

Excavations at Erglodd, Llangynfelyn, Ceredigion: prehistoric/Roman lead smelting site and medieval trackway

By NIGEL PAGE, GWILYM HUGHES, RICHARD JONES and KEN MURPHY¹

with contributions by A. E. Caseldine, C. J. Griffiths, J. Crowther and Nigel Nayling,² Simon Timberlake,³ D. Smith, C. Jolliffe, K. Nayyar, F. Sharrock, E. Tetlow and D. Vaughan⁴

This paper describes the discovery and salvage recording of a wooden trough dating to the Bronze Age (1690–1380 cal. BC) and the subsequent excavation of a prehistoric/Roman lead smelting site and a medieval trackway on the south side of Cors Fochno (Borth Bog), Llangynfelyn, Ceredigion, between 2002–05. Extensive spreads of buried spoil, at least 200m by 150m, characterised the lead smelting site, with a single open hearth or bole furnace discovered in the relatively small area investigated by the excavation trenches. Analyses have shown that the smelting process was efficient, despite the basic technology employed, and that lead was the metal being extracted from the locally sourced galena ore, although silver production cannot be entirely ruled out. The dating of the smelting is reliant on radiocarbon determinations, and by relation to peaks of palaeopollution captured in the dated peat sequences. A decline in local woodland during the period of lead smelting is also recorded in the peat sequences. It is likely that lead smelting began in the late prehistoric period and continued until the early/mid-second century AD. However, it is possible that production may have been entirely under Roman military control from c. AD 74 through to AD 120–140.

The trackway ran from the earlier lead smelting site across Cors Fochno for 800m to Llangynfelyn 'island'. Lead smelting spoil was used as trackway foundation at the dry-land/wetland margin, but timber was the trackway's main component. Radiocarbon determinations and dendrochronological dates show that the timber trackway was constructed in the early- to mid-eleventh century AD and that it was repaired and timbers replaced for a century or so, with the last datable replacement in or soon after AD 1136. Some time after this date, perhaps decades, lead smelting waste was laid down forming a camber over the timbers. A second phase of camber material was later laid down; the date of this is unknown.

INTRODUCTION

In 2002, Mr Dilwyn Jenkin of Cerrigcaranau Uchaf and the owner of the land uncovered a planked timber box or trough during the excavation of land drains near Erglodd Roman fortlet on the fringes of Cors Fochno (Borth Bog), Llangynfelyn, north Ceredigion (Figs 1–5). The discovery was reported to Dyfed Archaeological Trust, who, in September 2002, undertook a rapid salvage excavation. A burnt mound was later recognised close to the trough. The trough was subsequently radiocarbon dated to the Bronze Age. During the salvage excavation a linear earthwork, assumed to be a trackway, was noted running out from close to the trough across the bog. Dyfed Archaeological Trust obtained funding from Cadw to undertake an evaluation excavation of this possible trackway in March 2004. This work revealed a stone and timber track, some timbers of which were radiocarbon dated to the tenth/eleventh centuries

AD. The evaluation in March also highlighted the fact that the timbers were deteriorating at a fairly rapid rate due to the de-watering of the site over the past few centuries, but more critically as a result of more recent land drainage. As the trackway was potentially of considerable archaeological importance and as its timbers were clearly deteriorating an application was made to Cadw for grant-aid for an excavation. This application was successful and the excavation was undertaken in July 2004. During the excavation extensive deposits of industrial waste, considered to be the result of lead smelting, were discovered pre-dating the track. Cadw therefore grant-aided a second season of excavation to examine these industrial deposits. This excavation took place in July 2005. Dyfed Archaeological Trust and the Institute of Archaeology and Antiquity, University of Birmingham, carried out the excavations.

The site of the archaeological investigations (SN649296) lies on the south-east edge of Cors Fochno in the parish of Llangynfelyn, Ceredigion (Fig. 1). The bog edge lies about *c.* 5m OD and the site of the trough at 10m. To the south and east the land rises gently to a terrace that carries the A487 Aberystwyth to Machynlleth road then rises more steeply to the high points of Allt y Crib at over 230m, part of a broken north-east/south-west ridge marking western edge of the Ceredigion uplands. The excavation site is located below a point where the ridge is breached, giving a slightly more open aspect to the south-east and providing inland access along the valleys of the Afon Ceulan and Afon Leri.

