Late Glacial and Post-Glacial molluscan successions from the site of the Channel Tunnel in SE England

R.C. Preece

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R.C. Preece, Department of Zoology, University of Cambridge, Downing Street, Cambridge CB2 3EJ, England.

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A summary of the molluscan succession at Holywell Coombe, Folkestone, Kent is given. The replacement of arctic-alpine communities of the Late Glacial by the diverse woodland assemblages of the early and mid Post-Glacial are described. The impact of early man on the faunas since the Neolithic is also assessed. This succession is related to the vegetational history by means of pollen analysis and a detailed chronology is provided by radiocarbon dating. This is the most complete and best dated molluscan succession yet known from Britain.

Contents

Introduction

The Chalk escarpment in the vicinity of Folkestone, Kent, can boast of a number of spectacular dry valleys, known as 'coombes'. Particularly impressive is that immediately west of Sugarloaf Hill, known as Holywell Coombe (Fig. 1). In the late 1960s trial pits were excavated through the infill of this valley as a prelude to the construction of the Channel Tunnel. These exploratory pits revealed the presence of organic sediments that had survived oxidation by virtue of being waterlogged. The stratigraphy of the Quaternary sediments above the Gault Clay that floored the valley was found to comprise (a) basal solifluction debris, consisting largely of reworked Gault Clay and Chalk, emplaced during the Late Glacial, (b) calcareous tufa deposited by springs during the early to mid Post-Glacial and (c) hillwash resulting from forest clearance since the Neolithic. Detailed biostratigraphical analyses of the molluscan and plant successions from samples taken from these trial pits have already been published (Kerney et al., 1980). They demonstrated the changing assemblages from

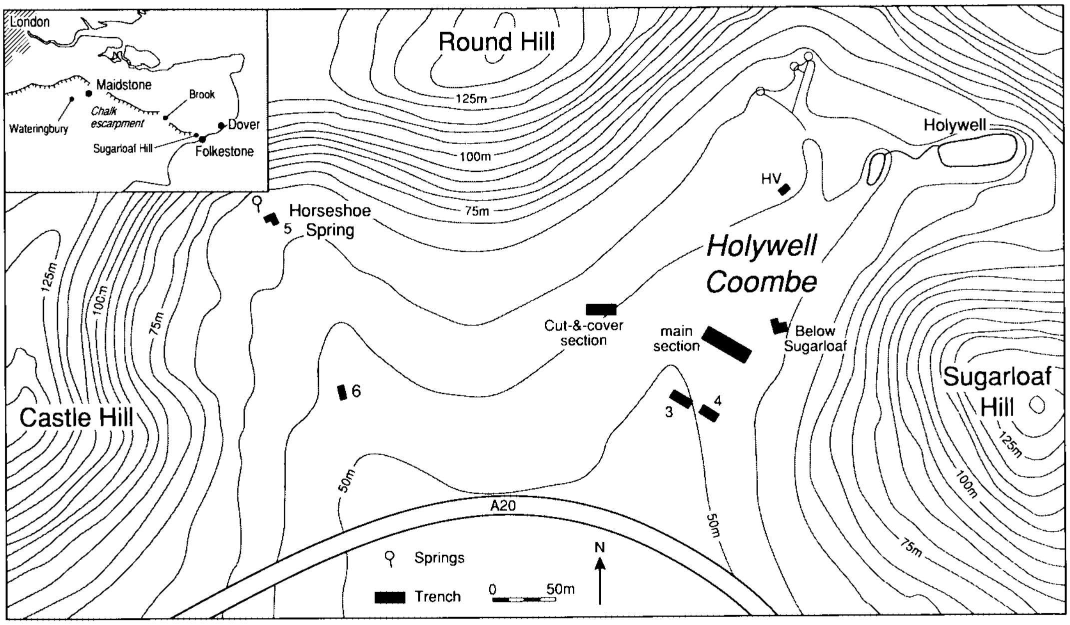


Fig. 1. Location map of Holywell Coombe, Folkestone.

early arctic-alpine communities of the Late Glacial to the diverse communities of the mid Post-Glacial forest optimum to the essentially open-country faunas of the last 5000 years. The pattern of colonization was so clearly displayed that Holywell Coombe was selected as the type site for a molluscan zonation scheme that was found to be applicable to large areas of southern Britain. These faunal changes could be linked to the vegetational history by means of pollen analysis, at least for the early Post-Glacial, and organic horizons provided ample material for radiocarbon dating, which provided a chronology.

