Relict cryogenic mounds at Owlbury, near Bishop's Castle, Shropshire

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Abstract: A group of relict cryogenic mound landforms developed in proglacial lacustrine sediments is documented. The morphological expression is circular to oval ramparted depressions containing ponds or marshy ground. These features are closely spaced and in some cases overlap. They are interpreted as the remnants of mineral palsas rather than hydraulic (open system) pingos. Segregated ice growth by cryosuction processes in silt-dominated sediments led to mineral palsa formation after the regional Late Devensian deglaciation. Other sites in England and Wales previously interpreted as relict "pingos" are possibly mineral palsa remnants similar to Owlbury.

Introduction

Some localised areas within contemporary permafrost environments display discrete relief features cored by ground ice. These may collectively be termed cryogenic mounds which may be defined as "any mound-shaped landform produced by ground freezing combined with groundwater movement or the migration of soil moisture" (Harris *et al.*, 1988). Normally they are ascribed to either palsa or pingo categories, a classification system which depends upon the specific ice growth processes involved in their development. Palsas are permafrost mounds with a core consisting of alternating layers of segregated ice and peat or mineral sediment. In contrast pingos have a core consisting of massive ice derived primarily by water injection. Both pingos and palsas have a sediment cover which is seasonally thawed and which insulates the permanently frozen core. In the field, the discrimination of palsas from pingos on the basis of morphology alone is often difficult since usually the interior structure is unknown. Mineral palsas are a particular variety of palsas which have become better known during the last decade and may occupy an intermediate position between classical palsas and pingos (Worsley *et al.*, 1995).

Relict cryogenic mounds occur in regions no longer part of the permafrost realm and are thus valuable palaeoclimatic indicators. Such features were first recognised in the United Kingdom by Albert Pissart in what has become a classic pioneering study (Pissart, 1963). In this, he compared morphological and stratigraphical evidence from Belgium and Wales and suggested that it related to the former presence of "pingos". This work followed the publication of two papers concerned with the "viviers" (literally fish-ponds) of the Hautes Fagnes Plateau of the Belgian Ardennes (Pissart, 1956) and of the closed depressions in the area south of Paris (Pissart, 1958). Pissart's work in Wales was undertaken whilst he was a visiting scientist at the University of Wales, Aberystwyth, and during that time he inspired Edward Watson and his wife Sybil to research the relict periglacial features of Wales. Subsequently they became the authorities on Welsh "pingo" relics (Watson, 1971; 1972; 1976; 1982 and Watson and Watson, 1972; 1974).

The Owlbury site to be discussed here was first identified by the late Edward Watson during an aerial photograph search for new sites in Wales, although no follow-up fieldwork was conducted (Sybil Watson *pers. comm.*, 1994). Indeed, the only published reference he made to the site was a single dot on a very small scale map (Watson, 1977, page 190) showing the distribution of relict "open-system pingos" recognised in England and Wales. Others have used this map as a data source (e.g. Bryant and Carpenter, 1987) when compiling updated distribution maps, but exact locational details of the Shropshire 'dot' have remained elusive. Clues to the precise location have been obtained from various documentary sources including the 'Watson Archive', a collection of Edward Watson's field notes, diagrams and other unpublished material currently held by The National Museum of Wales. Importantly, whilst the features investigated have been termed relict "pingos" by Watson, this should not be taken to imply a specific mode of formation. Even more than contemporary pingos, relict "pingos" are subject to considerable speculation in terms of genetic classification.

The study area

The site to be documented lies at an elevation of some 146m O.D. close to the floor of the river Camlad valley near the hamlet of Owlbury, about 3km north west of Bishop's Castle in south west Shropshire adjacent to the Welsh (Powys) border (Fig. 1). The Camlad rises just over 2km east of Owlbury and initially flows west in a broad valley and then north through the confined Marrington Dingle glacial meltwater channel before finally joining the River Severn.