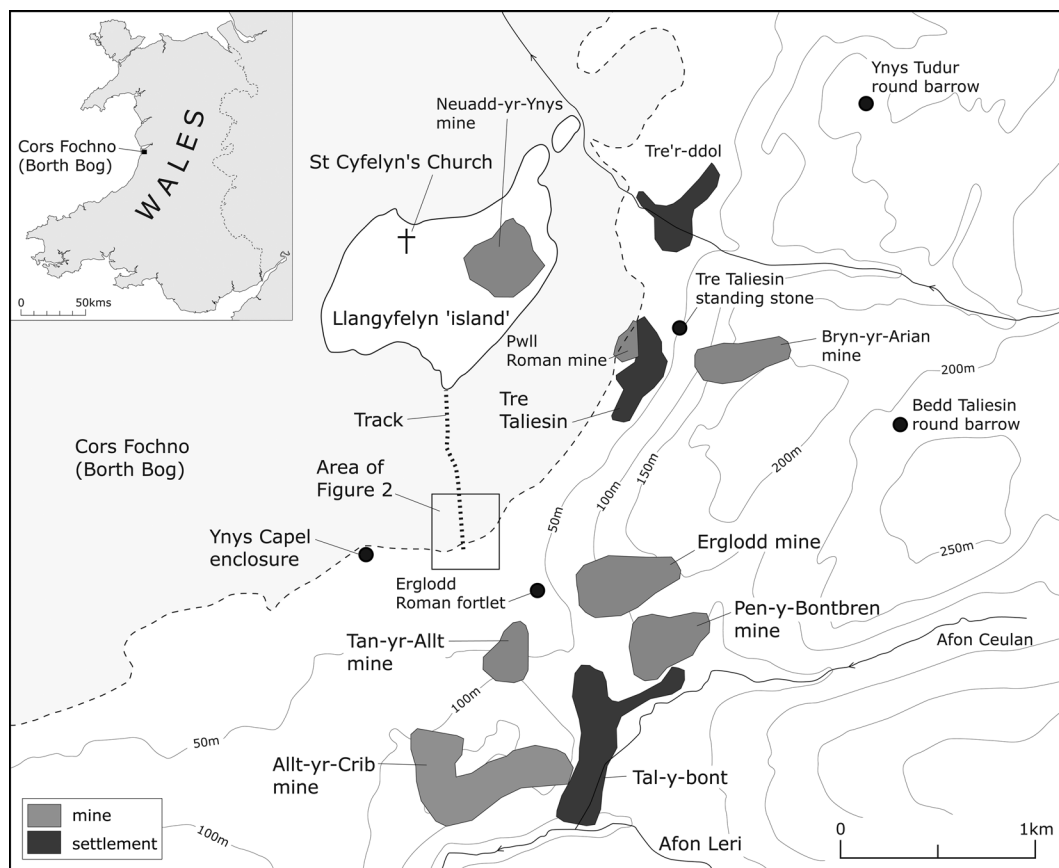


Fig. 1. Location.



Fig. 2. Aerial photograph of the excavations in June 2004 in the foreground, viewed from the south with Cors Fochno (Borth Bog) in the middle distance. The line of the trackway can be clearly seen crossing the bog. © Crown copyright: RCAHWM.

Cors Fochno is an extensive estuarine raised bog extending to approximately 200 hectares and represents the largest expanse of primary surface lowland bog in the United Kingdom, surrounded by approximately a further 400 hectares of degraded bog subject to past peat cutting and drainage (Poucher 2009, 8). The site is part of the Dyfi Site of Special Scientific Interest (SSSI), a National Nature Reserve, and in recognition of its international importance it is also Special Area of Conservation, a Ramsar site and the core area of the only UNESCO Biosphere Reserve in Wales. The raised bog ecosystem/habitat is the principal reason for its designations, but the site is also a geological SSSI based on the nationally important quaternary stratigraphic record. The bog's development in summary is that brackish reed swamp gave way to freshwater reed swamp *c.* 7000 cal. BP as the area became protected from the sea by

the development of a sand and shingle spit. This then gave way to fen followed by alder, then birch and then pine woodland and finally raised bog *c.* 6100 cal. BP (Hughes and Schulz 2001).