In 1987 plans to construct the Channel Tunnel were resurrected by Eurotunnel, an Anglo-French consortium who had been granted the concession to undertake the project, and the site at Holywell Coombe was immediately threatened. The importance of the site was discussed in front of the House of Lords Select Committee during the debate of the Channel Tunnel Bill. The outcome was twofold. First, Eurotunnel agreed to adopt the least damaging alignment to their 'Cut-&-Cover' Tunnel that would eventually be positioned obliquely across Holywell Coombe. Second, they agreed to fund a major 'rescue' operation so that as much information as possible could be obtained from the site before its ultimate destruction. A full account of this multidisciplinary project will appear elsewhere. This paper will summarise the essential features of the molluscan succession and discuss this in relation to the vegetational history and in the light of a greatly improved radiocarbon chronology (Preece, 1991).

The site and its stratigraphy

Holywell Coombe is situated immediately west of Sugarloaf Hill (Fig. 1). The stratigraphy of the valley infill has now been studied in great detail. A detailed borehole survey was undertaken to establish the morphology and spatial distribution of the colluvial sediments and to pinpoint organic units that would repay study in open section. Deep trenches, requiring shoring and de-watering, were then dug with mechanical excavators at these critical locations. Because the full stratigraphical succession is nowhere represented at a single spot, the sequence had to be reconstructed from composite profiles. Since there was substantial overlap in these adjacent profiles, they could be convincingly correlated using a combination of biostratigraphy and radiocarbon dating. The earliest Quaternary sediments in the initial study (Kerney et al., 1980) were assignable to the Younger Dryas (Loch Lomond Stadial) but the new work has shown that, elsewhere in the valley, the Late Glacial sequence extends back to at least 13,000 years before present (BP). The full sequence has now been shown to comprise:

(a) accumulation of marsh sediments during an interstadial climate (11,800-13,100 yr BP);

(b) brief episode of erosion from the slopes of Sugarloaf Hill (c. 11,500-11,800 yr BP);

(c) period of stability represented by the widespread occurrence of a soil horizon, the so-called 'Allerød soil' (c. 11,000-11,500 yr BP);

(d) re-activation of slope processes and the emplacement of thick units of coarse chalk rubbles by solifluction during the Younger Dryas (Loch Lomond Stadial) (c. 10,000-11,000 yr BP);

(e) climatic amelioration and the initiation of spring activity resulting in the deposition of calcareous tufa in a wooded environment during the early to mid Post-Glacial (c. 10,000-5000 yr BP);

(f) renewed erosion from the chalk slopes following forest clearance during the Neolithic and Bronze Age (post-5000 yr BP). Two phases of stability have been recognised during the accumulation of the hillwash, reflected by the occurrence of palaeosols.

Molluscan successions

A series of molluscan assemblage zones have been described from Holywell Coombe (Kerney et al., 1980). These zones have been labelled alphabetically with two Late Glacial (y and z) and six Post-Glacial zones (a to f). These are as follows:

Zone y (Age: 13,160 ± 400 yr BP until shortly before 11,530 ± 160 yr BP)

This was not represented in the original trial pits but was recently discovered at the base of several deep trenches at various places upslope of the present axis of Holywell Coombe. This zone comprises an impoverished pioneer community dominated by *Pupilla muscorum* (L., 1758) (large form), *Vallonia pulchella* (Müller, 1774), *V. costata* (Müller, 1774), and *Vitrina pellucida* (Müller, 1774). About 17 taxa are known from this zone including species such as *Catinella arenaria* (Bouchard-Chantereaux, 1837) and *Vertigo genesii* (Gredler, 1856), that are today commonly regarded as having arctic-alpine affinities. Another noteworthy member of this community is *Cochlicopa nitens* (von Gallenstein, 1852), which here co-existed with both *C. lubrica* (Müller, 1774) and *C. lubricella* (Porro, 1837) (Preece, 1992). The associated insect fauna and plant assemblage indicates that the contemporary climate was not excessively cold but was of interstadial character.

Zone z (Age: slightly before 11,530 ± 160 yr BP to 9820 ± 90 yr BP)

This is another open ground fauna but substantially more diverse than the previous assemblage. *Pupilla* and *Vallonia* continue to dominate but are now joined by *Abida secale* (Draparnaud, 1801), *Trichia hispida* (L., 1758), *Helicella itala* (L., 1758), and *Columella columella* (von Martens, 1830). *Nesovitrea hammonis* (Ström, 1765), *Arianta arbustorum* (L., 1758) and *Carychium minimum* Müller, 1774 are also present. It is virtually impossible to distinguish between the faunas of the 'Allerød soil' and those of the overlying units ascribed to the Younger Dryas. There are no obvious extinctions and no new arrivals. The most significant differences between these phases is the decline in the numerical abundance of taxa already present. However, it is possible that reworking complicates the issue.