With one important exception, little modern published work on the Quaternary geology of the study area *per se* is available. Eastwards, however, the British Geological Survey 1:50,000 scale Church Stretton map (Sheet 166) and allied memoir (Greig *et al.*, 1968), together with Wright (1968) and Cross and Hodgson (1975), give valuable data on the extent of the Devensian glaciation near its limit at the Last Glacial Maximum *circa.* 20,000 years BP. It is likely that the highest parts of ground to the north and east e.g. The Long Mynd and Stiperstones, were nunataks at the glacial maximum, enabling the products of the intensive periglacial weathering regimes which produced tors, stone stripes and extensive solifluction to escape destruction by the ice advance (Wright, 1968; Goudie and Piggott, 1981). Ice sourced in central Wales flowed eastwards up the Camlad (Dwerryhouse and Miller, 1930) and at Owlbury it probably attained a maximum thickness of about 300m. It has been suggested that the

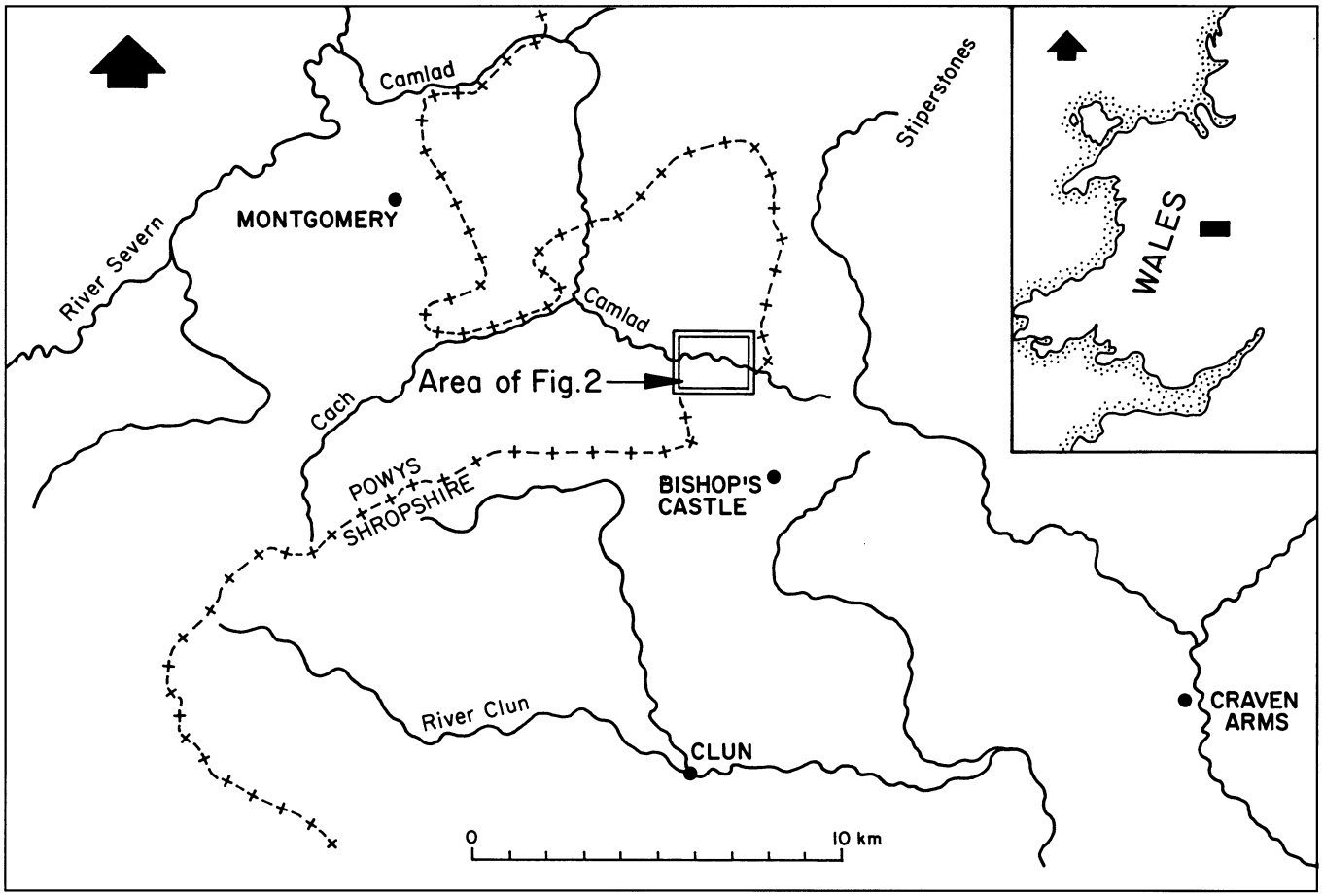

Fig. 1. Location map of the Owlbury site.