Over 250 archaeological sites are recorded on the Dyfed Historic Environment Record (housed with the Dyfed Archaeological Trust) in and around the bog, ranging in date from Mesolithic find spots to twentieth century military installations. Pertinent to this study are several Bronze Age funerary and ritual sites, broadly contemporaneous with the excavated trough, such as the round barrows of Bedd Taliesin and Ynys Tudur, and Tre Taliesin standing stone. Several burnt mounds of probable similar date have also been recorded on the fringes of Cors Fochno. Hillforts and defended settlements dominate our knowledge of the Iron Age in west Wales. These types of site are absent around Cors Fochno apart from a small cropmark enclosure at Ynys Capel 500m to the west of the excavation, which may be an Iron Age enclosed settlement (Figs 1 and 3). It has long been suspected that metal mining activity in the area has its origins in the Roman period or earlier, hence the name ‘Pwll Roman’ given to nineteenth-century mining at Taliesin, a name still preserved in the area as ‘The Romans’, and, indeed, Bronze Age mining in and around Llangynfelyn has been confirmed by recent fieldwork. For instance, at Llangynfelyn (Neuadd-yr-Ynys mine) charcoal from a spoil tip returned a radiocarbon date of 1860–1530 cal. BC (Timberlake 2003a, 21–42) and at Eglodd mine a date of 2340–2130 cal. BC was obtained from charcoal from the base of a spoil tip (Timberlake 2006, 83), and Migall *et al.* (2009) have investigated the prehistoric and later pollution record of Cors Fochno caused by nearby lead and copper mining. A Roman military presence is clearly attested by Eglodd fortlet, overlooking the site of the excavation. Direct archaeological evidence for occupation and exploitation in the post-Roman period is scarce, but it is likely that Llangynfelyn parish church, dedicated to St Cynfelyn, originated in the early medieval period. A church was established here by the fourteenth century, as were several small settlements, the occupants of which were probably engaged in agriculture and small-scale metal mining.

Records of nineteenth-century metal mines, mostly lead, dominated the Historic Environment Record for this part of north Ceredigion. The industry was at its peak at this time, with mines operating at Eglodd, Tan-yr-Allt, Allt-y-Crib, Pen-y-Bontbren, Pwll Roman, Bryn-yr-Arian and Neuadd-yr-Ynys. Some (as has been demonstrated) if not all of these mines had earlier origins.

ENVIRONMENTAL BACKGROUND

This section pulls together and summarizes the report on palaeoenvironmental investigations by Astrid Caseldine, Catherine Griffiths and John Crowther. A fuller but edited version of the report is included towards the end of this paper, and a complete report is included in the site archive. (See section on radiocarbon dates below.)

The earliest deposits investigated were recovered from Trench 20 (Fig. 4) and date from the early to mid Iron Age, 780–480 cal. BC and 470–410 cal. BC (Beta-222224) where the pollen record reveals alder carr along the bog edge and oak woodland on the dry slopes to the south. Low-level pastoral agriculture is hinted at by the presence of ribwort plantain and other grassland taxa as well as fungal spores indicative of dung. Microscopic charcoal within the sequence indicates fires, which may be related to domestic fires at settlements, fires associated with agricultural clearance or possibly in connection with industrial activity. The possibility of natural fires cannot be ruled out. Alder declines from around 510–200 cal. BC (Beta-211077), accompanied by a slightly later decline in oak, and an increasingly open environment.

Pollen from closer to the dry land/wetland interface confirms the composition of the woodland community, and may indicate a possible clearance episode. A decline in alder around 400–340 cal. BC and 320–200 cal. BC (Beta-241084) is accompanied by a slight increase in oak, and high microscopic charcoal values. Charred alder and hazel wood suggests human activity along the wetland edge.

