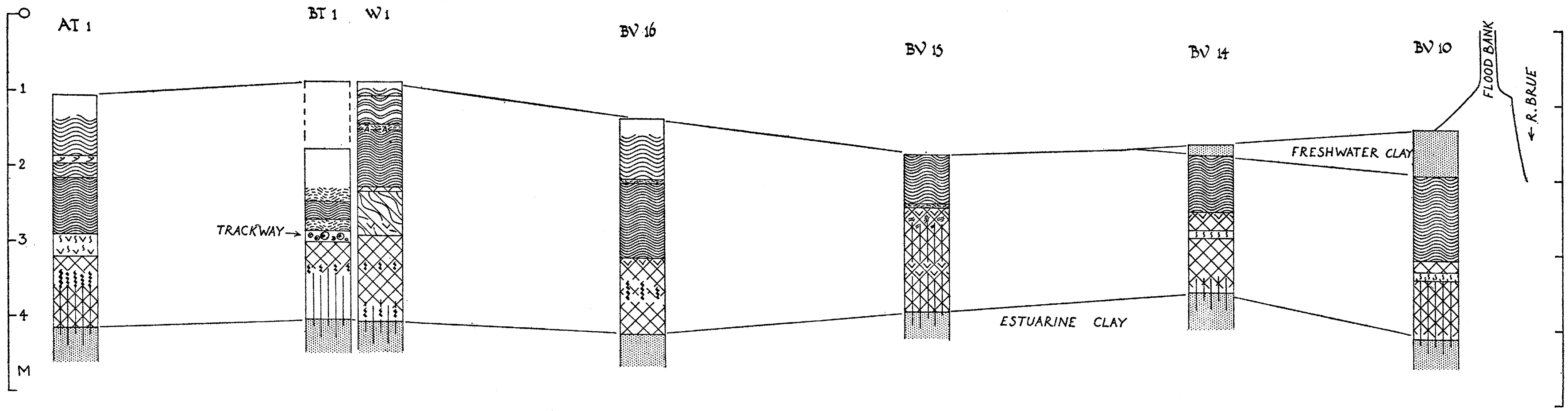

FIGURE 3

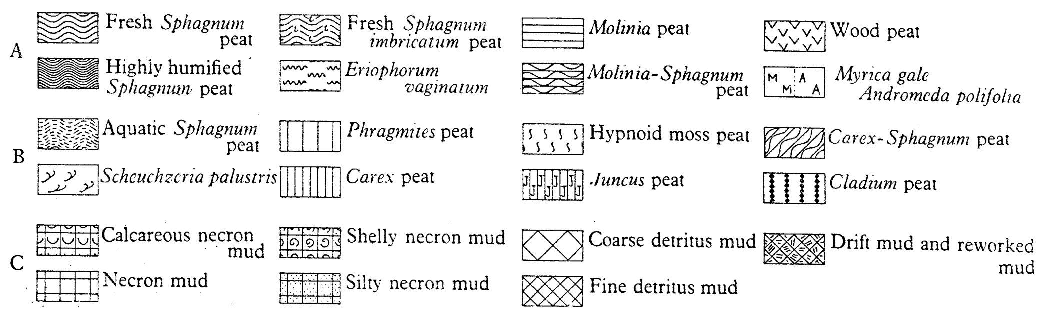

FIGURE 3*a*

FIGURE 3. Transect southwards from the River Brue downstream of Meare Pool showing limited occurrence of fresh-water river clay and absence of any natural channel. Symbols as in figure 3*a*.

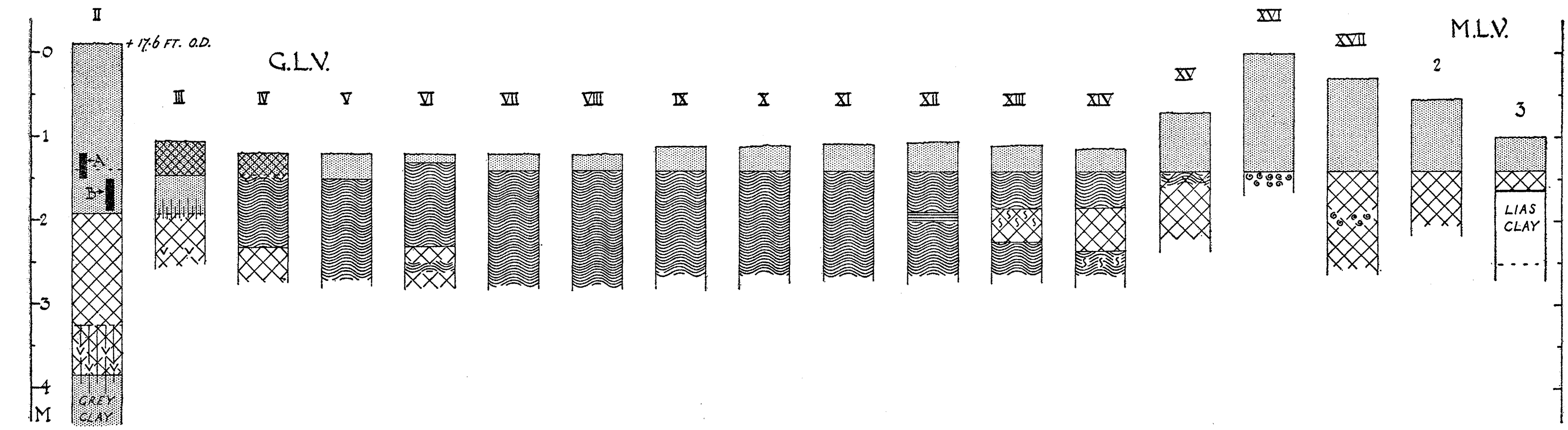

FIGURE 4. Transect from the edge of the Roman clay at Batch Farm to the south-east corner of the former Meare Pool and thence across it. Symbols as in figure 3*a*. The rectangles *A*, and *B* in GLV II indicate the samples submitted for foraminiferal analysis (see Appendix 1).

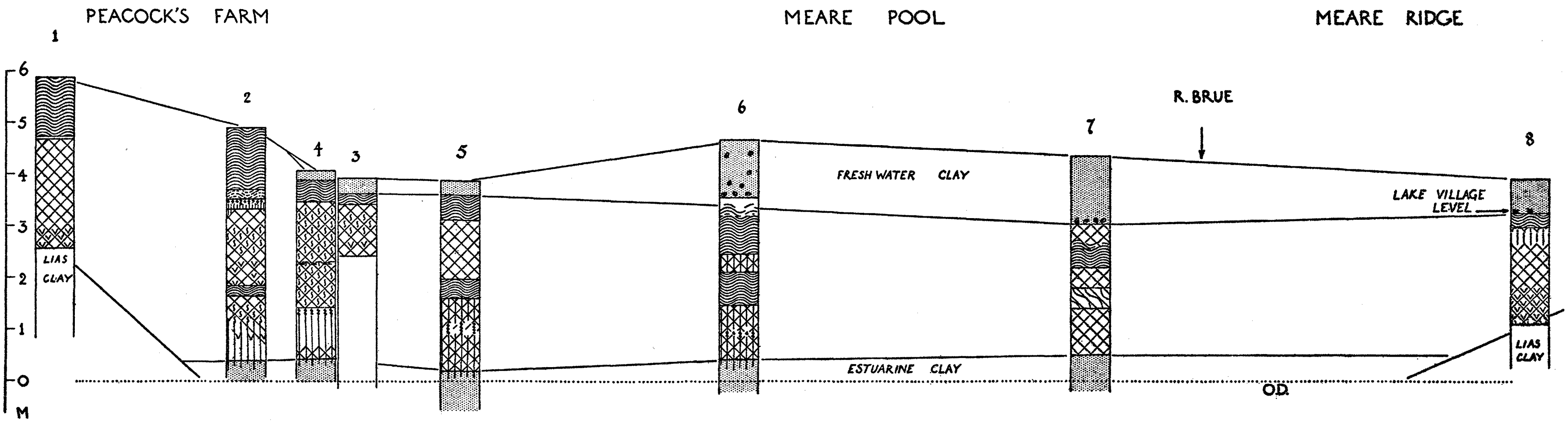

FIGURE 5. Transect across the western end of Meare Pool from the Meare Lake Village site northwards to the margin of the derelict raised bog on the far side of the pool. Symbols as in figure 3*a*.

The soft grey clay appears to be the estuarine late Boreal clay found throughout the Levels, a supposition supported by its determined level (+1·4 ft. O.D.). The basal sequence of muds and peats reflects precisely the same evolutionary story as that of the many raised bogs of the Wedmore–Polden valley, and of the whole bog system continuing northwards from this point. There is no evidence here for any natural outlet channel from Meare Pool, and it is apparent that the upper clay is fresh-water river clay and not an extension upstream of the Roman estuarine clay of the coastal belt.

The second series of borings was made about 2 km downstream from Westhay Bridge. These extended about 1 km southwards from the river margin and were also levelled. The results, set out in figure 3, show beyond doubt that a system of raised bogs formerly extended right across this line, and that raised-bog peat extends to the present river bank, where it is overlaid by a flange of river flood clay. It can be seen in the field that old raised bogs approach the river on the other bank also. It is evident that the present artificial river channel does not correspond to any original deeper channel, and that the upper clay is a product of the present river only.

A further contribution to understanding the gross stratigraphy of the lake is a line of borings stretching from near Batch Farm to the western end of Meare Pool, in an irregular line (see figure 2). With the exception of GLV II, which extended to a depth of 4·0 m, the borings were usually limited to a depth of 1·5 m, and were intended to disclose the nature of the general mantle of brown clay which constitutes the bed of the drained lake, and of the deposits immediately beneath. It is at once apparent (figure 4) that the clay is much thicker near the course of the present River Brue, and this, coupled with the presence of abundant fresh-water shells in its lower layers, makes it apparent that the clay is indeed fresh-water flood clay deposited since the present River Brue channel was dug. The late Dr A. Bulleid assured me that within his memory it was a practice to the east of Meare Village for river-borne clay to be trapped in a specially constructed dam which was filled at flood periods; the clay was later dug out and used to ameliorate the acidic peat land. It is furthermore clear that whereas at each end of the line of section the clay overlies organic lake-muds, there is a considerable region along the line (covering at least the 'East Waste') where it overlies *Sphagnum–Calluna* peat, and indicates the strong probability that until the present Brue channel was dug, large raised bogs occupied this area. Such bogs may at this period even have separated a western lake (Meare Pool) from an eastern one (Glastonbury Lake). At borings III, IV and V the flood clay formed only a thin admixture with the upper raised-bog peat. Borings GLV XIII and XIV indicate the likelihood of an interplay between the raised bog and lake in a marginal situation, but this matter has not been pursued. The excavations previously reported (Godwin 1941) have shown that the hearths of the Iron Age Meare Village are overlaid by the river flood-clay, and rest upon raised-bog peat itself based upon reed-peats and organic muds over the Lias of Meare Island. The terminal boring of the present series, MLV 3, shows that even on the north side of the Meare Pool, where raised-bog margins come down to meet the flat lake bed, the Lias may locally rise very close to the surface.