Upper Onny was formerly part of the Camlad catchment prior to the deposition of the 'moraine' by the last ice advance (Toghill, 1990) and this explains the broad nature of the valley at Owlbury despite proximity to the Camlad source.

Of great value in understanding the origin of the relict features at Owlbury is the British Geological Survey 1:25,000 scale solid and drift Shelve map (Special Sheet 44) which covers the Camlad valley (British Geological Survey, 1991). The reach of the Camlad under discussion is underlain by the Wenlockian Bromleysmill Shale Formation which unconformably laps onto the Ordovician Shelve inlier to the north. At the eastern end of the valley a tract of 'moraine' forms the low interfluve currently separating the Camlad and Onny river systems. Such 'moraine' is identified by a characteristic irregular relief, distinguishing it from till (boulder clay) for mapping purposes. To the west the 'moraine' is replaced by till and extensive areas of periglacial mass movement sediments (head) derived from both the 'moraine' and the till. Of particular significance is the widespread presence of a lacustrine alluvium unit in the upper Camlad lowlands. Indeed, in the eastern valley bottom, this unit extends right across the valley at the expense of any modern alluvium.

The recently published (1994) standard British Geological Survey 1:50,000 scale Montgomery map (Sheet 165) incorporates the area covered by the larger scale Shelve map. However, the lacustrine alluvium which is simply classified as Quaternary in age on the Shelve map is named as a lacustrine deposit and assigned a Flandrian age in the key of the newer map. This age assignment is clearly questionable since the periglacial sediment, head, is also given a Flandrian age. Assuming that the features under discussion are permafrost related, then clearly the lacustrine sediments must antedate the Flandrian (postglacial).

All the relict cryogenic features at Owlbury are located on the lacustine alluvium outcrop and several may be identified on the 1:25,000 scale map by circular outcrops of alluvium, marsh and peat occupying their centres. It is here suggested that during the retreat of the ice from the Severn valley, a proglacial lake was impounded between the 'morainic' belt at the interfluve and the withdrawing ice margin. Significantly, extensive lacustrine deposits are known in the Severn valley around Welshpool (Thompson, 1979). Following drainage of the lake, erosion by the Camlad system has developed the current channel network.

The Owlbury "pingo" relics

The permafrost-related features at Owlbury have not been mapped previously but their presence was originally deduced from aerial photograph interpretation by Edward Watson. Chiefly because they share all their main characteristics with the other known "pingo" relics, he concluded that they were relict cryogenic mounds of the "pingo-type". Figure 2 shows the location and extent of each depression and allied rampart as established by field mapping. It has to be

emphasised that the clarity of evidence for the features varies and Features 5 and 6 have only barely discernible ramparts. Identification problems are compounded by the presence of kettle holes in the area. For example, between Owlbury and Features 2 and 3 there is a depression over 100m in diameter with a drainage outlet northwards to the Camlad. This is judged to relate to the meltout of buried glacier ice which might have survived during the proglacial lake phase. However, the glacial ice meltout landforms are without ramparts which are an important diagnostic criterion for relict cryogenic mounds.

The broad morphological characteristics of these relict cryogenic features are directly comparable to those described from various sites in Wales. For example, the features are broadly circular in shape and have a central depression surrounded by incomplete, low, annular ramparts. These ramparts are raised above the adjacent land surface by up to 1m, and by up to 1.5m above the level of the central depression. The latter is characterised by wet, boggy or marshy ground with wetland vegetation which is clearly different from that of the surrounds (typically short, coarse grass). Some of the depressions contain ponds, probably due to anthropogenic removal of the peat fill. Some of these ponds disappear in summer but one, within Feature 4, is not known to have dried out. As with the Welsh sites e.g. Llangurig (Fig. 3), the depression would appear to be deep seated with the base of the infill extending for several metres below the ground surface.

