Caerwys and Ddol

Highlights

One of the thickest and most complex tufa deposits in Britain occurs here. These limestones and their contained fossils record a history of sedimentary, hydrological and climatic change through the latest Devensian and the Holocene.

Introduction

Caerwys and Ddol provide some of the finest tufa deposits in Britain. The site contains buried soils and an exceptional fossil record (molluscs, leaf-beds and vertebrate faunas) recording environmental changes in the late-glacial and Holocene. The tufa at Ddol incorporates fossil groups including beetles and plant macrofossils not represented at Caerwys. The Wheeler Valley tufas were first described by Maw (1866) and some additional work was carried out by Hughes (1885) and Strahan (1890). Jackson (1922) provided a comprehensive list of molluscs from the site. Since then, Wedd and King (1924), McMillan (1947), Millott (1951) and Bathurst (1956) have all added data on the tufa, its flora and fauna. Detailed accounts of the tufas were given by Preece (1978), Preece *et al.* (1982), McMillan and Zeissler (1985) and Pedley (1987).

Description

The tufas at Caerwys [SJ 129 719] and Ddol [SJ 142 714] in the Wheeler Valley are the most extensive in Britain, occupying an estimated 80ha (Maw 1866). They occur in two small tributary valleys that enter the Wheeler Valley from the north. The tufa deposits contain leaf, twig, moss, liverwort and cyanobacterial tufas (Pedley 1987) and they overlie red sands and gravels — probably Late Devensian fluvioglacial deposits (Brown and Cooke 1977).

The Caerwys deposit extends downslope into the Wheeler Valley as a delta-shaped fan (Pedley 1987). The tufa is well exposed in both current and abandoned quarry sections. In the main quarried deposit, the tufa reaches a maximum depth of about 12m (Pedley 1987). In the centre of the quarry, a basal dark grey peat passes up into a transition zone of organic-rich carbonates overlain by reworked tufa (Pedley 1987). Away from the axis of the valley, however, the succession is more complex; the peat is absent and the tufa is interdigitated with red sands and gravels. This is well illustrated in the old disused quarry [SJ 129 717] where only a thin tufa layer is interbedded with substantial thicknesses of red sand. For the most part, the Caerwys succession can be generalised as follows (Preece 1978; Preece *et al.* 1982):

6 Modern soil

5 Hillwash sediments

4 Main tufa deposit, devoid of organic material

3 Tufa with peat and soil horizons

2 Sandy tufa with two thin soil horizons

1 Fluvioglacial sands

However, it must be stressed that the sequence is highly variable both laterally and vertically. The distinction between each bed is not sharp, with beds grading imperceptibly into one another. The beds are frequently lenticular and sometimes interleaved. This complexity led Pedley (1987) to distinguish a number of lithological types, rather than to draw a stratigraphical sequence. He recognised five principal lithologies at Caerwys:

1 Tufa build-ups or encrustations on reeds, grass, mosses (phytoherms)

2 Oncoids (accretionary carbonate bodies, often oblate spheroids associated with pond sediments and frequently found in basal, fluvial channel fills)

3 Wackestones and lime mudstones (often reworked deposits believed to have accumulated in relatively shallow ponds between raised tufa build-ups)

4 Subaerial slopewash

5 Palaeosols

The Ddol tufas [SJ 142 714] are less extensive and less well exposed; the formerly extensive quarry exposures are now overgrown, and the tufa is less than 6m thick (Pedley 1987). Small sections, however, are visible along Mon Pant-gwyn and in small ditch exposures near the old workings at Felin-gonglog. The deposits at Ddol are richer in organic horizons than those at Caerwys (Preece *et. al.* 1982), and consist largely of brown organic tufaceous silts alternating with white nodular tufa, and beds intermediate in character and composition between these two.

Interpretation

The Wheeler Valley tufas were first examined by Maw (1866) who established the distribution and broad sequence of deposits. He noted the impressions of marsh plants in the tufa and recorded 19 species of land snail. He considered that the tufa was deposited by carbonate-rich streams emanating from the Carboniferous Limestone to the north. Brief accounts of the deposits were also given by Hughes (1885) and Strahan (1890). Strahan commented that the land snail fauna appeared to be entirely modern.

Jackson (1922) recorded 43 species of non-marine mollusc at Caerwys. A variety of other finds, including the tusks of wild boar, ox molars, horse and human remains was noted (Jackson 1922), although their precise stratigraphical context is unknown. Jackson considered the tufas to be Holocene in age, and he emphasised the similarities of the deposits with those of Neolithic age at Blashenwell, Dorset. The human remains recovered by Jackson (1922) have since been radiocarbon dated (Barker *et al.* 1971). A date of 2,100 ± 140 BP (BM-255) confirms that the burial was recent and intrusive. The tufas of the Wheeler Valley were also mentioned briefly by Wedd and King (1924) and by McMillan (1947) and Millott (1951).