The conclusions reached upon consideration of this series are confirmed and extended by a further series (PF 1 to 8) across the western end of Meare Pool northwards from Meare Lake Village (see figures 2 and 5). Bores 1 and 2 show the *Sphagnum–Calluna* peat of the raised-bog margin (now pasture). Bores 3, 4, 5 and 6 show that such peat extended far into the lake bed before it was overlain by the river flood-clay, but that there it is only a thin layer above detritus muds. The borings of this series were carried through the full extent of the organic lake deposits and it will be seen that they end, apart from the two

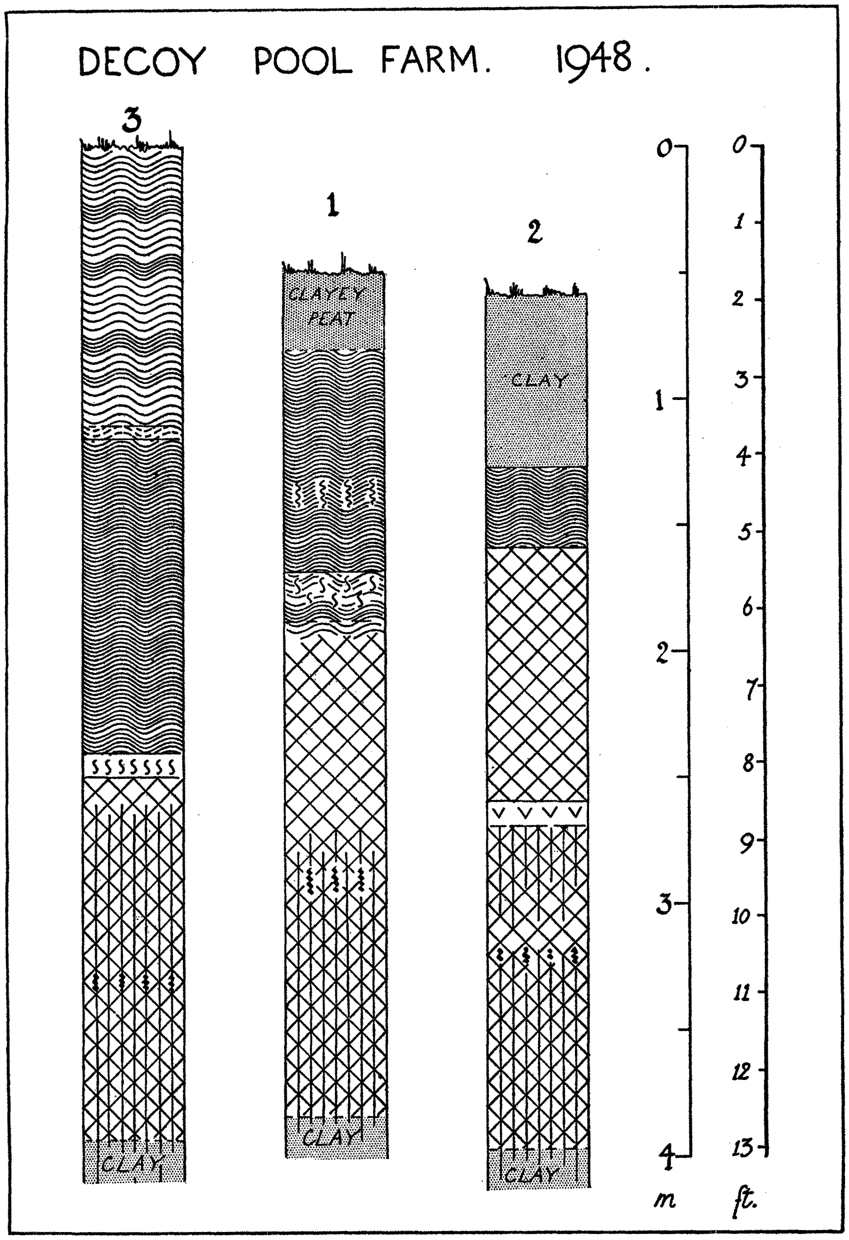

FIGURE 6. Transect across the northern margin of Meare Pool showing the contact between lake-muds and the *Sphagnum* peat of the raised-bog margin. Symbols as in figure 3*a*.

terminal bores which reach the Lias, upon the flat surface of soft blue clay at about +1 or +2 ft. O.D. This must be the late Boreal estuarine clay encountered throughout the Levels and it will be seen that coarse detritus muds and reed peats formed directly over it. The somewhat obscure stratigraphy of the organic deposits of the lake can be left to later discussion, but it may nevertheless be noted that there was apparently a phase, shown in boring 1, when organic lake deposits attained a height of +16 ft. O.D., and water-levels in the lake must therefore have been even higher. We shall later see that pollen analyses at PF 2 and PF 7 show this high-water-level phase to have been early in Zone VIII, the period when calcareous water flooded over the undrained raised bogs of the whole Shapwick–Meare area (Clapham & Godwin 1948). At one of these sites, PF 6, samples of the upper clay were collected for foraminiferal analysis. The results given by Dr W. A. Macfadyen (see appendix 1) provide 'unequivocal evidence of fresh-water conditions of deposition' with fresh-water rhizopods and gastropods, and no indigenous Foraminifera.

The raised-bog margin of the lake is again recognizable south of Decoy Pool Farm (see figure 2), and it will be apparent that the series of three borings DPF 1 to 3 (figure 6) rests upon the late Boreal clay. Whereas at DPF 3 once raised bog was established (presumably as in the big raised bogs at Shapwick early in Zone VII*b* (Godwin 1941)) lake deposits never invaded it, at DPF 1 marginal lake conditions persisted alongside the raised bog for a considerable time, and at DPF 2 even longer, so that at the latter site, raised-bog peat only grew out as a floating bog for a short while before the river flood-clay swept over it.

Somewhat farther eastwards the northern boundary of the lake meets a quite different deposit, the clay of the Romano-British marine transgression. It is shown in §1 that this clay fills the valley of the Axe and through the Panborough–Bleadney gap enters the Wedmore–Polden valley where it makes a spread over a mile wide and pushes through the gap in the next ridge, east of Godney, to form a final and smaller extension southwards. A series of borings, GO I to GO IX, now elucidates the relationship of the marginal lake deposits to this clay. Those towards the lake centre all disclose the brown upper fresh-water clay, about a metre in thickness, with abundant shells at its base, and overlying a substantial depth of organic mud with fruits of aquatic plants such as *Potamogeton* cf. *pectinatus* and *Menyanthes*. GO IX, which lies nearest the former shore, is of critical significance:

GO IX

(Surface level = +14·6 ft. O.D.)

cm	
0–125	Brown stiff crumbly clay, below 30 cm with abundant fresh-water shells.
125–162	Transition—darkening with increasing organic content: at 128, 131 fruits of *Potamogeton* cf. *pectinatus*.
162–180	Dark brown detritus mud with shell fragments, bark, *Phragmites* and *Calluna* twig.
180–188	Yellow-brown and coarser detritus mud with more *Phragmites*.
188–219	Grey-blue clay with large *Phragmites* content (surface = +8·4 ft. O.D.).
219–255	Yellow-brown sedge peat with secondary penetration by *Phragmites*: abundant hypnoid moss at 234 to 250 cm.
255–275	Coarse detritus mud: twig at 275 cm.
275–292	Dark chocolate brown *Sphagnum–Calluna* peat with roots of *Eriophorum angustifolium*.
292–300	Yellow-brown *Carex* peat with some *Hypha*.
300–430	Dark brown fine detritus mud with *Menyanthes* at 307, 308, 315 cm; from 309 cm an increasing amount of wood and bark (cf. *Betula*) to 350 cm; *Phragmites* increasing between 400 and 430 cm.
430–441	Blackish brown detritus mud.
441–444	Transition.
444–	Soft grey clay with a little *Phragmites* at top (surface = 0 ft. O.D.).

The grey-blue clay (188–219) is absent from borings farther off-shore and must represent the extreme limit of the Romano-British clay intrusion, which is thus demonstrated to be considerably older than the upper fresh-water clay. The fresh-water character of the uppermost clay is strongly confirmed by Dr Macfadyen's report of its microfauna, from samples taken in the two bores GO II and GO VII (see appendix 2).

South of the Godney Island, Batch Farm is situated upon a slightly raised area (a 'batch' in local language) of clay, and Dr Bulleid recorded a set of borings which encounter the western edge of it close beside the Godney to Glastonbury road. The strong supposition that this is the Romano-British clay is confirmed by the boring GLV II, the record of which follows.

GLV II

(Surface level = +17·6 ft. O.D.)

cm	
0–207	Stiff clay, mottled at top, but grey and softer at base.
207–300	Dark brown detritus mud with *Menyanthes* seeds at 228, 240, 245 cm: *Potamogeton* at 265 cm.
300–385	Coarser detritus mud with occasional twigs (cf. *Salix*) and stone of *Rubus* at 345 cm.
385–395	Coarse detritus mud with frequent wood and *Phragmites*.
395–	Grey-blue soft clay (Surface at +4·6 ft. O.D.).

Samples of the upper clay were submitted to Dr W. A. Macfadyen for foraminiferal analysis, and he reports the sample taken between 120 and 150 cm to have a marked estuarine character, and that taken between 150 and 200 cm to be no more than brackish (see appendix 1).

A simple synthesis of the history of the Meare Pool on the data thus far presented shows that it presumably owed its origin to systems of raised bogs accentuating the effect of a partial bar of Lias near Westhay. The pool was in existence long before the clay of the Roman period entered its north-eastern corner. The fresh-water clay which forms the present surface is apparently related to the period after digging of the artificial channel of the present River Brue. Information is lacking as to the eastwards extent of the lake in prehistoric time, but in Early Iron Age time it seems likely that raised bogs intervened between it and the open water at the Glastonbury Lake Village site.

4. The lake deposits and evolution of Meare Pool

The nature of the deposits which accumulated in the Meare Pool was ascertained from field inspection of the borings, from inspection of the grosser fragments sieved off in preparing samples for pollen analysis, and by inference from the behaviour of some local components in the pollen diagrams. The most informative series is that set out in figure 5, constituting a section across the western end of the pool, from the easterly Meare Lake Village northwards. Details need not be given, but as example we set out a contracted record of the sequence at PF 2.

PF 2

cm	
0–25	Strongly mouldered *Sphagnum–Calluna* peat.
25–120	Unhumified *Sphagnum–Calluna* peat with cymbifolium *Sphagna*, abundant *Eriophorum vaginatum*, ericoid twigs and rootlets, and moss (cf. *Aulacomnium*).
120–128	Aquatic *Sphagnum* peat with *Eriophorum angustifolium* and ericoid twigs.
128–160	Coarse detritus mud with (?) *Cladium* rhizome at 145 and *Menyanthes* seed at 149 cm, cf. *Scirpus* fruit at 151 cm.
160–170	Reed stems (cf. *Phalaris*), *Molinia* and *Eriophorum vaginatum*.
170–275	Coarse detritus mud with abundant hypnoid moss and frequent *Menyanthes*: occasional twigs.
275–305	Very coarse detritus mud with abundant twigs and some leaves, decayed *Molinia* (possibly flooded surface of layer below).
305–325	Moderately humified *Sphagnum–Calluna* peat with *Eriophorum angustifolium*, *E. vaginatum* and ericoid twigs.
325–335	Laminated coarse mud with twigs, *Menyanthes*.
335–405	Coarse detritus mud with abundant rootlets and hypnoid moss, frequent *Menyanthes*. Some *Phragmites* and wood at base.
405–448	Reed swamp peat of *Phragmites* with *Salix cinerea* leaf.
448–	Soft grey clay.

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For the moment we should except PF 7 from consideration as a special case; the rest of the series then yield a consistent story. To appreciate this fully we shall need to make use of the pollen diagrams of PF 2 which are set out in figures 7, 8 and 9.