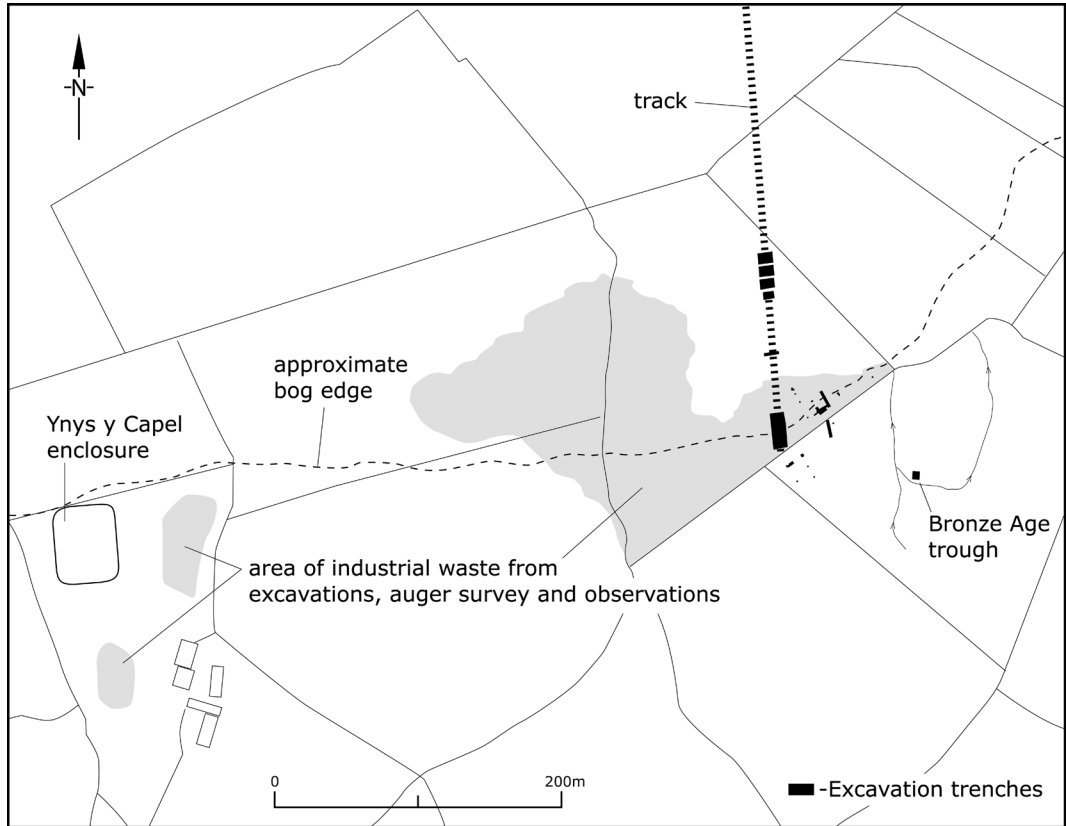


Fig. 3. The area of the site showing the extent of the industrial deposits.

By 110 cal. BC–cal. AD 130 (Beta-222223) there is evidence for marked impact on oak and alder woodland. This clearance immediately precedes and is contemporaneous with the beginning of industrial activity; a slight increase in lead values may indicate low-level mining or smelting. An increase in agricultural indicators for mixed farming occurs immediately prior to industrial activity, whilst microscopic charcoal indicates burning activity.

Following a minor regeneration episode there is clear evidence for renewed impact on oak woodland, with oak values declining to a minimum. This coincides with maximum lead values, suggesting that the decline in oak is directly related to lead mining and smelting. During this period charcoal values increase, and decreasing alder and birch values indicate the exploitation of local carr woodland as well as oak. Although there is then a slight recovery in oak and birch woodland, maximum lead levels are maintained. After this lead levels fall and small declines in oak and birch and fluctuations in alder suggest the impact on woodland was at a reduced level as industrial activity declined. Throughout this period of industrial activity there is evidence for continued agricultural activity, including cereal cultivation as well as pastoral farming, with a small peak in cereal cultivation initially.

A date of cal. AD 340–540 (Beta-235895) from a peat formation immediately above the industrial deposits demonstrates that lead smelting had ceased by that date, if not earlier. There is some regeneration of birch and alder woodland between cal. AD 210–440 (Beta-222222) and cal. AD 530–780 (Beta-235892).