A preliminary study showed pollen from lime, alder, oak, pine and hazel to be present in one of the peat beds at Caerwys (Bathurst 1956). He concluded that such an assemblage of trees was not present in the British flora until early Pollen Zone VI (Holocene) (Godwin 1941). He also described the numerous tree leaf impressions in the tufa. These included hazel, willow, elm, oak, poplar, ivy and beech; the latter, he suggested, did not enter the British flora until the Holocene climatic optimum (Pollen Zone VII /early Neolithic times).

McMillan and Zeissler (1985) analysed the land snail fauna from the Caerwys tufa, recording a total of 54 species. Their study classified the molluscan assemblage in terms of environmental preferences (there were 22 woodland species, 11 catholic, 4 characteristic of short-turf grassland, 8 marsh species and 9 freshwater), and showed that most of the assemblage was therefore terrestrial with many obligatory marsh dwellers and species preferring marshy habitats. The snail fauna was used to demonstrate that freshwater habitats in the succession were restricted to only small bodies of water (McMillan and Zeissler 1985).

Recent investigations have attempted to interpret a sequence of palaeoenvironmental events and conditions from the molluscan evidence (Preece 1978; Preece *et al.* 1982) and the sedimentary evidence (Pedley 1987).

Preece (1978) and Preece *et al*. (1982) emphasised the difficulties of relating particular molluscan assemblages to individual beds within the highly complex and laterally and vertically changeable sequences at Caerwys and Ddol. However, detailed analysis of molluscs sampled from the beds at both sites allowed a number of molluscan assemblages to be recognised and the tufa to be zoned. The definition of the biozones was based principally on molluscan evidence from Holywell Combe, Kent (Kerney *et al.* 1980; Preece *et al.* 1982), where six molluscan biozones were recognised from the Holocene sequence. These principal zones were also recognised at Caerwys and Ddol, and although they cannot be related to specific beds, and traced throughout the quarries, the zones A, B and C broadly correspond with bed 3 at Caerwys, zone D with bed 4, and zones E and F with beds 5 and 6, respectively.

At Caerwys, molluscan zone A is dominated by terrestrial species. There is also an open-ground fauna, and a few species suggesting bare soil conditions. The assemblage indicates improving conditions in the early Holocene, following the cold conditions of the Younger Dryas. A radiocarbon date of 9,780 ± 200 (Q-2343), from organic material associated with a molluscan zone A type fauna at Ddol, supports the ascription of this molluscan assemblage to the early Holocene, and allows its correlation with Pollen Zone IV (Preece *et al.* 1982).

Molluscan zone B is characterised by a woodland fauna, demonstrating the development of woodland in the area. It is correlated with Pollen Zone V and the early part of Pollen Zone VI (Preece *et al.* 1982). Molluscan zone C also has a woodland assemblage and occurs largely within a prominent soil layer developed immediately above an erosion surface in the tufa succession (bed 3). The faunal boundary therefore corresponds with a change in lithology; there followed drier conditions in which the soil formed, and tufa formation temporarily ceased. The soil horizon has been radiocarbon dated to 7,880 ± 160 BP (BM 1736) (Preece *et al.* 1982).

The succeeding molluscan zone D is also dominated by woodland species, and is thought to correlate with the later part of Pollen Zone VI and Pollen Zone VIIa. The implication is clearly that the bulk of the tufa deposit (bed 4) at Caerwys formed at this time. A radiocarbon date of 6,260 ± 120 BP (Q-1533) was obtained from sediments associated with a molluscan zone D fauna at Ddol, but this does little to establish the duration and timing of the phase as a whole.

Molluscan zones E and F at Caerwys show a clear change to open-ground conditions, with a decline in shade demanding species and an increase in grassland species (beds 5 and 6). In bed 5, horizontally bedded tufa has been weathered into small slabs and incorporated into a rubbly colluvium or hillwash. These hillwash sediments and the modern soil (beds 5 and 6) were correlated with Pollen Zones VIIb and VIII, respectively. The abrupt change in which woodland species of the tufa are replaced by open-country forms in the colluvium, is thought to have resulted from woodland clearance (Preece 1978; Preece *et al.* 1982).

In addition to the molluscan zones associated with Holocene tufa development at Caerwys, an additional trench cut into the floor of the main quarry (Preece 1978; Preece *et al.* 1982) revealed a thin lower sequence of tufa and soil horizons (bed 2) overlying fluvioglacial sand (bed 1). Molluscan analyses from bed 2 show a restricted fauna composed mainly of ecologically tolerant species, many of which have modern ranges that extend well into the Arctic Circle (Preece *et al.* 1982). Also, several Arctic–Alpine species were recorded which no longer live in Britain. The soil horizons within the bed were not marked by any faunal changes. The beds are devoid of identifiable pollen and their precise age is unknown. The molluscan evidence would appear, however, to indicate a Late Devensian late-glacial rather than a Holocene age (Preece 1978; Preece *et al.* 1982).

At Ddol, the entire exposed section of tufa and interbedded organic deposits contains a molluscan fauna of zone D type. Analyses of core samples show, however, that zone A, B and C type assemblages are also present in the sequence below. The exposed tufa is dominated by woodland species and by a freshwater fauna indicating a flooding event. In contrast with Caerwys, a heavily shaded stream environment is suggested, where local conditions favoured the preservation of much organic debris. Both at Caerwys and Ddol, pollen grains and ostracods were recorded (Preece 1978; Preece *et al.* 1982). Although certain pollen assemblages were recognised, there had been a very marked differential destruction of pollen grains in the strongly alkaline environment; the results are of little use for palaeoenvironmental reconstruction. Similarly, the limited ostracod fauna has proved extremely difficult to interpret (Preece 1978).

