The Cledlyn Valley

Highlights

A locality showing the finest suite of fossil pingo features in Wales and some of the best examples in Britain. Formed in permafrost areas by the freezing of groundwater and the subsequent melting of sediment buried ice masses, their formation in relation to former ice-sheet limits has been the subject of controversy.

Introduction

Pingos are dome-shaped hills that occur in permafrost regions as a result of uplift of frozen ground by the growth of large convex masses of ground-ice in the substrate. Melting of the ice lens leads to a central depression or crater surrounded by a characteristic rampart of displaced substrate. Where permafrost conditions have ceased, the craters and surrounding ramparts are known as fossil pingos. The Cledlyn Valley contains probably the best preserved examples of pingo scars in Wales. The common occurrence of such features in northern Dyfed has been used as evidence for ice-free conditions in west Wales during the Late Devensian. The pingos were first described and mapped by Watson (1971) and the stratigraphy of the basin deposits investigated by Watson and Watson (1972). A detailed account of the Holocene pollen biostratigraphy from deposits mulling the pingo central depressions was provided by Handa and Moore (1976), and radiocarbon dates on the basal organic sediments by Shotton and Williams (1973) and Shotton *et al.* (1975). The site has also been referred to by Watson (1976, 1977c, 1982), Watson and Watson (1974, 1977) and Bowen (1977a).

Description

Widespread evidence for pingo development in the form of pronounced ramparts enclosing marshy tracts can be found in west Wales. The most notable groups of these features are near Llangurig (Pissart 1963, 1965; Trotman 1963), in the Cletwr Valley (Watson and Watson 1974; Handa and Moore 1976; Watson 1977c) and in the Cledlyn Valley (for example, Watson 1971; Watson and Watson 1972; Handa and Moore 1976).

The Cledlyn group of pingos — see (Figure 17), is best developed in the more open part of the valley between 0.5 to 2.0 km above Cwrt Newydd. The features lie between 165m and 215m OD, particularly on long, low-angled north-facing slopes. They do not occur on slopes in excess of 8°. The altitude of the features rises with the valley since they are essentially valley bottom and valley side landforms (Watson 1971).

Characteristically, the tops of the ramparts are level and few of them completely surround the basins. Even in the case of isolated pingos, the upslope side of the rampart is frequently missing. Such 'mutually interfering' pingos (Watson 1971) show a range of forms; some are completely round or oval, others are more elongated with ramparts forming distinct linear ridges.

Although the steepest upper parts of some of the ramparts reach 23.5°, others have been ploughed and are therefore more subdued than they would have been in their natural state. The largest feature has a diameter of c. 200m, with ramparts up to 6m high enclosing a basin mire which is some 135m across.

The ramparts are formed in solifluction deposits consisting largely of unsorted gravelly clay (Watson 1971). The succession of deposits enclosed by the ramparts (up to 1 lm deep) appears to be consistent across the group, comprising a series of organic deposits and grey clay and silt overlying the gravelly clay of the ramparts (Watson and Watson 1972). Full details of the morphology and distribution of the features, their precise dimensions, relationship to slopes and the local drifts can be found in Watson (1971), and details of the basin deposits, their stratigraphy and textural characteristics are to be found in Watson and Watson (1972).

Interpretation

Fossil pingos were first recognised in Britain by Pissart (1963, 1965) near Llangurig. A preliminary pollen study (Trotman 1963) established that the basin deposits they enclosed were of Holocene age. Subsequently, similar structures were described in the Cledlyn and Cletwr Valleys of west Wales (Watson 1971; Watson and Watson 1972, 1974; Handa and Moore 1976), in Ireland (Mitchell 1971, 1973), and in the Isle of Man (Watson 1971); and all were interpreted as fossil pingos. Comparable structures have also been described in East Anglia at, for example, East Walton Common (Bell 1969; Sparks *et al.* 1972). Sparks *et al.* (1972), however, preferred to describe the features using the non-committal term 'ground-ice depressions'.

The Cledlyn pingo remains are the most studied in Britain. Watson (1971) compared them with contemporary pingos in the Yukon and Alaska. The modern examples were considered to be of the 'open-system' type, formed by water under pressure coming from strata beneath the permafrost. He argued that ice lenses were formed repeatedly causing a complex pattern of intersecting ramparts from which it is difficult to distinguish individual pingos. Watson and Watson (1972) considered that the 'mutually interfering' form of the features in the Cledlyn Valley was highly indicative of the open-system type of pingo. Similarly, ramparts which were open on their upslope sides, were also extremely characteristic of this type of pingo. The restricted distribution of the features, to valley side and valley bottom locations on gentle slopes, reflected the requirements for the growth of open-system pingos stressed by Müller (1959), Sinclair (1963) and Holmes *et al.* (1968): namely, that the water flowing below or within the permafrost should be small in amount as well as close to freezing point.