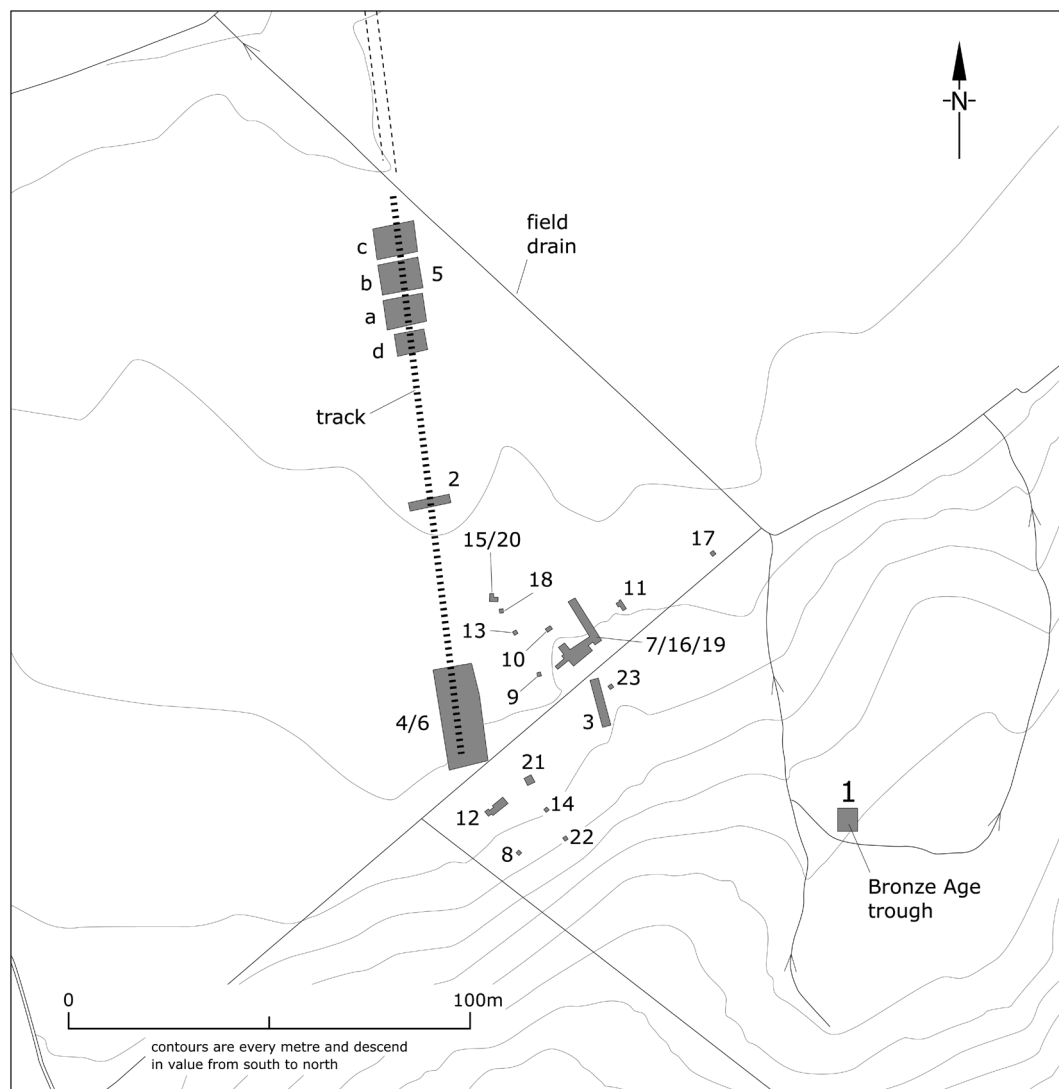


Fig. 4. Location of the excavation trenches. Trenches are numbered.

Weed taxa are largely absent at some sites, suggesting a reduction in agriculture in the area, and possibility more localised activity. A peak in lead values occurs soon after cal. AD 210–440 (Beta-222222), which may represent a further episode of mining or smelting, although an increase in minerogenic sediment suggests that this is more likely to be the result of eroding spoil tips.

Although the timing varies according to the location of the different pollen samples, sometime after cal. AD 530–780 (Beta-235892) or cal. AD 680–890 (235894) there appears to be an increase in oak woodland with a suggestion that some land may have gone out of agricultural use. However, by cal. AD 860–1010 (Beta-235893) clearance of oak and birch was taking place, although alder seems to have been

little affected. This reduction in woodland was possibly the result of deliberate clearance, or sustained grazing activity may have prevented regeneration.

THE BRONZE AGE TROUGH AND BURNT MOUND

The salvage excavation and recording of the timber trough was undertaken under very difficult conditions in September 2002. The work was undertaken during the insertion of land drains when the whole field had the appearance of a battle site making the observation of the context almost impossible. The trough was rapidly exposed (partly by hand and partly by machine) and the timbers and stratigraphy recorded. Due to the conditions and lack of resources it was only possible to retain a sample of the timbers.

The trough was *c.* 3m long, 1.5m wide and 0.6m deep (Fig. 5). The individual timbers were, on average, 60mm thick. The trough was sealed by a deposit of water-worn pebbles up to 0.6m thick. A number of friable branches suggested that the trough was covered by a timber 'corduroy'. The trough timbers were identified as oak with evidence of having been worked with an adze. They returned radiocarbon dates of 1630–1380 cal. BC and 1690–1430 cal. BC (Beta-189526 and 189527). A site visit was made following ploughing in April 2004. This had exposed a spread of burnt and shattered stone approximately 20m in diameter in the immediate area of the trough, suggesting that it had originally been associated with a burnt mound.