Zone a (Age: from 9760 ± 100 yr BP to sometime before 9530 ± 75 yr BP)

This is the earliest Post-Glacial assemblage which is similar to zone z but has a poorer representation of species of bare ground (notably *Pupilla*) and a corresponding expansion of catholic species (terrestrial group 'A'). A range of other taxa appear including *Carychium tridentatum* (Risso, 1826), *Vitrea* and *Aegopinella*.

Zone b (Age: slightly before 9460 ± 140 yr BP to 8630 ± 120 yr BP)

This is a woodland fauna dominated by *Carychium tridentatum* and *Aegopinella* (terrestrial group 'B'). *Discus ruderatus* (Férussac, 1821), a boreo-continental species now extinct in Britain, is characteristic.

Zone c (Age: 8630 ± 120 yr BP to just before 7650 ± 80 yr BP)

A similar assemblage to the previous one except that *Discus rotundatus* (Müller, 1774) has now replaced *D. ruderatus*.

Zone d (Age: just before 7650 ± 80 yr BP to sometime before 5620 yr BP)

In the original study this zone could be subdivided into an earlier zone d^1 defined by the appearance of *Oxychilus cellarius* (Müller, 1774) and a later zone d^2 defined by the appearance of *Spermodea lamellata* (Jeffreys, 1830), *Leiostyla anglica* (Wood, 1828) and *Acicula fusca* (Montagu, 1803). In the new sections studied during the recent work all these species expanded at about the same time (in fact single shells of *Spermodea* and *Leiostyla* were recovered from the sample below that containing *Oxychilus cellarius*). These subzones cannot therefore be sustained and this assemblage is best referred to an undivided zone d.

Zone e (Age: lower boundary diachronous,
5620 ± 90 yr BP and 3980 ± 70 yr BP to 2850 ± 70 yr BP)

Open-ground taxa such as *Vallonia* and *Trichia* expand at the expense of the shade-demanding species (terrestrial group 'B'). A number of shade-demanding taxa (e.g. *Vertigo pusilla* Müller, 1774, *V. alpestris* Alder, 1838) are eliminated. *Helicella itala* returns and *Monacha cartusiana* (Müller, 1774) appears.

Zone f (Age: from 2850 ± 70 yr BP)

An open-ground fauna similar to the last but with the appearance of *Helix aspersa* Müller, 1774 [and *Monacha cantiana* (Montagu, 1803)].

Vegetational history

Full details of the palynological work will be given elsewhere but it is important to consider how the faunal succession described above relates to the vegetational history. Pollen is only preserved where the sediments have remained permanently waterlogged and not subject to oxidation. Only the basal levels, below the water-table, were found to be polleniferous and not all of these yielded adequate quantities. Some levels, although lacking pollen, did produce fruits, seeds and other macrofossils but in comparison with the molluscan sequence the palaeobotanical record is very incomplete.

The pollen assemblages recovered from various trenches are shown alongside the mollusc zones on the far right of Fig. 2. Only the key taxa that define each pollen assemblage zone are shown but these nevertheless demonstrate the broad nature of the changing plant communities and how they relate to the molluscan succession. The birch (*Betula*) and juniper scrub (*Juniperus*) of the Late Glacial gave way first to birch and pine (*Betula-Pinus*) and subsequently to hazel woodland (*Corylus*) in the early and mid Post-Glacial. Elm (*Ulmus*) begins to make a showing towards the upper levels of the tufa, but the record is lost above this point.

Radiocarbon dates

On the left of Fig. 2 are a series of radiocarbon dates that were obtained from this sequence. They consist not only of conventional dates measured at the Godwin Laboratory in Cambridge (Lab. Ref. 'Q') but also a majority that were measured by accelerator mass spectrometry (AMS) at the University of Oxford (Lab. Ref. 'OxA'). This technique, which was not available when the original study was undertaken, has enabled the sequence to be dated with much greater precision. This results from the fact that only a few milligrams of carbon are required for each determination, allowing the dating of critical levels formerly undatable using conventional techniques. For a full discussion of these, and other, dates from Holywell Coombe, the reader is referred to Preece (1991).