It appears that the history of the infilling was generally as follows. The soft grey clay was laid down to an approximately flat surface about +1 or +2 ft. O.D. Its originally

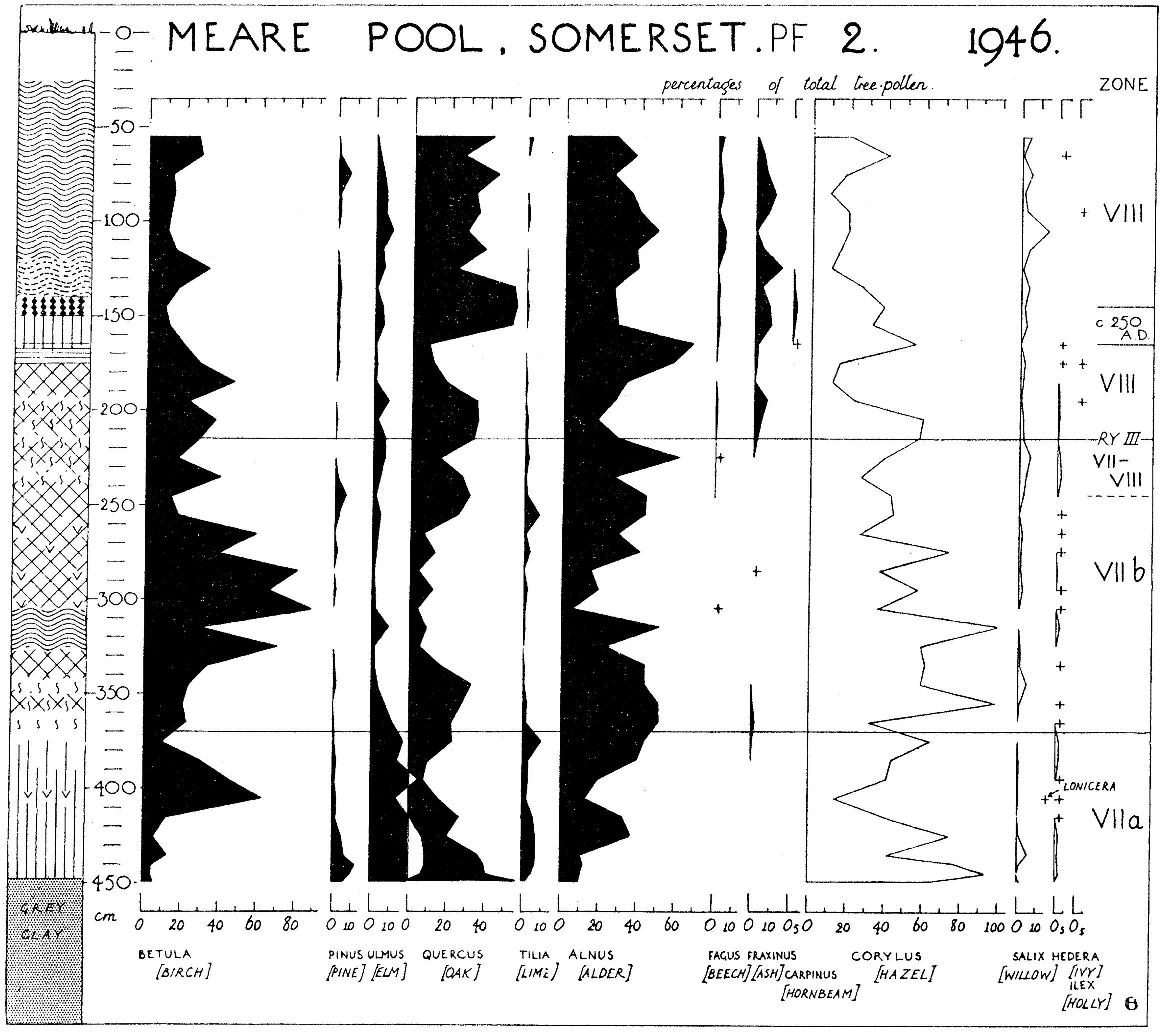

FIGURE 7. Pollen diagram at PF 2 on the north shore of Meare Pool: trees and woody plants.

brackish condition is indicated by the very high values for pollen of Chenopodiaceae type in the bottom samples (figure 9), but it is evident that throughout the latest stages of clay deposition *Phragmites* was growing abundantly. Shortly the water freshened and there appear pollen maxima of *Nymphaea*, *Typha* and Cyperaceae (figure 8). *Salix cinerea* was present and this, with the high fern spore values, suggests local fen-woods.

There then followed a phase of generally open water with varying appearance in different places, here open stands of *Phragmites* and there beds of *Cladium*, and sometimes (as at PF 2, 405 cm) a clump of *Betula* carr. Towards the end of this phase floating hypnoid moss became abundant in the shallowing water, along with *Menyanthes*, and upon this loose mat there was established the next phase, a short but definite period of ombrogenous peat formation. This is represented quite clearly in borings PF 2, 5 and 6 as typical raised-bog peat, and the maximum of ericoid pollen in PF 2 at this level will be noted (figure 9). It is not surprising that the two terminal sites should not show this, since drainage water from the Lias islands would exclude ombrogenous peat formation; they presumably bore fen carr at this time, and a 'lagg' may even have intervened between the incipient raised bog and the upland margins.

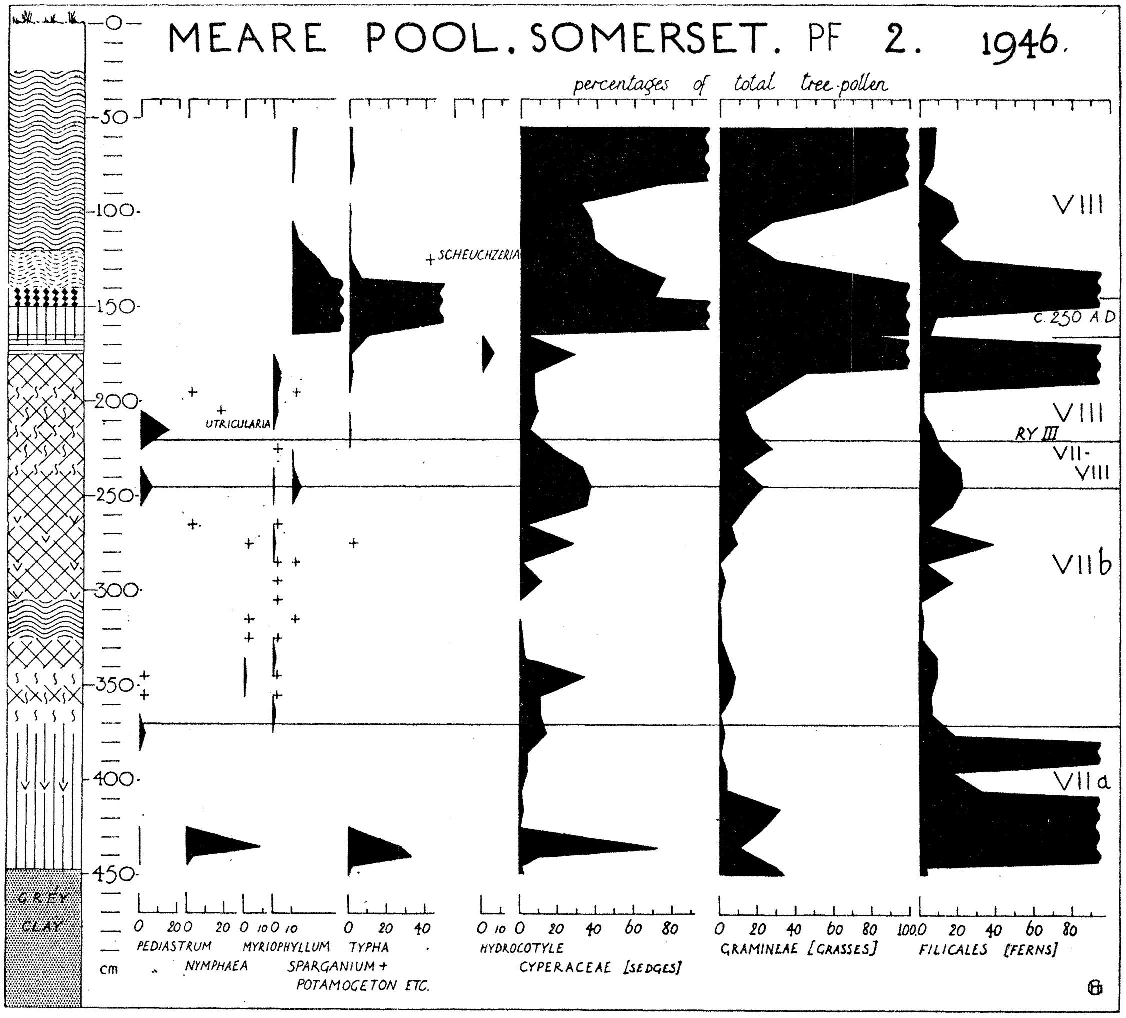

FIGURE 8. Pollen diagram at PF 2: aquatic plants, grasses and ferns.

The phase of ombrogenous peat growth was succeeded by a considerable rise in water level, for now ensued a long period when the whole area was a waterlogged, soft and floating morass of hypnoid mosses and *Menyanthes* with an occasional willow bush. There was not much open water, but low frequencies of pollen of *Myriophyllum*, *Sparganium* plus *Potamogeton*, *Utricularia* indicate its presence, as also the maxima of *Pediastrum* colonies at certain levels (figure 8). The organic muds of this phase extend to very high levels in PF 1, (almost +16 ft. O.D.) and indicate a very high level of water. This sequence corresponds with that already noted at WB 2.

Like the previous phase of open-water conditions this too gave way to a phase of general ombrogenous mire formation. It was variously introduced in different sites, *Typha*, sedges, *Cladium*, reeds such as *Phalaris* and *Molinia* being locally associated. All occurred in PF 2, and in the pollen diagram for this site (figure 8) striking and sudden maxima will be noted in various curves associated with these reed-swamp and fen dominants, and an instructive maximum of *Hydrocotyle* preceding them. There was some time after this, a stage of open but acidic pools with aquatic *Sphagna* and the characteristic associate, *Scheuchzeria palustris*. At all sites, not only in this section but elsewhere in the lake, there now followed