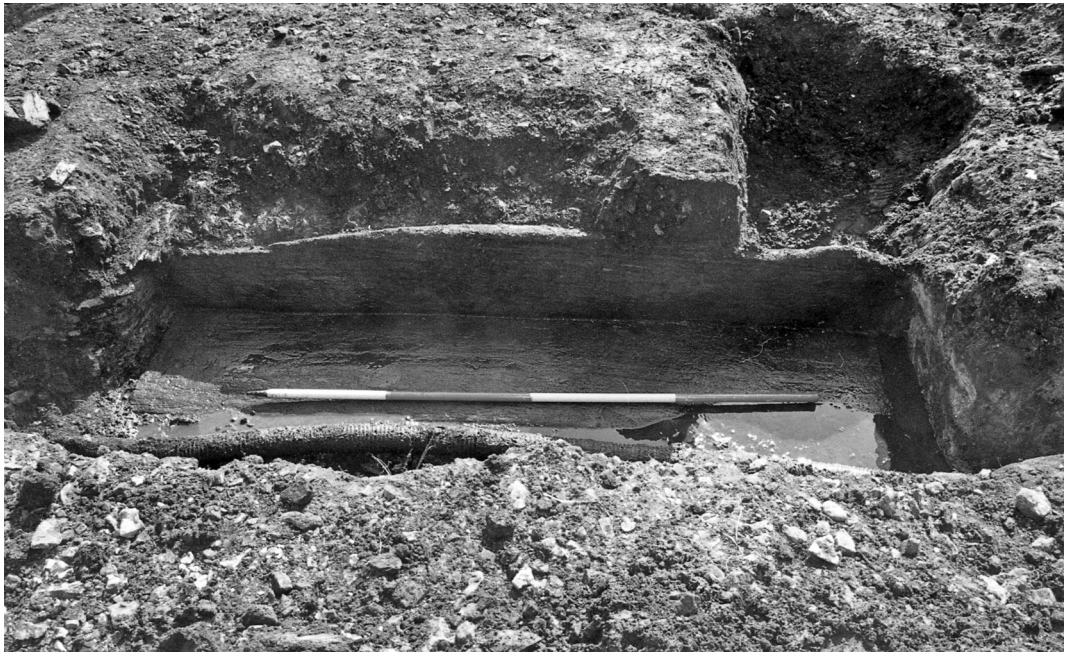


Fig. 5. Bronze Age timber trough. Scale 2m intervals. *Photograph: Nigel Nayling.*

THE LEAD SMELTING SITE

The extent and character of the lead smelting deposits

Attenuated grass growth provides clear evidence for the extent of lead smelting waste immediately below the ground surface. This evidence, coupled with observations in the sides of drainage ditches, excavation, auger survey and geophysical survey provides a good, although not complete, indication, for the extent of the lead smelting deposits along the southern margins of Cors Fochno (Fig. 3). Some of this evidence, including that from geophysical survey, was collected during a 2009 project (Poucher 2009, 45–49).

The lead smelting waste occupies a *c.* 200m long and 100–150m wide strip along the margin of Cos Fochno in the vicinity of the medieval trackway excavation, with further deposits close to Ynys Capel. It is likely that these two areas of deposit form a continuous strip along the bog fringe.

The lead smelting deposits were investigated in a series of excavation trenches, Trench 3 in 2004 and Trenches 6 to 22 in 2005 (Fig. 4), plus the deposits investigated as part of the trackway excavation in 2004 (Trench 4). Only the remains of a furnace (Trench 21) are described in detail here. Waste deposits from lead smelting, essentially an extensive spoil tip, were present in all the trenches. For the most part the deposits comprised horizontal bands of charcoal, charcoal-rich ash, smelting waste, fragments of furnace lining and residues from post-smelting processing. However, the character of the deposits varied across the site, with more lead smelting waste present in Trenches 4, 6, 12 and 21 than elsewhere, suggesting that the area of these trenches was the focus for smelting operations. The deposits were also substantially thicker in this area than elsewhere, up to 0.75m in Trenches 4 and 6. Not only did the deposits thin out towards the east, although even in Trench 17 they were still 0.3–0.4m thick, their character also changed, with no obvious smelting waste present. Radiocarbon dates of cal. AD 20–220 (Beta-204040) and 90 cal. BC–cal. AD 90 (Beta-204041) were obtained from charcoal from the industrial deposits where they were overlain by the medieval trackway (Trench 4a), and two dates, 40 cal. BC–cal. AD 130 (Beta-238738) and cal. AD 50–240 (Beta-238739) were obtained from charcoal from the industrial deposits in Trench 20. Both pairs of these dates are inverted—the younger date coming lower in the sequence than the older date—but this is not entirely surprising given the character of the deposits. A fifth date of between 50 cal. BC–cal. AD 90 and cal. AD 100–120 (Beta-238737) was obtained from charcoal from the industrial deposits in Trench 17.