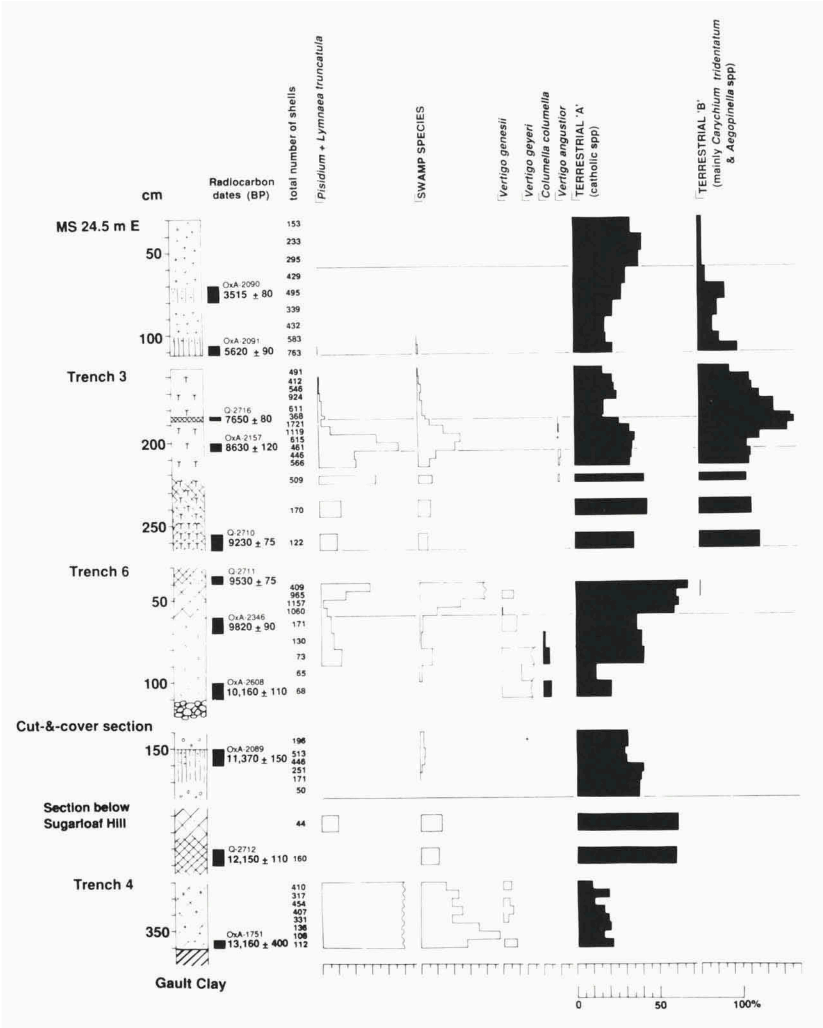
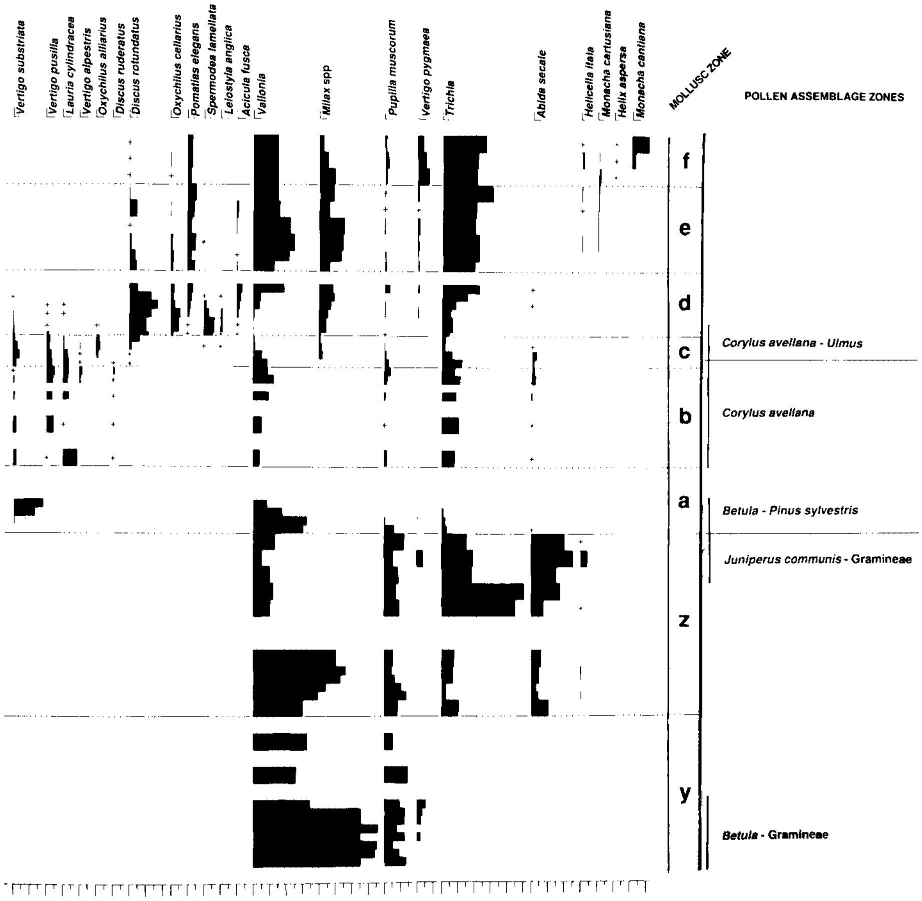