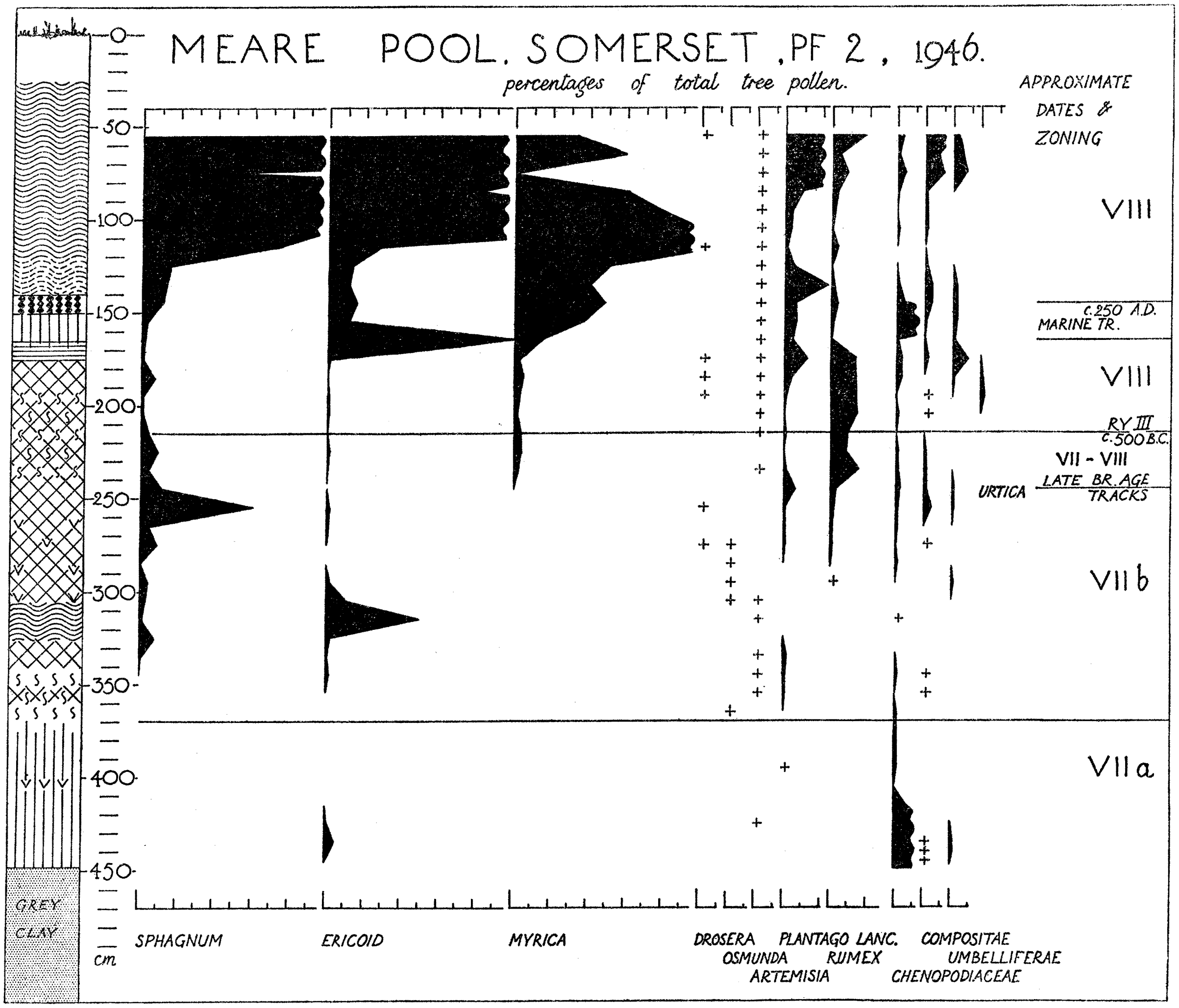

FIGURE 9. Pollen diagram at PF 2: non-tree pollen of local origin and of weeds.

widespread development of ombrogenous mire, and characteristic raised bog undoubtedly developed over the greater part of what had formerly been the (much-overgrown) lake. We cannot easily say how long this phase persisted, but during it the Early Iron Age villages at Meare were established, sited actually upon the southern margin of this raised-bog complex. On the other side of the lake, at Peacock's Farm, the bogs continued to build up many feet of raised bog peat. Finally, the lake of historic times was established and open water appeared yet again. Abundant fresh-water Mollusca now lived upon the old surface of the raised bog peat which suffered much secondary change, and may indeed have been substantially destroyed. Into this open lake finally discharged the flood clay of the River Brue, and this accumulated to a substantial and varying thickness, naturally greatest near the river.

We thus have an outline history of the evolution of the lake as exhibiting two long phases of more or less open water, each concluded by the development of raised bog, and then a final stage of open water extending to historic time.

We may now attempt to date these developmental stages and possibly to bring them into relation with events in the Shapwick–Meare Heath district. The tree-pollen diagram for PF 2 gives us the means of dating. Its zoning follows the principles already established for the region.

The first open-water phase occupies the whole of Zone VII *a*, during which time throughout the Shapwick Meare district when the basal clay surface was somewhat higher *Phragmites* or *Phragmites–Cladium* reed-swamp grew. The first phase of ombrogenous bog growth in the Meare Lake began early in Zone VII *b*, but whereas in the Shapwick–Meare region this type of mire persisted at least until the opening of Zone VIII, in the Meare Lake it was quickly replaced by reversion to open water. It may, indeed, be that the growth of large areas of raised bog westwards down the valley so clogged up the drainage that the drainage waters of the Brue, Whitelake and Sheppey rivers accumulated to the east in the Meare Lake region. It is also possible that increased rainfall may have been responsible. It will be noted that the rise of water-level in Zone VII *b* now for the first time explains the stratigraphy at Meare Heath II (Godwin 1941, p. 123), where humified Regeneration-complex peat is at this time replaced by a wet *Carex–Sphagnum* peat. The boundary between Zones VII *b* and VIII seems well attested in the PF 2 pollen diagram, not only by the tree pollen (especially *Fagus* and *Tilia*), but also by the weed pollen (figure 9) in relation to that of the Decoy Pool Wood diagram (Godwin 1948). There is little evidence that the flooding which so strongly affected the raised bogs at this time (equivalent to the opening of the Sub-atlantic period) altered the vegetation of the lake, but it will be noted that high values of *Pediastrum* occur at this level in PF 2, as also at the onset of the rather ill-marked transition Zone VII–VIII. On the raised bogs of Shapwick and Meare the first flooding horizon about 500 B.C. was followed by a second about A.D. 50 and the calcareous water must there have attained a height of at least +17 ft. O.D. However, we have seen already that in PF 1, before the onset of the final ombrogenous peat formation the open water muds formed to a height of +16 ft. O.D. The actual water-level must have been somewhat higher. The upper flooding horizon here referred to cannot be otherwise recognized in the lake, but the Romano-British marine transgression which, as we have seen, entered the north-eastern corner of the pool, does seem to be indicated. The evidence for it is to be seen in the enormous maxima of pollen of Chenopodiaceae between 145 and 165 cm whilst other weed-pollen types sharply diminish and there is also a setback in the newly risen curve for ericoid pollen. It is apparent that the transgression did not greatly affect the lake, and indeed if its water-level had already been about +20 ft. O.D., it would have been very near the height of the brackish water which laid down the Roman clays at Batch Farm and beside Godney.

This dating of the Romano-British transgression into site PF 2 gives a dating of at least A.D. 300 for the onset of ombrogenous peat formation at that point, but it is evident that this phase began much earlier elsewhere in the lake, since the Meare Lake Villages (*ca.* 60 B.C. to A.D. 50) were built upon a substantial thickness of raised bog peat. This is not, however, a surprising conclusion in a region where the local aggregation of drainage water could delay or prevent the growth of *Sphagnum* bog.

What is perhaps more remarkable is this: why should the onset of the Roman transgression not interrupt the extensive development of raised bogs, seeing that it laid down big deposits of clay in the Godney and Panborough gaps? It is clear that the effect was not to worsen the drainage of this part of the valley, but rather to improve it, and it seems possible that it was now that the waters of the Brue, Whitelake and Sheppey rivers were first directed into the Axe valley. Such a supposition would perhaps explain the remarkable cessation of growth of the Shapwick raised bogs in late Roman time, a point noted earlier (Godwin 1941). This explanation leaves the course of the *pre*-Roman River Brue still obscure, but it may well have lain on the north side of the Wedmore–Polden valley.

Leaving aside for the time being further comment upon the pollen analyses of PF 2, we may consider the stratigraphy and pollen analyses of PF 7, the site in this series lying nearest the present River Brue.

Although somewhat difficult to determine, the stratigraphy may be represented as follows:

PF 7

cm	
0–65	Grey-buff river clay with abundant fresh-water shells at base.
65–105	Grey-black organic lake-mud.
105–130	Much decayed residue of *Sphagnum–Calluna* peat probably *in situ*.
130–140	Transition layer with abundant coarse dicotyledonous leaf fragments—possibly a fen-carr.
140–220	Detritus mud peat with frequent *Menyanthes* and occasional *Betula* twigs, some fresh *Sphagnum* leaves apparently increasing in abundance to 220 cm.
220–315	Detritus mud peat with much derived *Sphagnum–Calluna* peat; abundant fern sporangia at 315 cm.
315–325	Rootlet mud with *Carex–Phragmites–Pediastrum*.
325–	Soft blue clay.

Its upper layers are conformable with the rest of the series, showing river clay with abundant fresh-water shells, especially at its base above a layer of *Sphagnum–Calluna* peat. Below this the stratigraphy is unlike that of the series. At the base there is no reed-swamp peat as occurs so generally under all the raised bogs of the levels and in PF 2 to PF 6, but some 10 cm only of a *Carex* rootlet mud with abundant *Pediastrum* and a little *Phragmites*. Above this followed a substantial thickness of peat containing much blackened *Sphagnum–Calluna* peat, apparently the product of erosion of older raised-bog material. By about 220 cm, however, the derived material had given place to a mud type far more like that in the rest of the series at equivalent levels, the product of a floating mat of *Menyanthes* and *Sphagna* with occasional wood in the upper layers before establishment of ombrogenous bog *in situ*.

When we consider the pollen diagram of PF 7 with this history in mind, it seems quite apparent that none of the deposit was laid down in Zone VII*a*. The presence of *Fagus* and *Plantago lanceolata* to the base clearly indicates this. It would seem that when, part-way through Zone VII*b* there was the general rise in lake-level already demonstrated, some erosion of the newly-formed raised bogs took place, the debris accumulating in channels, in one of which PF 2 seems to have occurred. No doubt the pollen analyses in part represent contemporary pollen, and in part pollen derived from the older *Sphagnum–Calluna* peat; this would account for the high ericoid pollen values below 220 cm, and possibly the high and curiously fluctuating values for *Ulmus*. Towards the end of Zone VII*b* lake conditions were quiet, and in Zone VII–VIII ombrogenous mire established itself. This is quite in conformity with the sequence of events at the Meare Lake Village site, PF 8.

It seems probable here that open water was re-established early in Zone VIII above the *Sphagnum–Calluna* peat, but before the river clay was laid down; if so it would agree with the postulation we have made of high lake-levels about A.D. 50.

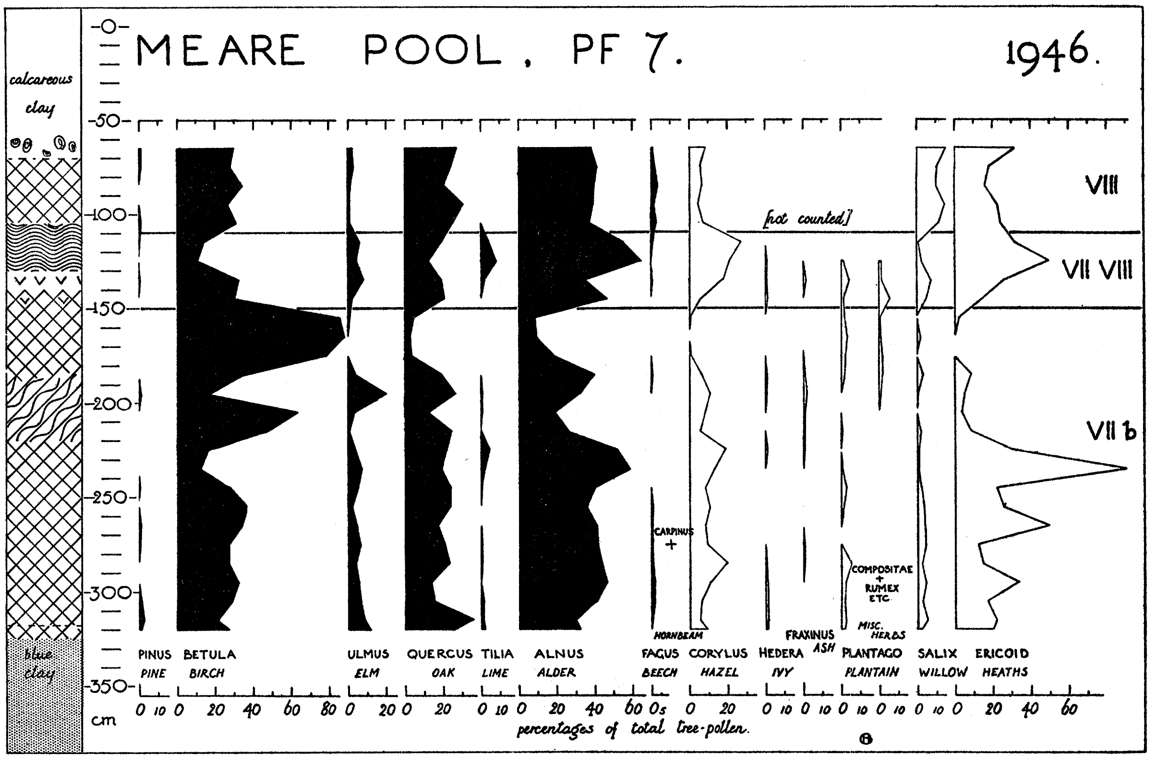

FIGURE 10. Pollen diagram at PF 7.