Each of the features numbered in Figure 2 are described in the following section. Table 1 summarises the basic characteristics of the features.

Table 1. Basic characteristics of the Owlbury landforms.

Feature number	*Grid reference*	*Approximate plan dimensions*	*Approximate rampart height*	*Permanent pond?*
1	SO 309919	90 by 90m	1.5m	Yes
2	SO 311919	80 by 80m	1.5m	Yes
3	SO 312919	95 by 90m	1.7m	No
4a, b	SO 314919	105 by 50m	0.4m	Yes
5	SO 311921	50 by 45m	0.5m	No
6	SO 310920	40 by 35m	0.5m	No
7	SO 306920	80 by 75m	1.0m	Yes

Feature 1 is the most obvious feature at Owlbury, being occupied by a pond of some 60m^2 surrounded by rushes and marshy ground. This pond is possibly due to the removal of peat which accumulated in the depression after its formation. It is enclosed by a circular rampart which is breached on the northwest side by a narrow drainage ditch. The rampart on the eastern side of this feature merges with that of the adjacent landform Feature 2.

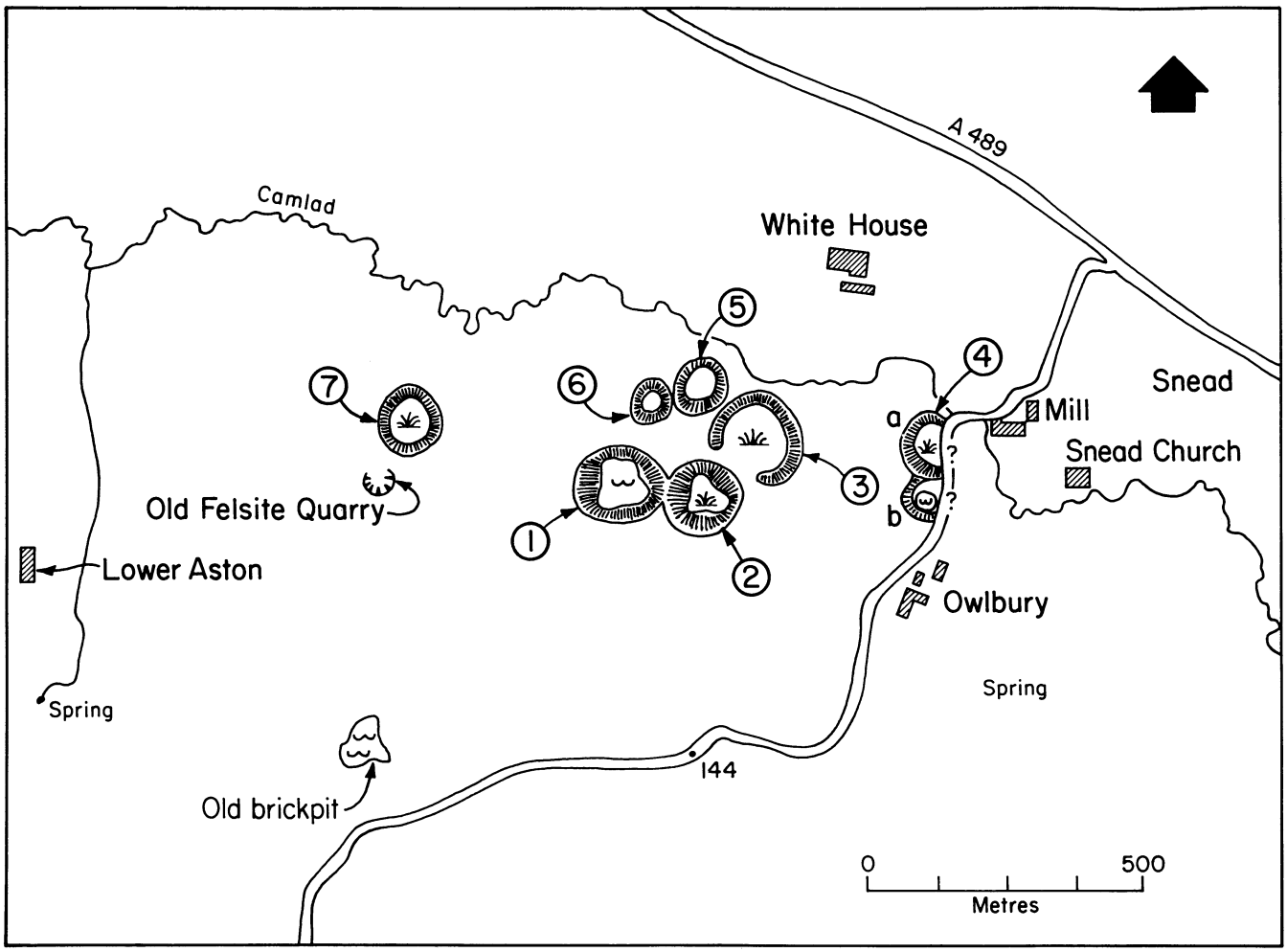

Fig. 2. Map indicating the location of the Owlbury features, their morphological form and the numbering system used in the text.