Fig. 2. Composite summary diagram of the molluscan succession from Holywell Coombe, Folkestone. The frequencies of the freshwater (*Lymnaea* and *Pisidium*) and obligatory swamp species [*Carychium minimum* Müller, 1774, Succineidae, *Vertigo antivertigo* (Draparnaud, 1801), *V. genesii* (Gredler, 1856), *V. geyeri* Lindholm, 1925, *V. moulinsiana* (Dupuy, 1849), *V. angustior* Jeffreys, 1830, and *Zonitoides nitidus* (Müller, 1774)] have been excluded from the main summation total and are shown as percentages (open histograms) of the remaining land species. Terrestrial group 'A' consists of catholic species of wide tolerance such as *Cochlicopa*, *Columella edentula* (Draparnaud, 1805), *Punctum*, *Vitrina*, *Nesovitrea*, *Deroceras/Limax*, *Euconulus*, *Arianta/Cepaea*. Those of group 'B' are more critical in their requirements, being commonest in deciduous woodland and similar well shaded places (*Carychium tridentatum* (Risso, 1826), *Acanthinula*, *Ena*, *Aegopinella*, Clausiilidae, *Helicigona*).



Discussion

The molluscan succession from Holywell Coombe, Folkestone, is the most complete and best dated sequence yet obtained from the British Isles. The changing plant and animal assemblages can be traced from the early pioneer communities of the Late Glacial to the diverse woodland communities of the mid Post-Glacial to the impoverished grassland faunas of the late Post-Glacial. In the early part of the sequence (zones y to d inclusive) the controlling process is clearly one of migration in response to climatic change, acting either indirectly through the vegetation (e.g. causing the replacement of open-ground species by shade-demanding taxa) or more directly providing suitable conditions for molluscs with particular thermal requirements. Thus one might have expected species such as *Discus rotundatus*, *Oxychilus cellarius* and *Acicula fusca*, which have relatively southern modern ranges, to have appeared after arctic-alpine taxa such as *Catinella arenaria*, *Columella columella* and *Vertigo genesii*.

The Late Glacial zones (y and z) contain faunas of peculiar and diagnostic character (Kerney, 1963). As with the flowering plants, one finds a curious mixture of biogeographical elements, whose modern ranges seldom if ever overlap. It may be that climatic changes were sufficiently abrupt to allow for the co-existence of different biogeographical elements, albeit for brief periods.

Similar mixtures can be found in the early Post-Glacial [e.g. *Discus ruderatus* and *Lauria cylindracea* (da Costa, 1778)]. By the mid Post-Glacial the communities reached their maximum diversity, containing an array of species (e.g. *Vertigo pusilla*, *V. alpestris*, *V. angustior* Jeffreys, 1830, *Spermodea lamellata*, and *Leiostyla anglica*) that are now only relict in southern England. It is not yet clear whether the decline in such taxa is due to climatic or anthropogenic factors.

There is little doubt that the two later zones (e and f) are the result of human activity. Not only was he responsible for transforming the broad nature of the landscape from forest to essentially one of grassland but has also been responsible for draining large areas of wetlands. Evans (1972) provides a full account. Several species (e.g. *Monacha cartusiana*) were introduced, probably accidentally by the early farmers. Other species, such as *Helix aspersa*, may have been introduced deliberately as food. The popular belief that this was done by the Romans may well be correct, despite an AMS date on the earliest *H. aspersa* from Holywell Coombe of 2850 ± 70 yr BP (OxA-3558). Great care must be exercised when interpreting radiocarbon dates from shell carbonate because of the difficulty in estimating the amount of 'dead' carbon incorporated into their shells during life.

Work undertaken elsewhere has shown that the broad succession outlined above can be demonstrated in many other parts of southern Britain. Regional differences have been demonstrated in sites in western Britain, particularly with respect to the early occurrence of species such as *Leiostyla anglica* (compare Preece, 1980). It remains to be seen to what extent this pattern of colonization holds good on the continental side of the Channel.

Acknowledgements

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