5. GLASTONBURY LAKE VILLAGE

The Early Iron Age lake village at Glastonbury, whose excavation by Bulleid and St George Gray was such a landmark in British archaeology, lies well within what we call the Meare Pool region, although possibly outside the northern limit of the historically known lake. In contrast with the Meare Lake Village, which has been shown to have the structure of a crannog laid upon the surface of a raised bog (albeit close to open water), the Glastonbury Lake Village was much more like a true lake-dwelling, being built as a raft upon the surface of a morass, supported by a multitude of piles and with open water beside it.

The examination of such a site stratigraphically and by pollen analysis offers at once the prospect of a long continuous record of vegetational history, a definite archaeological correlation, and the opportunity of determining maximum water-levels during the period of occupation of the village, a period we may provisionally take as falling between 50 B.C. and A.D. 20.

Two borings were made, one in 1946 and one in 1947, and the stratigraphic record is compiled from both. The site is on the flank of one of the hearth sites (no. V) on the western side of the village, and the characteristic materials of the occupation floor were easily recognizable in boring through the uppermost layers.

GLV 1

(Ground at +16·1 ft. O.D.)

cm	
0–60	Grey-brown stiff clay with abundant charcoal fragments.
60–92	Mouldered brown peat with abundant wood fragments (cf. *Salix*) and stone of cf. *Crataegus* at 92 cm.
92–110	Fine detritus mud with occasional wood fragments. Fruits of *Potamogeton* (cf. *natans*) at 99 cm, *Nuphar* and *Eleocharis*.
110–400	Coarse detritus mud with occasional wood fragments (large wood between 205 and 225 cm and abundant wood 345 to 350 cm and 380 to 400 cm).
400–435	Fine detritus mud.
435–	Soft grey-blue clay.

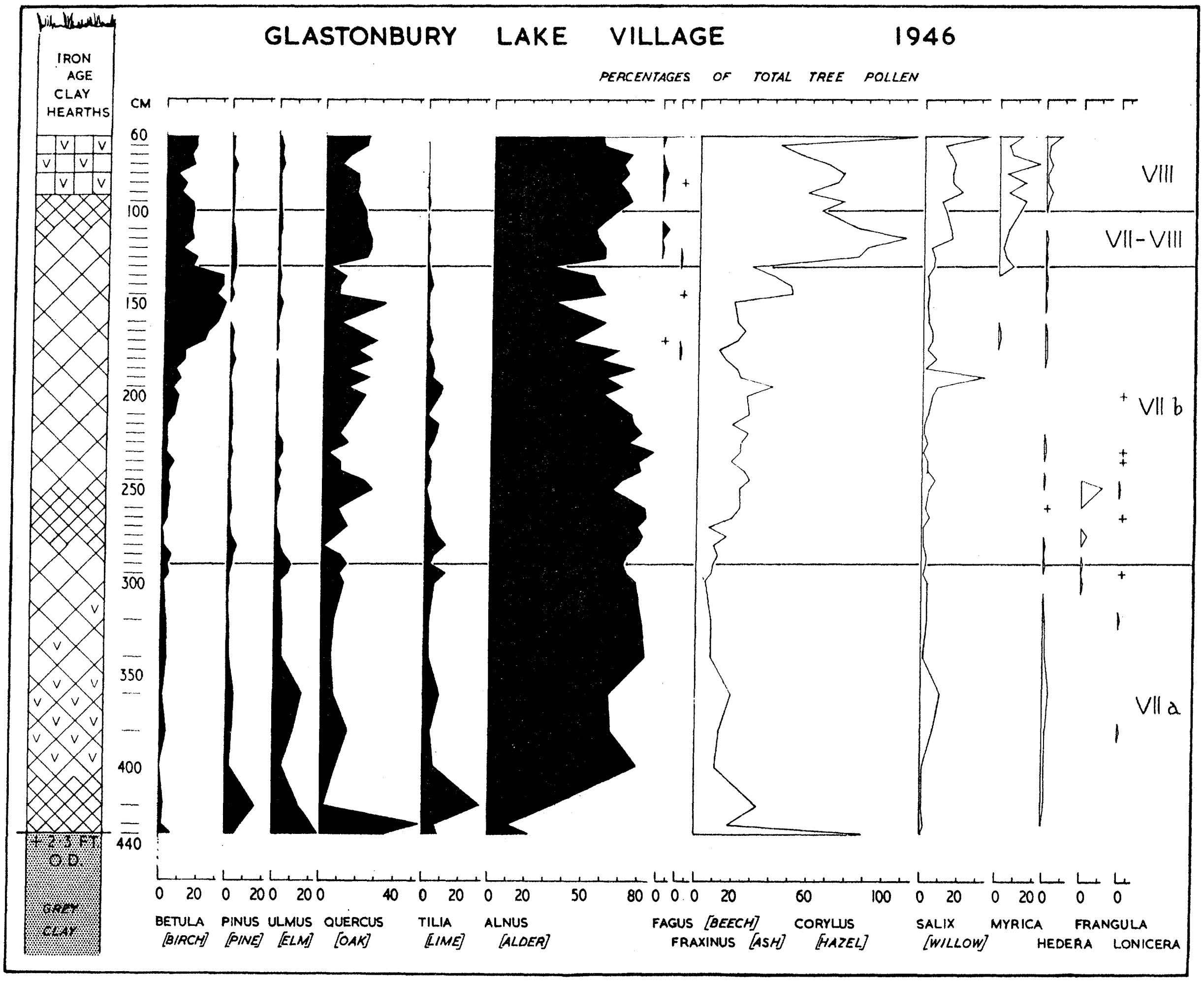

FIGURE 11. Pollen diagram at Glastonbury Lake Village: trees and woody plants.

It is clear from this that from late Boreal time when the basal clay was deposited, the site was more or less open water. The brackish water influence at first is shown by the high values for pollen of chenopodiaceous type (figure 13), and high values for *Typha*, *Typha*+*Sparganium* and Gramineae immediately after indicate conversion to fresh open water with reed-swamp. There was presumably a little fen carr upon the floating mat.

The occurrence of *Osmunda* and *Frangula alnus* at the opening of Zone VII*b* possibly suggests a tendency to form acid bog close by, but somewhat deeper water conditions are indicated later by the pollen of *Nuphar* and *Nymphaea* and colonies of *Pediastrum* (figure 12).

The openness of the lake throughout is stressed by the very low values for ericoid pollen and *Sphagnum* spores; not until Zones VII–VIII and VIII do they appear, and then only in modest amount. They are significantly coupled with a rise in pollen of *Myrica*, and the corresponding rise in pollen of '*Corylus*' may be associated with much *Myrica* wrongly identified (figure 13).

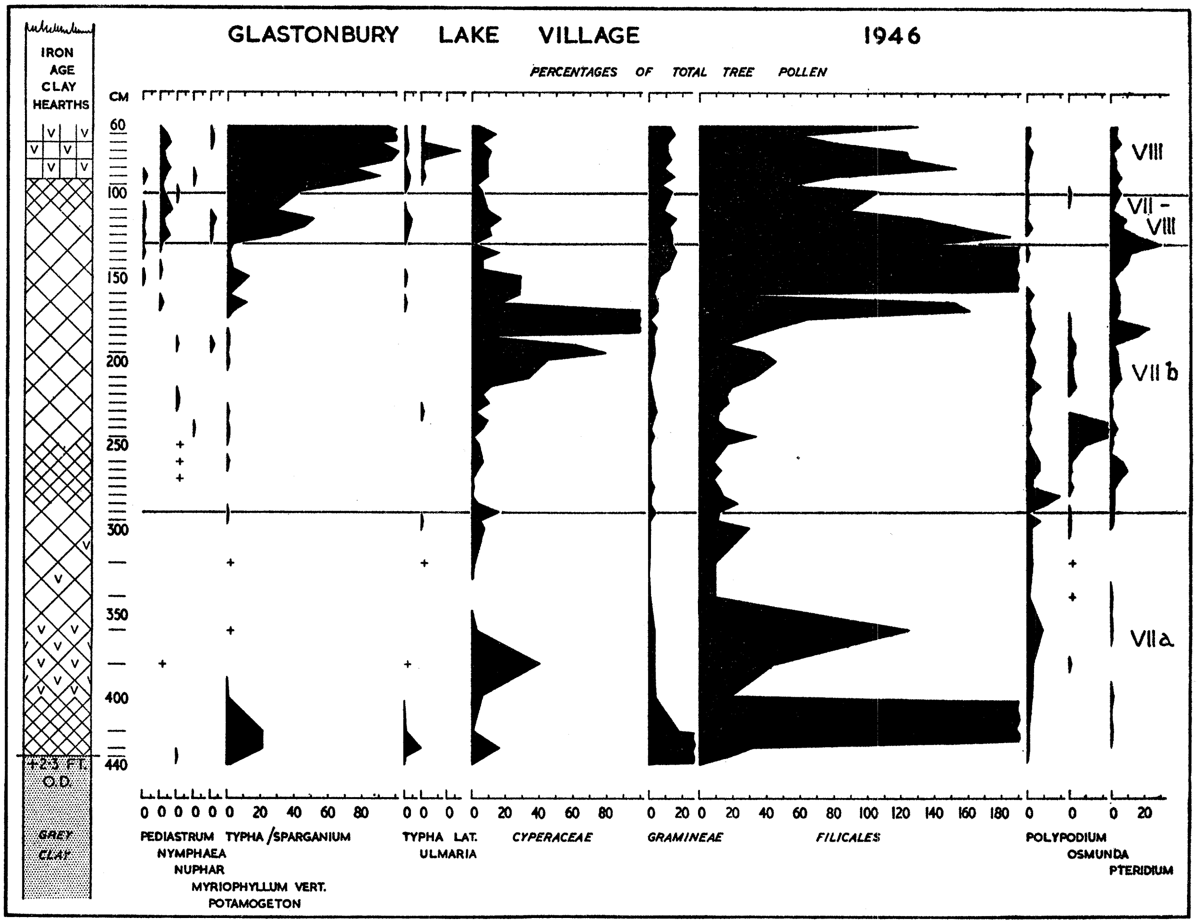

FIGURE 12. Pollen diagram at Glastonbury Lake Village: aquatic plants, grasses and ferns.

It is to be recalled that Bulleid and C. Reid gave indisputable evidence that the village foundations were laid upon a fen carr of alder and willow cleared by axe for the purpose, and field stratigraphy and pollen curves both indicate a layer of wood peat at the expected level. There are very high preceding values for *Typha–Sparganium*, a maximum of *Ulmaria*, and fairly high values for *Salix*. It is apparent that during the phase when ombrogenous peat was forming extensively in the Meare Pool region, at this actual site the succession only advanced as far as floating fen carr. Likewise the phase of ombrogenous peat formation which affected the western parts of Meare Pool region early in Zone VII*b*, was reflected at the Glastonbury Lake Village site, if at all, merely by a shallowing and perhaps by local fen carr. The conclusion seems evident that maintained supplies of fresh water fed this end of the valley throughout its history.

The tree-pollen diagram (figure 11) on which the zoning is based shows, as would be expected in an open lake site, a very smooth run of the tree-pollen curves, uninterrupted by local vegetational developments. In this it resembles the diagrams from the deep raised bogs on Shapwick and Meare Heaths, and contrasts with diagrams just considered from the western part of Meare Pool. Comment upon the weed-pollen curves may be reserved.