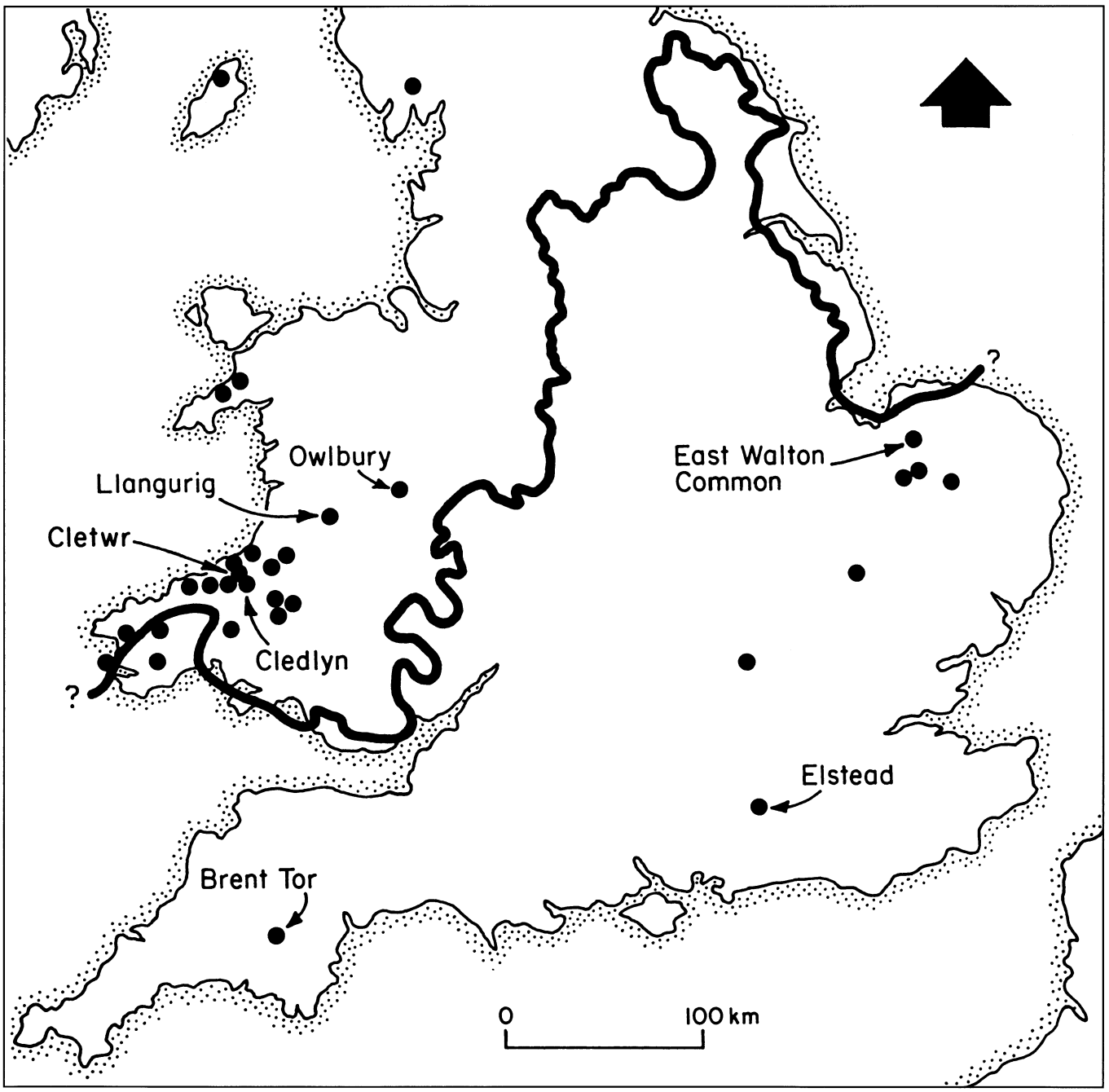

Fig. 3. Distribution of the main cryogenic mound landform sites in England and Wales. The heavy line corresponds with the limit of the Late Devensian ice sheet. Note that the sites lie both within and outside the glacial limit.

Feature 2 is very similar to Feature 1, although it is smaller and contains less open water. The circular rampart is continuous except for a lower area on the southern side. The clearest part of the rampart is that which abuts, without overlap, the rampart of Feature 1.

Feature 3 is not easily defined from aerial photographs even with the aid of stereoscopic cover. On the ground, however, it can be seen to be an oval feature with the lowest part of the depression coinciding with a hedge-line. A rampart is clearly visible only on the northern side of the feature, where it rises about 1.7m above the base of the depression (Fig. 4). The outlet of the depression has again been artificially created and occurs on the northwest side of the feature.

Feature 4 is located immediately adjacent to a minor road with the consequence that its eastern side is lost in the hedge-line. The depression has been largely obscured by waste dumping and hence it is not easy to define its geometry. It appears likely that it is composite in form and originally consisted of two separate depressions (hence the 4a/b subdivision used in Table 1). As already noted there is no record of the pond ever having dried out and it must be fed by a spring.

Feature 5 is adjacent to Feature 3; it is rather subdued on the ground and virtually indistinguishable on the aerial photographs. Nevertheless, it forms a depression enclosed by an annular rampart. The base of the depression has little vegetational difference to the surrounding area apart from the presence of *Juncus* spp.

Fig. 4. Feature 3 viewed from the southeast. The base of the depression is flooded (March 1995). The northern rampart is silhouetted against the trees along the Camlad.