Watson (1972) argued that pingos were widespread in west Wales, both inside and outside the maximum limit of the 'Newer Drift' (Late Devensian) ice-sheet mapped by Charlesworth (1929). He observed that because pingos in the Yukon were only found in high densities outside the limit of the last (Late Wisconsinian) glaciation, and that they required a long time to develop, Charlesworth's reconstructed ice limit in south-west Wales was therefore incorrect. More recent work around the coast of Wales (for example, Bowen 1974) has shown that this area of south-west Wales was glaciated during the Late Devensian.

Moreover, other studies using radiometric techniques (for example, Handa and Moore 1976) indicate that the Cledlyn and Cletwr pingos formed at some time during the Devensian late-glacial. This has thrown considerable doubt on Watson's use of fossil pingos as indicators of glacier ice-free conditions in south-west Wales during the earlier Late Devensian. Moreover, open-system pingos have now been mapped in considerable densities inside the Late Wisconsinian limit in North America.

Radiocarbon dates are available for muds at the base of selected pingos from both the Cledlyn and Cletwr Valleys (Shotton and Williams 1973; Shotton et *al.* 1975). The small sample size resulted in large standard errors, but it appears that organic sedimentation commenced in the pingo basins between *c.* 10,300 and 9,000 BP (Handa and Moore 1976). These determinations show that the pingos had formed and that some sedimentation had occurred prior to the rise *of Juniperus* pollen at the close of Godwin's Pollen Zone III. Handa and Moore (1976) considered that this placed the date of pingo formation during the Younger Dryas. To some extent this is supported by Trotman's (1963) preliminary study of the Llangurig pingos which showed that organic sedimentation commenced at the boundary between Pollen Zones III and IV. Pollen studies from the East Walton pingos (Bell 1969; Sparks et *al.* 1972), however, suggest the presence of Older Dryas and Allerød deposits, indicating an even earlier phase of formation, perhaps at the close of the Older Dryas (Godwin's Pollen Zone I). Similar Allerød sediments have been recorded from pingos in Belgium (Pissart 1963). This led Watson (1971) to suggest that the Welsh pingos formed in Pollen Zone I or earlier. Evidence from the Cledlyn pingos, however, suggests that this is unlikely (Handa and Moore 1976): because the temperature threshold for ice melt in the pingo cores was lower than that for juniper flowering, it seems probable that the threshold would have been crossed in Pollen Zone I. Moore (1970) showed that *Juniperus* flowered even in upland Mid Wales during the Allerød, suggesting that the pingos' ice could not have survived this warm phase. Handa and Moore (1976) concluded, therefore, that the Cledlyn and Cletwr pingos both formed and collapsed during the cold Younger Dryas, showing that conditions were severe enough to provide at least discontinuous permafrost in the lowlands of west Wales at this time.

Handa and Moore's (1976) pollen study of the basal sediments in selected pingos from the Cledlyn and Cletwr sites permitted a reconstruction of regional and local vegetation succession during the transition from Late Devensian to Holocene times. The basal deposits show that sedimentation began before woodland invasion and prior to the initial expansion *Juniperus* at the beginning of the Holocene. The early Holocene pollen spectra closely resemble those obtained from the upland valley site at the Elan Valley Bog (Moore 1970), although several important differences were noted (Handa and Moore 1976). First, the pingo sites show very low frequencies of montane and arctic/alpine taxa in marked contrast to the record from the Elan Valley. Second, the records do not show the early rise of *Corylus* documented at other sites. Handa and Moore suggested that the invasion and spread of *Corylus* had probably been localised to what is now the Cardigan Bay area, and that although pollen from this area was carried to the exposed upland sites such as that at the Elan Valley, it did not penetrate south-east into the Teifi Valley area. The pollen evidence also indicated that *Pinus sylvestris* and *Alnus glutinosa* (L.) Gaertn became established in the Cledlyn Valley soon after the extinction *of Juniperus.*