We may note that the present height of the base of the Iron Age hearth is about +14 ft. O.D., a figure comparable with the present height of +11 ft. for the corresponding position at the Meare Lake Village. Both values are substantially below the

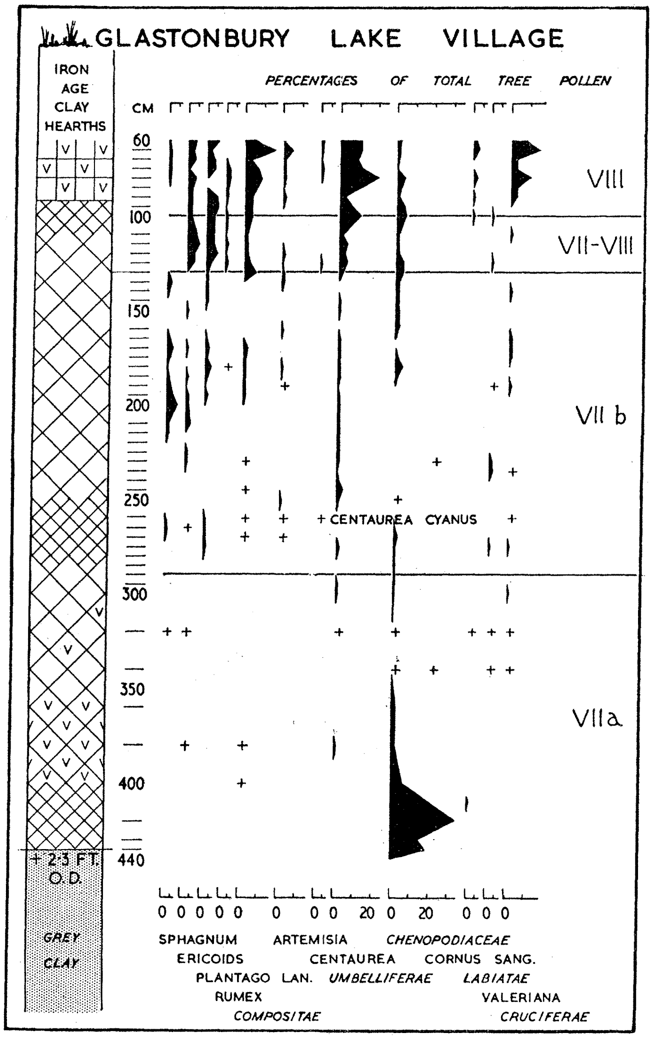

FIGURE 13. Pollen diagram at Glastonbury Lake Village: non-tree pollen of local origin and of weeds.

values already derived for the highest water phase of Meare Pool. The upper layers of both Lake Village sites are too decayed to allow the certain recognition of lake mud over them and beneath the river-flood clay, but it seems highly likely that this period of high water-level followed that of the Lake Village occupation and may indeed supply the reason, hitherto lacking, for cessation of the occupation.

The brackish-water clay of the Romano-British transgression appears not to have reached quite so far as the Lake Village site, but Bulleid gives a section (p. 39, Bulleid and Gray

1911) at a site 200 yards north of the village, showing near the surface two clay layers separated by peat. These are presumably referable to the marine transgression and the succeeding river-flood clays respectively.

6. Drake's Drove: stratigraphy and pollen analyses

'Drake's Drove' is a site which lies somewhat far from the Meare Pool series so far considered. It is on the line from the Panborough Gap to Meare Lake Villages, but whilst only 730 m from the Panborough Gap, it is 1700 m from the historic lake margin near

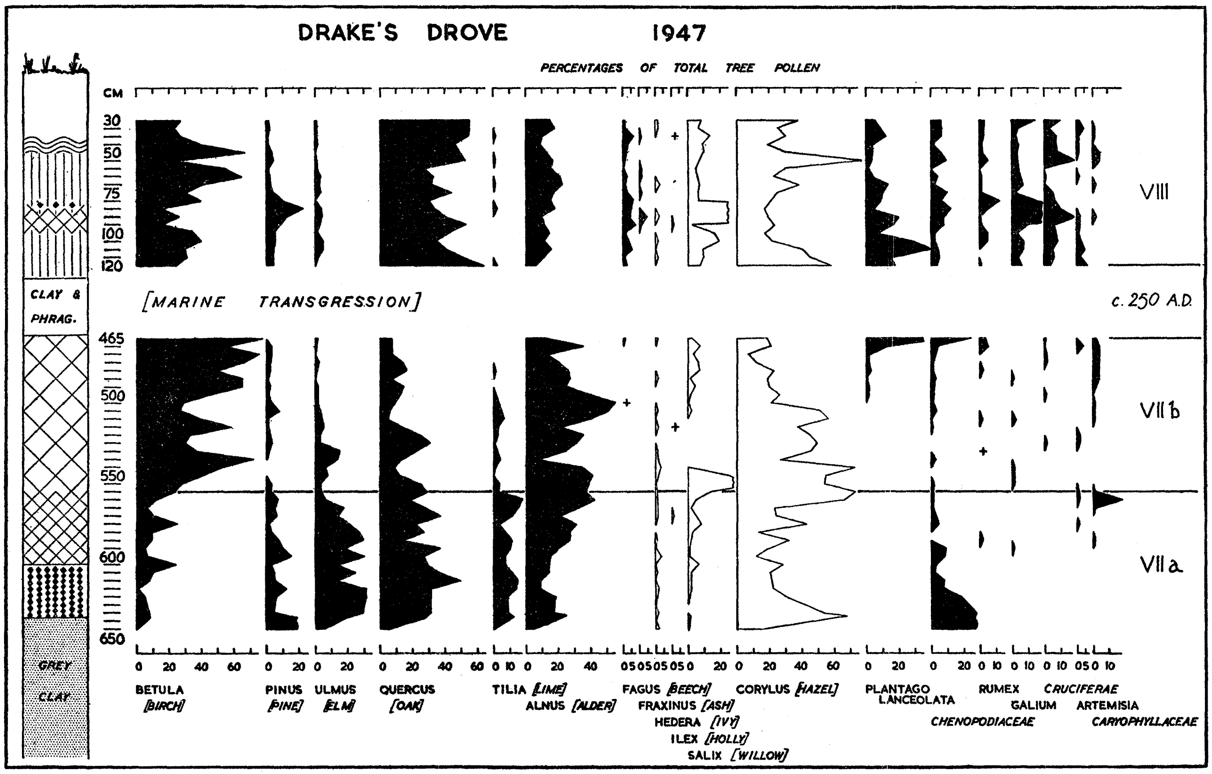

Figure 14. Pollen diagram at Drake's Drove, peats and muds above and below Roman clay: pollen of trees and woody plants, and of weeds.

Peacock Farm measured along the same line. It was chosen as a site within the spread of the Romano-British clay where it might prove possible to secure pollen analyses from the organic deposits which here lie in considerable thickness both above and below it. The results of these analyses are set out in figures 14 and 15.

Stratigraphy is given below.

Drake's Drove
(+22·7 ft. o.d.)

cm	
0–50	Chocolate-brown very mouldered peat (? *Calluna* peat).
50–85	Yellow-brown sedge-peat with *Cladium* rhizomes at base.
85–128	Grey detritus mud with *Carex* rootlets: *Menyanthes* at 98 and 109 cm.
128–463	Blue clay with *Phragmites* throughout but more abundant at top (+18·5 ft. o.d.).
463–560	Coarse detritus mud, compressed at top: *Menyanthes* throughout, occasional wood fragments, *Planorbis* at 510 cm.
560–605	Fine detritus mud (possibly formed in deeper water than that above).
605–638	Black peat with abundant *Cladium* rhizomes.
638–	Soft blue-grey clay with *Phragmites* in upper layers (+1·8 ft. o.d.).

The absolute level of the basal soft clay conforms with that elsewhere in the Somerset Levels. The level of the top of the Romano-British clay here is +18·5 ft. O.D., which is much the same as along North Chine Drove, but a little less than the clay surface under Berrow Hill close to the Panborough gap.

The tree-pollen diagram beneath the Roman clay appears to represent the regional pollen rain throughout Zone VII*b*, but thereafter to be much affected by high *Betula* values, presumably birch growing on bog surfaces nearby. The opening of Zone VII*a* is again shown by high values of chenopodiaceous pollen to have been brackish, but this

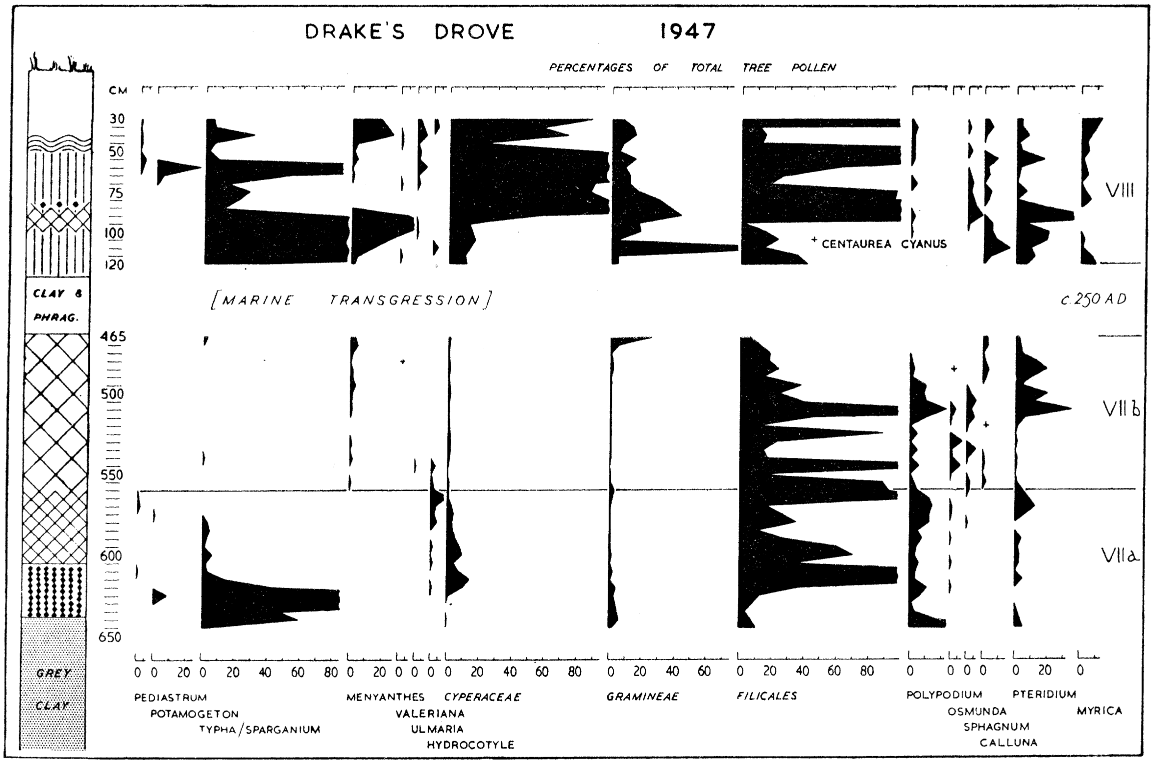

FIGURE 15. Pollen diagram at Drake's Drove: aquatic plants, grasses and ferns.

phase was quickly followed by fresh-water conditions in a *Cladium* reed-swamp where there are maxima of pollen of *Potamogeton* and *Typha/Sparganium*. The *Cladium* fen gave place to more open water, but at the close of Zone VII*a* a maximum of *Hydrocotyle*, and later *Salix*, at a time when low *Sphagnum*, *Calluna* and *Menyanthes* values establish themselves, suggests a transition to a floating scraw bog, just as we have seen to be the case at PF 7. A maximum of *Osmunda* at this transition recalls the same phenomenon at a corresponding stage in GLV I. The tendency to ombrogenous peat formation here, as at GLV I, was not carried very far, but local birch growth must have been very pronounced.