Fig. 5. Feature 7 viewed from the east. The figure towards the right of the frame is standing on the rampart crest.

Feature 6 is the smallest of the features at Owlbury and is indistinguishable on the aerial photographs. Similar to Feature 5, it takes the form of a closed depression surrounded by a low, broad rampart.

Feature 7 is the most impressive landform at Owlbury and is a worthy candidate for protected conservation. It has a classic circular depression surrounded by an annular rampart. The depression contains a distinctive wetland vegetation and a limited area of open water (Fig. 5). Obvious attempts have been made to drain the feature and a long and extended land drain cuts directly through the rampart on its northwest side. This feature is slightly elongated in a northwest-southeast direction.

Also of note is the existence of a small, abandoned brickpit (SO 306 915). The brickpit has similar dimensions to the largest of the features and the lacustrine alluvium crops out in its walls. Whether this

was originally a relict cryogenic feature is unknown. In a small gully (at SO 303 918) there was an exposure of a smooth, plastic blue/grey silt-clay very similar to material from some of the Welsh "pingo" fills e.g. at Llangurig (Pissart, 1963).

Apart from the sites mentioned, the only other sections occur in the stream banks of the Camlad. These exposures are quite numerous since this small channel has incised into the floodplain between 1 and 2m. Normally these sections only reveal alluvial (plough wash) silts of probable late Holocene age, overlying somewhat coarser alluvium with abundant plant macrofossils. In some places a stiff blue/grey clayey silt similar in character to the gully sediment noted above is exposed in the channel bottom. Samples from a site at SO 3070 9213 were subject to particle size analysis using a Coulter (LS130) laser diffraction grain size analyser (see Loizeau *et al.*, 1994) and the particle size distribution is shown in Figure 6.