Timberlake (see below) undertook a mineralogical and textural analysis of seven samples, four from Trench 21, where the only definite furnace was located, and one each from Trenches 6, 12, and 17. The samples from Trench 21 were associated with the furnace, or from nearby earlier and later furnaces. The absence of part-smelted ore and lead droplets indicates a fairly efficient smelting process, despite other indicators suggest that smelting was undertaken in a fairly primitive bole furnace or hearth. Layers of charcoal and large amounts of charcoal in waste and slag layers demonstrate that vast amounts of charcoal were raked out of the lead smelting furnaces. There was ample evidence for the crushing of slags and other waste for re-smelting. Crushing may have been done by hand, or there may have been a mill on site. Some of the slags contained quartz; this may have been added as a flux to aid slag separation. The sample analysed from Trench 12 contained slags indicating a furnace in the general area, but not in the immediate vicinity, and analysis of the sample from Trench 6 suggests the industrial waste in this area was deposited a little distance from source, perhaps partly by natural processes. In the most easterly trench (17) deposits contained charcoal and unburnt fragments of wood, possibly oak, and a few fragments of burnt stone, but no smelting waste, indicating that different processes took place in this area, perhaps charcoal burning. Charcoal clamps may have been constructed close to streams or pools in case the clamp caught fire, and the pollen evidence from Trench 17 (see below) suggests there was open water nearby.

Metallographic and other analyses undertaken by Lorna Anguilano of the Institute of Archaeology, University College London (Anguilano 2007) showed that the composition of the slags was not

homogeneous, but the temperature suggested by these compositions was fairly homogeneous, and between 720/780°C. This sort of temperature is easily reached within a wind blown bole furnace. The presence of metal, oxide, sulphate and sulphide indicates very variable red-ox conditions, which are once again an indication of a wind blown furnace.

The different metals present within the slags suggests the use of a mixed and complex ore for smelting. However, the ore was predominantly galena (lead sulphide) associated with quartz in the gangue. The quartz may have been left in to assist as a flux, for the purpose of forming a slag, confirming the conclusion of the mineralogical analysis.

The galena was associated with other minor sulphides and also the arsenides of antimony, copper, iron, nickel and zinc. The presence in one sample of a silver rich phase might suggest that some of the veins were argentiferous. Nickel, copper, silver, arsenic and antimony are probably all present in minor amounts within the range of ores from nearby mines. However, it would seem that the galena was exploited for lead and not for silver, although there is a slight possibility of silver production.

Resources available for the lead smelting

All the resources required for lead smelting in a simple wind-blown bole furnace were available within a short distance of the site: lead ore, wood, a fairly constant wind blowing from the west across the open landscape of Cors Fochno, and to a lesser extent, water. The ore used was principally galena associated with quartz. Anguilano (2007) suggests Erglodd mine as a possible source, a suggestion supported by the results of excavations where Bronze Age workings had been disturbed by later, but still ancient, workings possibly for the procurement of lead (Timberlake 2006). Ore could also have come from Allt y Crib mine or Tan yr Allt mine (John Mason pers. comm.). All three of these mines lie within 1.2 kilometres of the site, and there are numerous other mines and smaller workings within 5 kilometres of the site.

Caseldine and Griffiths examined 20 charcoal samples from the industrial deposits across the site. Oak dominated the samples, although the results suggest that a wide range of species were used from the surrounding area as fuel. The use of local wood as a fuel is attested by the palaeoenvironmental analysis which records a sharp reduction in oak and alder during industrial use of the site. At Llangynfelyn a fire of charcoal or wood could have been used, although higher calorific value charcoal is not necessary for smelting 'black ore' galena and wood alone could have been used (Homer 1991; Craddock 1995). Charcoal was necessary for smelting 'white ore' and to rework litharge (residual lead after silver extraction from argentiferous lead).

Trench 21 furnace

The excavated portion of this furnace consisted of a *c.* 0.65m diameter sub-circular patch of orange and grey highly heat affected clay surrounded by a stony charcoal-rich layer and sitting in a shallow, *c.* 0.1m deep, hollow (Fig. 6). Part of a low furnace wall, 0.2m high, survived in poor condition on the west side. This wall was constructed from clay and stones some of which were heat affected and some had slag adhering to them, indicating that they had lined the furnace interior. The wall on the east side had collapsed or been demolished and was spread over the north-east quadrant of the trench. The furnace was cut into earlier smelting waste (1091 and 1109) and was sealed by a thick deposit of slag and crushed slag from later episodes of smelting (1085). Two deposits (1091 and 1093) filled the furnace. The lower fill (1091), which directly overlay the furnace base and spread outside the furnace, consisted of charcoal, but with some slag, unburnt shale and soil, and was probably the result of raking out of the furnace. The upper fill (1093) was charcoal rich and included black glassy vesicular slag containing traces of oxidised lead. It is possible that it was waste from another furnace located a short distance away.