Pedley analysed the carbonate sedimentology of the tufa deposits at Caerwys, and recognised five main lithologies — see site description. In tracing the complex distribution of these elements, he was able to reconstruct the following sequence of events. Initially, the entire tributary valley at Caerwys formed the site of braided stream deposition, with oncoid and clastic tufa being formed, derived from upstream carbonate areas. Subsequently, ponding occurred as two tufa phytoherm barrages developed. Later, a single larger tufa barrier became established downstream causing ponding and flooding of the earlier tufa constructions. Ultimately, this led to the development of a single tufa marsh complex, upstream from the barrier. According to Pedley the phytoherms were sub-parallel, forming downstream-convex porous dams. The barrage-dammed ponds functioned as efficient sediment traps, perhaps even maintaining high upstream water-tables, while palaeosols developed in other downstream areas. Pedley envisaged that water from narrow ponds seeped through and trickled over the barrages sustaining the surficial colonies of mosses and liverworts. In doing so, the water descended via a series of plant-colonised gutters and micro-terraces and the principal barrage, and onto the clastic tufa fades. This promoted braided stream activity as well as the development of small reed phytoherms. Pedley noted that palaeosols and humus-rich levels are restricted to the downstream part of the Caerwys sequence. Finally, the last episode of the tufa succession was the breaching of the deposits by the River Wheeler tributary stream with a resultant lowering of the water-table. No tufa deposits are forming at Caerwys today.

An important characteristic of the Caerwys and Ddol deposits is their considerable vertical and lateral variability; the floral and faunal remains described in many of the earlier studies were thus not assigned to any particular bed or even lithology. The level of palaeoenvironmental reconstruction achieved was, therefore, limited. Recent studies at the site have redressed this situation, although the nature of the deposits has mitigated against a detailed stratigraphic interpretation of the sequence in the accepted sense.

The work of Preece (1978), Preece *et al.* (1982) and Pedley (1987), in particular, has helped to establish a clearer pattern of events. It has been shown that springs and seepages emanating from the Carboniferous Limestone, led to tufa formation over large areas of marsh. Calcium carbonate was precipitated around the stems and leaves of marsh and tree vegetation. In places at Caerwys, large encrustations of tufa (phytoherms) formed 'rims' and ponded back water in a series of small and larger barrages. The complex series of cascades, standing pools, marshes, and the drier land towards the margins, provided varied environments, each supporting a molluscan fauna. Evidence of the constantly changing pattern of tufa formation, as ponds developed, braided streams changed course and tufa was eroded and redeposited, is superimposed on the environmental framework of the Late Devensian late-glacial and Holocene. The Caerwys tufa, in particular, demonstrates the interrelationships between constructional and clastic sediments in an ancient barrage tufa complex.

Despite the problems outlined of correlating the beds and their fossil contents throughout the quarries, an environmental sequence has been detected from the land snail evidence (Preece 1978; Preece et *al.* 1982). The open-country assemblages of the late-glacial are replaced by more shade-demanding, woodland species in the early and middle Holocene. Eventually, a return to open-ground conditions with grassland communities is shown in the upper colluvial and soil horizons, and this is thought to be in direct response to Man's activities and his clearance of woodland from the local slopes. This record demonstrates that the tufa-forming ecosystem was extremely fragile; with increased run-off, the streams began to cut down, rather than trickle and seep through and over the vegetation, and tufa formation ceased (Preece et *al.* 1982).

It has not yet been possible to correlate the various organic horizons at Caerwys and Ddol precisely with the established record of Holocene vegetational changes in Britain. Nonetheless, a broad pattern of environmental changes based on molluscan zones has been established from the sites, and from a small number of tufa sites in Dorset, Somerset, Northamptonshire, Lincolnshire and Kent. The records from North Wales form an important element in this range of localities that have helped to establish regional patterns and variations in Holocene environmental conditions based on mollusc zonation.

The sequences at Caerwys and Ddol are also important for understanding the mechanisms and conditions required for tufa formation. There has been debate as to whether calcium carbonate precipitation is the result of biochemical reactions involving micro-organisms, algae and even mosses, or whether it is a straightforward chemical process in which plants play an indirect role. Lengthy ancient sequences such as those at Caerwys and Ddol, and sites where there is contemporary tufa formation (Cwm Nash and Matlock Bath), offer scope for elaborating the possible processes and mechanisms involved.

Studies of the leaf impressions and beetle faunas recovered offer considerable scope for further elaborating the nature and sequence of events at this site.

Conclusions

The Wheeler Valley tufas are the best exposed and most extensive of the documented tufas in the British Isles. The land snails in the tufa provide an important record of environmental and climatic changes over the past 14,000 years. Caerwys is the only accessible example of tufa formation in Britain from towards the end of the last ice age.

References