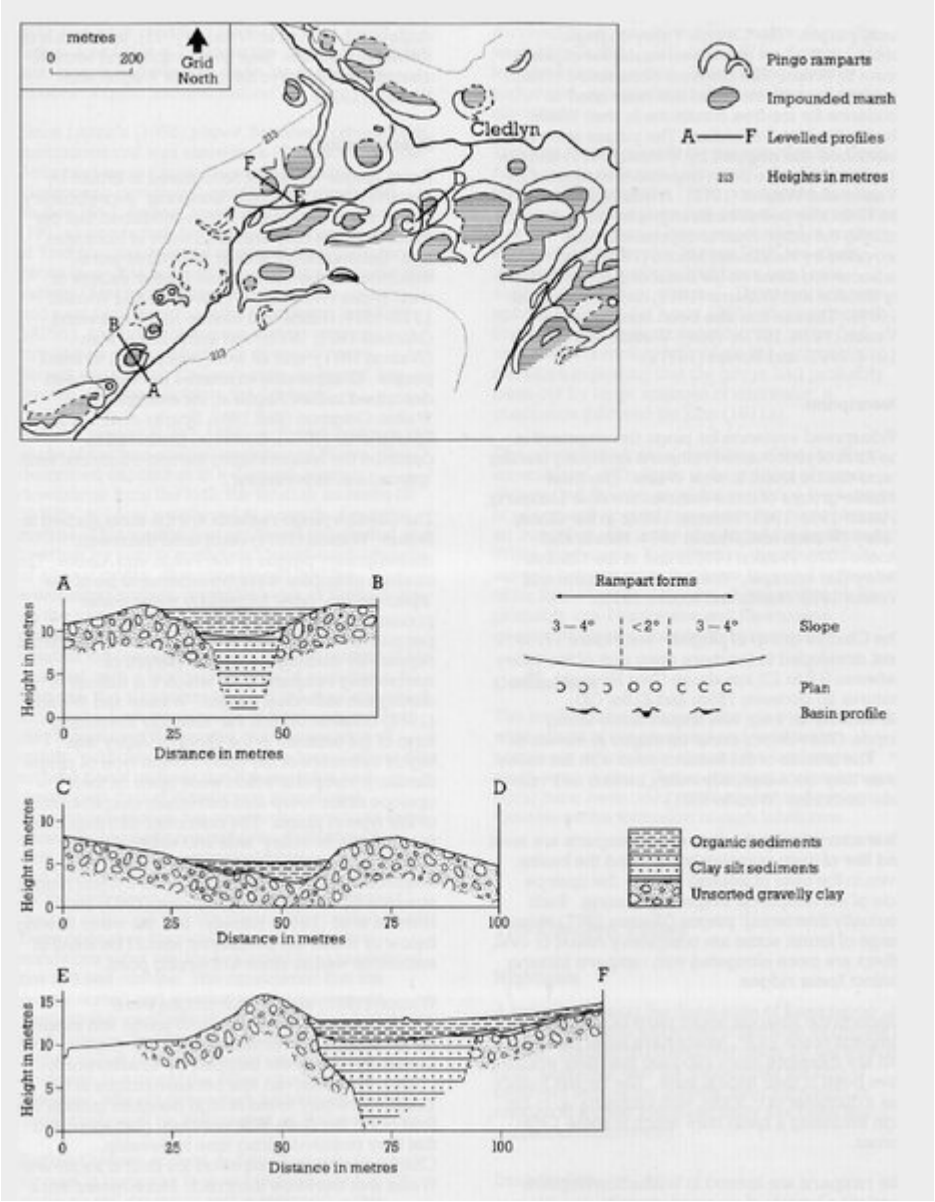
Examples of fossil pingos are rare in Britain. Possible examples have been described from Cumbria (Bryant *et al.* 1985) and west Surrey (Carpenter and Woodcock 1981), but the classic areas for the study of such features are East Anglia and Wales. The Cledlyn Valley contains the best developed group in Wales. Organic sediments infilling the pingo basins provide an important record of vegetational changes in lowland west Wales during Devensian late-glacial to Holocene times. The pingos are most probably of the hydrostatic (open-system) type, having developed in an area of discontinuous permafrost; and pollen and radiocarbon evidence suggests that this development was probably during the Younger Dryas (Handa and Moore 1976). However, this should perhaps be regarded as a minimum age, since De Gans *et al.* (1979) have argued that pingo remnants on the Drenthe Plateau date from *c.* 18,000 BP, and Sparks et *al.* (1972) have suggested that there may have been two periods of formation in East Anglia; an initial period of development during the Late Devensian or early Devensian late-glacial (Pollen Zone I) and a subsequent phase during the Younger Dryas (Pollen Zone III). Borings in the Cledlyn pingos have not proved organic sediments dating from earlier than the Holocene. However, such deposits may exist, particularly in view of Watson's suggestion that the Cledlyn group comprises clusters of mutually interfering pingos of different ages. It follows that although the latest of these may have been formed during the Younger Dryas, others may prove to be older.

Together with comparable features at East Walton Common in East Anglia, the Cledlyn pingos are morphologically the best developed examples of these landforms in Britain. The clearly defined ramparts enclosing peat-filled basins are thought to be remains of open-system type pingos, formed by the collapse of melting ice lenses which had developed during permafrost conditions. Detailed stratigraphical, pollen and radiocarbon evidence shows that deposition in the basins began at the start of the Holocene (*c.* 10,000 BP), but the ramparts and basins may have formed during the Younger Dryas or even earlier. The basin deposits provide a valuable record of Holocene vegetational changes in lowland Dyfed.

Conclusions

The Cledlyn Valley contains the remains of pingos. Pingos are large circular mounds which contain a core of ice and are found in areas of permanently frozen ground (permafrost) in the Arctic today. The remains of such pingos consist of central depressions surrounded by ramparts. The Cledlyn pingos are some of the best developed examples of such landforms in the British Isles. Pollen and radiocarbon evidence shows that they were probably formed between 11,000 and 10,000 years ago. They are important because they show the former existence of permanently frozen ground in Wales at that time.

References



(Figure 17) The Cledlyn Valley pingos (after Watson 1971; Watson and Watson 1972)