There is no indication in the tree-pollen curves of the onset of Zone VIII below the Romano-British clay, nor is there any indication of increased water-levels such as affected the Meare Pool vicinity. It may be that a gap in the record exists here, the upper layers of organic mud having been removed in this phase of high water-levels. The high values of *Plantago lanceolata* pollen just below the clay may well reflect the occupation phase of the Lake Villages; the high Chenopodiaceae may reflect the brackish water conditions (figure 14).

The organic deposits that lie above the clay are no doubt early post-Roman. Their tree-pollen curves show such a substantial and consistent *Fagus* curve as to make local presence of that tree certain, and the same might well be said of the *Carpinus*. The curves for *Sphagnum*, *Calluna*, *Osmunda* and *Myrica* all indicate the continuing tendency to ombrogenous mire formation.

7. Further indications from pollen analyses

In our discussion of the pollen diagrams from the Meare Pool region we have exploited the indicator value of different pollen and spore types so as to reconstruct a picture of the local vegetation at different places and times. Thus pollen of Chenopodiaceae as indicative of salinity, pollen of *Menyanthes*, *Utricularia*, *Nymphaea*, *Nuphar*, *Myriophyllum* and *Potamogeton* of open water, pollen of *Typha* of reed-swamp, pollen of *Drosera*, *Scheuchzeria*, ericoid plants and spores of *Sphagnum* and *Osmunda* of ombrogenous bog, pollen of *Hydrocotyle* and *Ulmaria* of fen, and pollen maxima of *Salix*, *Alnus*, *Frangula* and *Betula* under certain conditions as indicators of fen carr.

The chief tree-pollen types have been employed as indicative in large degree of the general forest cover of the uplands as a whole, and upon them the pollen-zoning already established in this valley has been applied to the diagrams of the Meare Pool region. No fresh comment is needed here upon them, although it will be noted how the diagrams from the open lake show a less distorted picture than those from sites where fen carr was locally present.

It is to be noted that among woody plants there is evidence of the pollen of *Lonicera* and of *Cornus sanguinea* in both Zone VII *a* and Zone VII *b*. As in the Decoy Pool Wood diagram (Godwin 1948) so in PF 2 and possibly in Drake's Drove, there is a tendency for higher *Fraxinus* and *Ilex* values. The behaviour of *Hedera* differs as between one site and another, falling off in Zone VIII at PF 2 and Drake's Drove, but not (in the earliest part of Zone VIII at least) at Glastonbury Lake Village.

There remains for consideration the category of pollen types which are apparently linked with disforestation and agriculture, a category including *Plantago lanceolata*, *Centaurea cyanus*, *Rumex*, *Artemisia*, *Urtica* and the aggregates grouped under Cruciferae, Umbelliferae, Compositae and Chenopodiaceae (in fresh-water deposits). Although members of the genera and families here named may well have place in undisturbed communites of the region, it is generally agreed that where their pollen occurs abundantly with frequent pollen of *Plantago lanceolata*, it can be considered evidence of a weed population. Accepting this view the diagrams of the Meare Pool region indicate low frequencies of weeds early in Zone VII *b* corresponding with Neolithic occupation, and the first grain of *Centaurea cyanus* occurs at this level. The first consistent rise of weed pollen curves is in the transition Zone VII–VIII, corresponding with the Late Bronze Age. Somewhat ill-developed maxima occur before and after the stage of Roman marine transgression indicating the effects of both Early Iron Age and Romano-British settlement. At PF 2, early in Zone VIII, a maximum of *Urtica* may correspond with the period of Lake Village occupation, and at Drake's Drove *Centaurea cyanus* occurs in late Roman time. The highest weed-pollen values of all occur in the uppermost samples of PF 2, in layers almost certainly post-Roman. It is interesting to note that the curve for *Pteridium* seems to be correlated fairly closely with that of the weed pollen, and it may be that the bracken spread as a result of forest clearances. The general course of agricultural activity in this region appears to correspond in general with that shown previously in Shapwick Heath, with maxima at approximately the same stages, but the clear regression of the weed population during periods of flooding that emerged so clearly in the Decoy Pool Wood diagram is less apparent here where samples were taken at much longer intervals.

8. Conclusions

The clays in the Meare Pool region have been sharply separated into an upper fresh-water clay of late, probably medieval date, an intermediate clay of estuarine character at levels from +8 to +20 ft. O.D. that was due to marine invasion in the late Romano-British period and a basal estuarine clay only just above mean sea-level which was deposited at the end of the Boreal period and which fills all the levels. It is shown that the Roman clay filled the Axe valley and through the Panborough gap passed the Wedmore Ridge to form a substantial deposit across the landward end of the Wedmore–Polden valley to within a short distance of the former GLV site. In concert with this finding it is suggested that the natural Brue channel thereafter also ran from Glastonbury through the Panborough gap. It seems improbable that at the onset of the Romano-British marine transgression there was any large natural estuary entering the Wedmore–Polden valley, otherwise the marine clay would have penetrated by it directly into this valley. That it did not do so is shown by the absence of Romano-British clay in the series of borings at the westward end of Meare Pool, although the Roman clay reached the *eastern* end of the lake by the Panborough gap route. This clear evidence disposes of any suggestion that Meare Pool might have owed its origin to blocking up of its natural seawards outlet by deposition of the Roman clay.

Stratigraphic investigations have indeed established that all the Somerset Levels were occupied by shallow open water in Atlantic time (Zone VII *a*), but whereas at the Glastonbury Lake Village site and Drake's Drove lake conditions persisted throughout the Sub-boreal also (Zone VII *b*), in the bed of the historic lake during two periods there was great encroachment by the growth of raised bog. The first of these periods was early in VII *b*, the second, more vaguely dated, began near the close of Zone VII *b* and was interrupted by a phase of very high lake levels in the Romano-British period, during which time marine transgression brought weakly brackish water into the upper end of the lake.

The Meare Pool region was thus throughout Atlantic and Sub-boreal time intermediate in its developmental history between the Shapwick–Meare region where raised bogs once established maintained their growth, and areas towards the north and east end of the valley where lake conditions persisted. Only as a result of the growth of surrounding raised bogs was the historic outline of the lake determined and this appears to have been as late as Sub-atlantic time; before this the Meare Pool area was merely part of more extensive sheets of open water.

It is disappointingly difficult to interpret the lake stratigraphy in terms of the water-level changes which caused the flooding episodes already established for the raised bogs. Many factors can be adduced to suggest why this should be so, among them the late constriction of the lake, the possibilities of erosion, and the insensibility both of floating vegetation and of deeper water deposits to changes in lake-level. We may nevertheless note that early in Zone VII *b* when ombrogenous mires were already permanently established in the Shapwick–Meare region, there took place the first invasion of the Meare Pool region by raised bog peat, and that the high stands of water which flooded the raised bogs about A.D. 50 appear to be represented by very high levels of water in the Meare Pool region also. Such levels were undoubtedly much above those in the immediately preceding period of occupation of the Meare and Glastonbury Lake Villages.

The onset of flooding of the raised bogs which induced building of the Late Bronze Age trackways is difficult to recognize in the Meare Pool deposits.

The general course of the tree-pollen diagrams here recorded conforms closely to the vegetational sequence already established for the region, and the Glastonbury Lake Village occupation floor and the late Roman clay afford new time indices in relation to it. The progress of disforestation and the spread of agriculture in the region is clearly reflected in the non-tree-pollen diagrams; the sequence of slight agricultural activity in Neolithic to Middle Bronze Age, increasing activity in the Late Bronze Age, and again in the pre-Roman Iron Age, which had been already noted on Shapwick Heath, is encountered again and extended by a further maximum in Late Romano-British time. The pollen diagrams furnish evidence also of the presence of numerous species of biogeographical interest, such as *Centaurea cyanus*, *Plantago lanceolata*, *Frangula alnus* and *Cornus sanguinea* at specific times, and strengthen the evidence for the indigenous status of the beech (*Fagus sylvatica*) in this region.

I must express my most sincere gratitude to many friends who have helped me in the laborious field work, particularly Mr P. A. Tallantire, Mr J. S. Jennings, Professor A. R. Clapham and Mr H. S. L. Dewar. The late Dr A. Bulleid gave me unstinted help from his vast knowledge of the Levels and passed over his notes and maps for my use. To Miss R. Andrew, Mrs M. E. Robinson and Mrs M. Dainty I am indebted for the pollen analyses, and to Dr W. A. Macfadyen for the foraminiferal analyses published in the appendices.

Appendix 1

The microfauna from two clay deposits at Meare Pool, Brue Valley, Somerset

By W. A. Macfadyen

Four samples were received from Dr Godwin on 22 April 1946 as follows:

A. 'GLV II, near Batch Farm, 120–150 cm clay.' $6\frac{1}{2}$ oz. fine clay, light grey with traces of brown shading. Residue fairly small, almost wholly of peaty fragments, practically siltless.

B. 'GLV II near Batch Farm, 150 to 200 cm clay'. About 8 oz. (not weighed), fine grey clay. Residue, medium sized, almost wholly of peaty fragments, practically siltless.

C. 'Near PF 6. Junction of top clay and peat beneath: 8/4/46.' $14\frac{1}{2}$ oz. (8 oz. washed); brown earthy clay, powdery, with a little vegetation. Residue fairly large, almost wholly of peaty fragments, trace of silt.

D. 'Near PF 6. Upper clay about 1 ft. above junction with peat; Meare Pool.' 13 oz. (8 oz. washed); brown earthy clay, powdery with traces of vegetation. Residue fairly large, almost wholly of peaty fragments, with traces of silt and comminuted non-marine molluscan shells.

The microfauna and microflora found in the washed residues is recorded as follows. The samples were washed through a 150 mesh/inch sieve, with square apertures about 0·09 mm side. The mud that passed this sieve was ignored.

	A	*B*	*C*	*D*	Largest diameter (mm)	Water group‡ (Macfadyen 1938, *Geol. Mag.* p. 415)
Foraminifera						
Quinqueloculina fusca Brady	2	3	.	.	0·28	IV
Q. subrotunda (Montagu)	3	.	.	.	0·15	III
Cornuspira involvens (Reuss)	2	.	.	.	0·16	III
Ophthalmidium balkwilli Macfadyen	6	.	.	.	0·18	.
Trochammina macrescens Brady	7	31	.	.	0·46	VI
T. squamata Jones & Parker	9	.	.	.	0·45	V
Bolivina pseudoplicata H-A. & E.	5	.	.	.	0·18	V
Cassidulina crassa d'Orbigny	1	.	.	.	0·09	II
C. nitidula (Chaster)	2	.	.	.	0·14	.
Lagena inaequilateralis Wright	1	.	.	.	0·17	.
L. marginata Walker & Boys	2	1	.	.	0·22	III
L. marginato-perforata Seguenza	1	.	.	.	0·17	.
Polymorphinid (unidentified initial chamber)	1	.	.	.	0·11	.
Globigerina bulloides d'Orbigny	3	.	.	.	0·20	III
?*G.* sp.	.	.	.	2	0·15	.
Discorbis williamsoni Chapman & Parr	1	.	.	.	0·15	III
Lamarckina haliotidea (H.A. & E.)	2	.	.	.	0·18	II
Streblus beccarii var. *lucida* (Madsen)	20	19	.	.	0·40	VII
Nonion depressulus (Walker & Jacob)	11	.	.	.	0·40	VII
Elphidium incertum (Williamson)	2	1	.	.	0·18	VI
Fresh-water Rhizopoda						
Arcella vulgaris Ehrenberg	.	.	3	45	0·14	.
Centropyxis aculeata var. *ecornis* (Ehr.) Leidy	.	.	6	.	0·14	.
Difflugia constricta (Ehr.) Leidy	.	.	6	.	0·14	.
D. (?) *globulus* Ehrenberg	.	.	11	.	0·14	.
D. oblonga Ehrenberg	.	.	10	1	0·21*	.
D. (?) *pristis* Penard	.	.	.	12	0·07	.
Nebela tincta (Leidy) Averintzev	.	.	5	.	0·09	.
Other microfauna and microflora						
Gastropods (non-marine)	.	.	+	+	.†	.
Ostracods	1	13	.	.	0·48	.
Sponge spicules (*Geodia*)	1	.	.	.	0·12	.
Diatom: *Triceratium favus* Ehrenberg	8	7	.	.	0·17	.
Chara fruits	.	.	2	.	0·58	.
Tailed brown globes§	X	V	C	M	.	.
Plant seeds	2	.	1	.	.	.