Discussion

Features of the Owlbury type have been previously interpreted as the remains of former "open system" or more correctly, hydraulic pingos (for example, Pissart, 1963; Watson, 1971; 1972; 1976; 1982 and Watson and Watson, 1972; 1974). This interpretation was based principally upon the morphology of the features and their location within an upland environment. Subsequently, Pissart has reinterpreted these features, along with those from the Hautes Fagnes Plateau of the Belgian Ardennes, by suggesting that they may be more closely related to mineral palsas than hydraulic pingos (for example, see Pissart and Juvigné, 1980 and Pissart, 1987). His reasons for reinterpretation arise from a greater knowledge of the relict features, which in itself suggests limitations with the "pingo" hypothesis. Furthermore, increased understanding of cryogenic mounds in the modern permafrost realm has highlighted the potential role of mineral palsas as analogues for many of the relict features seen in now temperate regions (Pissart and Gangloff, 1984).

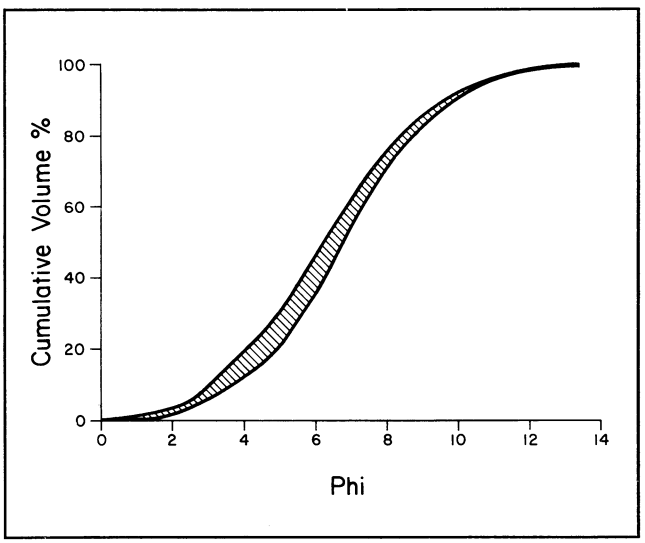

Fig. 6. Results of 8 particle size analyses of the lacustrine alluvium, Phi versus cumulative volume (n.b. the laser diffraction technique measures volume rather than weight).

Using the mineral palsa reinterpretation as a working hypothesis, it is possible to reconstruct the processes of growth and collapse of these features and derive landforms similar to the present day situation (Worsley *et al.*, 1995). Most importantly such an exercise must resolve the problems inherent in the previous interpretations of the evidence. These problems are chiefly connected with the infill of the "pingo" depressions or basins. For example, Watson and Watson (1972) admitted that if the infill sediments at the Welsh "pingo" sites are derived from the rampart material through the processes of rampart decay and subsequent resedimentation in the "pingo" pond, then it would be expected that the coarse fraction of the rampart sediments should be represented in the basin infill. None of the coring activities undertaken at the Welsh sites by the Watsons and ourselves (Gurney, 1995), has revealed coarse material within the basin fills apart from a scattering of gravel size material. Yet even a cursory examination of the rampart sediments shows that they contain much coarse material which is not evident in the basin infill. A problem therefore exists with the traditional pingo collapse hypothesis, as noted by Watson and Watson (1972, page 221). Furthermore, there would also seem to be a problem reconciling the thickness of the "pingo" basin infill. It does not seem feasible that such a thickness of fine-grained sediment could be sourced purely from the mass wasting of the rampart deposits.