* One specimen 0·39. † ?4 spp. in each sample; different.

‡ Provisional classification of tolerance of brackish conditions, from group I, with purely marine forms intolerant of any admixture of fresh water, to group VII, including the most tolerant species which will live in nearly fresh water.

§ Frequency of occurrence: I = very rare, 1–4 specimens; V = rare, 5–9 specimens; X = frequent, specimens found in tens; L = common, specimens found in fifties; C = very common, specimens found in hundreds; M = flood; + = present.

Note. Determinations of the fresh-water Rhizopoda above are provisional and approximate and must be accepted with caution until they can be checked by better authority.

Discussion

GLV II, *sample A* (120–150 *cm*)

This is the only one of the four samples in which an estuarine (nearly normal marine) component is clearly evident. One is tempted to regard the foraminiferal fauna as in two parts:

(i) An indigenous component of brackish water far removed from sea water, with *Trochammina macrescens*, *T. squamata*, *Streblus beccarii* var. *lucida*, *Nonion depressulus*, with other species less in evidence, such as *Quinqueloculina fusca*, *Bolivina pseudoplicata*, of about normal size, i.e. 0·25 to 0·45 mm.

(ii) An estuarine component, particularly indicated by *Ophthalmidium balkwilli*, *Cassidulina crassa*, *C. nitidula*, *Lamarckina haliotidea*, the rare *Lagena* spp., the *Geodia* spicule, and the diatom *Triceratium favus*; the Foraminifera are of abnormally small size, mostly between 0·1 and 0·2 mm.

Why the estuarine forms should be so few in numbers and so small in size is a problem to which the answer is not evident from these samples. This component is recognizable as part of the normal west coast of England and Wales shallow water, probably estuarine, fauna, found notably in the post-Glacial deposits at Swansea Docks, and at Westbury on Severn, and as a pale reflexion at Combwich Brick Pit, 480 cm sample.

GLV II, *sample B* (150 *to* 200 *cm*)

This has a scanty brackish water microfauna, without any real evidence of estuarine influence from the Foraminifera. The diatom *Triceratium favus*, however, is apparently considered by Brockmann as a marine form.

Clays from near PF 6, *samples C and D*

Both these samples show unequivocal evidence of fresh-water conditions of deposition. The only Foraminifera found were two strays in sample D. These are apparently of one species (? of *Globigerina*) and may be derived fossils from some older rocks. I have not been able to assign them a specific name, and they seem to be of no real significance.

The main fauna found is of fresh-water rhizopods, such as I have not previously encountered in my fenland samples. There are also some four species of non-marine gastropods in each sample, apparently mainly different forms in each sample. Fruits of *Chara* were found only in sample C.

Note. The numbers in the above lists are of the specimens mounted. Except for the commonly occurring forms they are all that were found in the whole of the sample washed, though there is no doubt that more of the minute fresh-water rhizopods of the recorded species could be found by further search.

All the specimens recorded above are mounted on my slide no. 276, as follows:

Sample A on squares	1–7
B	13–17
C	8–12
D	20–23

Appendix 2

Foraminifera etc. from the Somerset Levels. Clays collected south of the Panborough Gap in the Wedmore Ridge

By W. A. Macfadyen

Eight samples of this series were submitted by Dr Godwin on 11 March 1950, described by him as follows:

(i) Drake's Drove, Site A, 150–200 cm. Soft blue clay with horizontal *Phragmites*.

(ii) Drake's Drove, Site A, 250–300 cm. Stiffer and less *Phragmites*.

(iii) Drake's Drove, Site A, 350–400 cm. Stiffer and less *Phragmites*. (This clay overlies deep lake mud and fen peat.)

(iv) Cross-roads 500 yards north of Brook Farm, South of Panborough Gap. Clay taken from ditch by dredger. 26. 8. 47.

(v) Third field south of road, south of Panborough Gap. Sample by digging in south-east corner, under 2 ft. of peat. 26. 6. 47.

(vi) Yeap's Bridge, south of Panborough Gap. Sample of dredger clay overlaid by 2 ft. of peat. 26. 6. 47.

(vii) Godney II, 55–65 cm. Brown-grey crumbly clay with fresh-water shells. 29. 6. 47.

(viii) Godney VII, 45–50 cm. Brown clay with fresh-water shells. 29. 6. 47.

These were examined with the following results. They were washed through a 150 mesh/inch sieve, and the mud passing this was disregarded.

Sample (i) 5 oz. grey clay with vegetation debris; tr. micaceous. Residue after washing *ca.* $\frac{1}{8}$ oz. or less (=say 2 %); almost wholly vegetation debris. Some Foraminifera. The washed residue contained some matter soluble in carbon tetrachloride to give a blackish solution.

Sample (ii) 5 oz. grey clay; tr. micaceous. Residue less than $\frac{1}{8}$ oz. (=say *ca.* 1 %); almost wholly vegetation debris. Very few Foraminifera. Abundant tiny pellets of red and slightly hardened clay, possibly burnt, up to about 1 mm diameter; some have a blackened skin.

Sample (iii) 5 oz. grey clay; tr. micaceous. Residue less than $\frac{1}{8}$ oz. (=say *ca.* 1 %); almost wholly vegetation debris. Few Foraminifera.

Sample (iv) 12 oz. light grey clay, clean-looking, with traces of brown mottling, and traces of vegetation debris. Residue *ca.* $\frac{1}{8}$ oz. (=say *ca.* 1 %); mainly vegetation debris. Very few Foraminifera.

Sample (v) 12 oz. light grey, but messy-looking, clay, with some brown mottling; considerable blackish vegetation debris, trs. micaceous. Residue $\frac{1}{2}$ oz. (=say *ca.* 4%); mainly comminuted and granular vegetation debris. Granules are up to 2 mm diameter; they are black and look charred, but they are tough, not brittle. Very few Foraminifera. The abundant seeds appear to be of one species only.

Sample (vi) 12 oz. light grey clay, with some brown staining, and considerable vegetation debris. Rather difficult to wash. Residue 1 oz. (=say 8 %), voluminous, finely comminuted, rather granular, mainly vegetation debris. Very few Foraminifera.

Sample (vii) 12 oz. brownish clay, with many fragments of non-marine molluscan shells. Residue *ca.* $\frac{1}{4}$ oz. (=say 2 %), mainly shell fragments, with some vegetation debris, and hardened clay fragments. It contains some matter soluble in carbon tetrachloride to give a blackish solution. No Foraminifera found.

Sample (viii) 12 oz. brown clay with many fragments of non-marine molluscan shells. Residue $\frac{1}{2}$ oz. (=say 4%), largely hardened clay pellets, and tubes up to 14 mm long by 3 mm diameter; perhaps these are 'mock Foraminifera', deposited round rootlets. Also shell fragments and traces of sand grains; little vegetation debris. No Foraminifera found.

The microfauna etc. found was as follows.

Indigenous Foraminifera

	i	ii	iii	iv	v	vi	vii	viii
Quinqueloculina fusca Brady	.	.	I	.	.	.	.	.
Triloculina oblonga (Montagu)	I	.	.	.	.	.	.	.
Cornuspira involvens (Reuss)	.	.	I	.	.	.	.	.
Ophthalmidium balkwilli Macfadyen	.	.	I	.	.	.	.	.
Trochammina globigeriniformis (Parker & Jones)	.	.	I	.	.	.	.	.
T. inflata (Montagu)	V	I	.	.	.	.	.	.
T. macrescens Brady	V	V	X	V	V	I	.	.
Buliminella elegantissima (d'Orbigny)	.	.	I	.	.	.	.	.
Virgulina fusiformis (Williamson)	.	.	I	.	.	.	.	.
Bolivina pseudoplicata H-A. & E.	.	.	I	I	.	.	.	.
B. variabilis (Williamson)	.	.	I	.	.	.	.	.
Lagena marginata Walker & Boys	.	.	I	.	.	.	.	.
Discorbis williamsoni Chapman & Parr	.	.	I	.	.	.	.	.
Streblus beccarii var. *lucida* (Madsen)	L	V	V	X	.	.	.	.
Elphidium incertum (Williamson)	I	.	.	.	.	.	.	.
totals	5	3	12	3	1	1	0	0

Other indigenous fossils

	i	ii	iii	iv	v	vi	vii	viii
Ostracods	.	.	.	.	.	.	V	V
Insect remains	.	.	I	I	.	.	I	.
Non-marine gastropods	.	.	.	.	.	.	X	X
Plant seeds	.	I	.	I	L	.	V	I
Chara fruits	.	.	.	.	.	.	I	X
Diatoms, large:								
Melosira arenaria Moore	.	.	I	.	.	.	.	.
Triceratium favus Ehrenberg	.	.	I	.	.	.	.	.
Incertae sedis:								
Tailed brown globes	V	I	I	.	X	X	C	C
Brown balls	.	.	.	V	.	.	.	.
Brown berries	.	.	.	.	.	.	C	.
Glossy spheres	.	.	.	.	.	.	V	X
Jet-like material	.	.	.	.	.	.	C	C
totals	1	2	4	3	2	1	9	7

Frequency of occurrence indicated as in Appendix I.

Specimens from samples i–vi are mounted on my slide no. 286.

Specimens from samples vii and viii on slide no. 287.

Discussion

As regards the Foraminifera, the samples seem to fall into three divisions.

(*a*) Samples i, ii, iii and iv, which have a meagre fauna of aspect suggesting a water of nearly fresh type, with just enough sea-water content to maintain a scanty population of

Foraminifera of most tolerant type, *Streblus beccarii* var. *lucida*, and *Trochammina macrescens*, with a few *T. inflata*.

Sample (iii) included either one or two specimens of very minute size, of ten species of Foraminifera of estuarine type. From their rarity and the smallness of the specimens it may be suggested that these were washed into the present deposit from outside, rather than being truly indigenous at the site where they were found. Sample (i) contained two similar odd specimens, both broken, and sample (iv) one odd minute specimen; these may be ignored as strays of little significance.

(*b*) Samples (v) and (vi) suggest still fresher water, the only Foraminifera found being a very few specimens of *Trochammina macrescens*.

(*c*) Samples (vii) and (viii), suggest completely fresh water, with no Foraminifera, but many non-marine Mollusca, *Chara*, and tailed brown globes, and a few ostracods.

The practically complete absence of silt from all the samples is noteworthy. A few grains of quartz sand were found in sample viii. No fresh-water rhizopods were recognized in any of the samples.

Sample (vii) contained many 'brown berries', *ca.* 0·46 mm in diameter, the individual globules being *ca.* 0·023 mm in diameter. These have not previously been recognized, and their nature is not identified. They would appear to be of organic origin.

The 'glossy spheres' are also recognized for the first time. The diameter is *ca.* 0·35 mm, and they are seen to be the outer covering, sometimes collapsed, of a body which may have been the egg of some small organism.

Samples (vii) and (viii) also contain abundant tiny angular fragments, up to about 1 mm in greatest diameter, of brittle, glossy black, jet-like material. It floats in carbon tetrachloride (stated to have a sp.gr. of 1·582 at 21° C), which does not appear to dissolve it.

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