Even assuming a periglacial cryogenic origin, any reinterpretation of the features described would require an alternative hypothesis of genesis to be put forward. Due to the present relatively rigid classification of cryogenic mounds, particularly the division between pingos and palsas, such an alternative hypothesis would require a new classification of these features. For example, Pissart's reinterpretation of the "viviers" of the Hautes Fagnes Plateau requires a reclassification of the features from relict "pingos" to relict mineral palsas. Thus, bearing in mind the genetic distinction between pingos and palsas, a totally different genetic system is inferred. Pingos require a groundwater pressure system driven by either an artesian head or hydrostatic pressure, whereas palsas are built through the process of cryosuction. Contemporary pingos are developed in various types of substrate ranging from predominantly fine-grained till through fluvial deposits to even bedrock. Palsas, however, universally require a frost-susceptible, fine-grained host medium. This is exemplified by the mineral palsas developed in glacio-marine muds in the Lac Hendry region of northern Québec, Canada (Worsley *et al.*, 1995). Therefore, if these relict "pingos" are to be reinterpreted as relict mineral palsas, then it is necessary to demonstrate the existence of a frost-susceptible fine-grained sediment within which cryosuction could have occurred. At Owlbury the lacustrine alluvium meets these requirements and could, therefore, have provided the setting for the growth of purely *mineral* palsas. Unlike classical palsas these cryogenic features are unlikely to have had a peat cover. However, it is possible that they shared the same growth process with palsas i.e. cryosuction in the frost-susceptible lacustrine deposits.

Following the reinterpretation of relict "pingos" in Belgium in favour of "mineral palsas" by Pissart and associated workers, it is perhaps surprising that the almost identical features from mid and west Wales have not been similarly reassessed. In the most recent comprehensive review of periglacial phenomena from the United Kingdom by Ballantyne and Harris (1994), a cautious approach has been adopted for it is stated that a reinterpretation of these landforms is not possible given only the morphological evidence. Subsequent field mapping at some of the Welsh sites has yielded evidence for silt-rich deposits, and as a consequence, a mineral palsa hypothesis is now considered more feasible (Gurney, 1995).

Strangely, included in the few examples of circular hollows which Ballantyne and Harris suggest are likely to belong to the "mineral palsa" category are the landforms investigated by Miller (1990) at Brent Tor, Dartmoor. Since data on this example are derived solely from an unpublished PhD thesis, the present authors are hesitant to comment, but consider that it cannot now be ignored. Paradoxically at this site, more than any other known to us, a classical hydraulic pingo genesis is likely to be the most plausible given the site's association with major thrust faulting in the underlying Carboniferous Culm Measures. Structures such as faults and intrusions often provide hydraulic pathways through permafrost suitable for sustaining a groundwater supply to the ice cores of hydraulic (open system) pingos. Furthermore, no major silt-rich substrate is identified at Brent Tor.

Dating

Since the Owlbury site is located within the Late Devensian (Dimlington Stadial) ice limit *circa*. 20,000 years BP (see Figure 3), it is proposed that these features are of either Late Devensian age *circa*. 16,000 years BP (following the immediate retreat of the ice) or of Loch Lomond Stadial age i.e. *circa*. 12,000 to 10,500 years BP. In both Cheshire and Staffordshire to the northeast, excellent ice wedge cast structures penetrating the Stockport Formation testify to the onset of widespread permafrost as the ice retreated (Worsley, 1987; 1991). These data suggest that the most likely date of mound formation at Owlbury is late Dimlington Stadial and their degradation might be linked with the climatic amelioration which heralded the Windermere Interstadial. This suggestion, however, must be tempered by the fact that cryogenic mound decay can occur without climatic change.

In 1990 the interior of Feature 3 was mechanically excavated by the local farmer to create a permanent pond. This revealed a peat containing 'worked' birch branches which were initially thought to be anthropogenic. Subsequent examination showed that the working was due to the gnawing activity of beavers (*Castor fibre*). A later trial trench established 0.7m of surface silty clay over a woody peat bed at least 1m thick. Pollen analytical examination of the peat suggested a Boreal age (Watson, 1995) and this gives an upper age limit (*circa*. 9,500 years BP) to the ground ice meltout.

Conclusions

The features documented at Owlbury would appear to represent further examples of mid-latitude relict periglacial cryogenic mounds. Conventionally, these would have been interpreted as a group of hydraulic "pingos". With a greater understanding of cryogenic mound formation and decay, however, these features appear to have a greater similarity with former mineral palsas than pingos, particularly in the context of the fine-grained frost-susceptible substrate within which they grew. By implication such an interpretation suggests that re-evaluation of many British relict "pingo" landforms is advisable, especially those of Llangurig, Cledlyn and Cletwr in mid Wales (see Figure 3), which have strong morphological and sedimentological parallels.

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