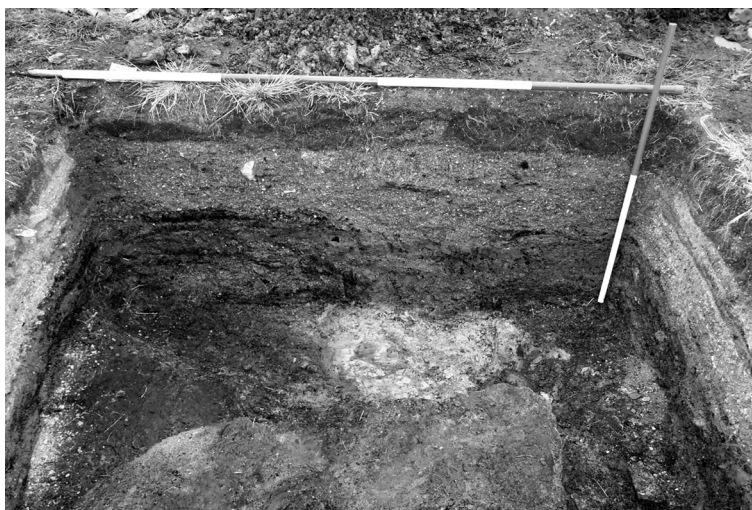


Fig. 6. Smelting furnace in Trench 21. Scale 0.5m intervals.

Date of the lead smelting

Dating of the lead smelting is entirely dependent on radiocarbon determinations. Five determinations were obtained from charcoal from the industrial waste and several dates from peat deposits underlying and overlying the industrial waste. Dating by proxy, relating to the peaks of palaeopollution captured in the dated peat sequences, is also possible, although interpolation is required using this technique.

The five dates from the industrial waste: between 50 cal. BC–cal. AD 90 and cal. AD 100–120 (Beta-238737), 40 cal. BC–cal. AD 130 (Beta-238738), cal. AD 50–240 (Beta-238739), cal. AD 20–220 (Beta-204040) and 90 cal. BC–cal. AD 90 (Beta-204041), range from 90 cal. BC through to cal. AD 240, with all five dates overlapping between cal. AD 50–90. These dates are in concordance with a clear palaeopollution event which reaches a maximum approximately midway between dates of 110 cal. BC–cal. AD 180 (Beta-222223) and cal. AD 210–440 (Beta-222222). A second peak in lead levels soon after cal. AD 210–440 (Beta-222222) may, as noted above, represent a further episode of smelting, or more likely erosion off spoil tips. Smelting had ceased by cal. AD 340–540 (Beta-235895) when peat began to form over the industrial waste.

A degree of caution must be exerted when interpreting the above data, given the limitations of radiocarbon dating for the late Iron Age and Roman period, and in particular when attempting to correlate scientific dates with historical events. From the available data it is possible that lead mining and smelting began in the late Iron Age and peaked in the late first/early second century AD, and ceased by the mid to late second century AD, but it is possible that mining and smelting was confined to a much shorter time span, perhaps as short as 20–30 years in the late first/early second century AD.

Discussion of the lead smelting activity

Although Bronze Age copper mining in the Ceredigion ore-fields is now well attested due to a series of excavations by the Early Mines Research Group in the 1980s and 90s, most notably at Copa Hill, Cwmystwyth (Timberlake 2003b), prehistoric and Roman working of lead is less well documented. Most evidence for such workings is either anecdotal or based on place-names, such as the mine known as Pwll

Roman (Roman Pool or Pit) at Taliesin, 1.2 kilometres to the north of the excavation site. Field survey by Simon Timberlake (2004b, 142–3) indicates that the ancient workings at Pwll Roman are likely to be Bronze Age rather than Roman. One piece of hard evidence to come to light so far is at Banc Tyddol, Cwmystwyth (Timberlake 2004a; Anguilano *et al.* 2010), where excavations revealed complex deposits including lead smelting in bole furnaces. Charcoal probably associated with the smelting produced a late Roman radiocarbon date (cal. AD 320–430), with another date in the early medieval period (cal. AD 670–840).

At Dolaucothi in Carmarthenshire Roman metal mining, for gold, is well known, but even here there is still some debate, recently articulated by Burnham and Burnham (2004, 329–30), as to whether it was exclusively Roman or had its beginnings in the later prehistoric period. A similar debate pertains at Llangynfelyn, although here the argument hinges on the interpretation of the radiocarbon dates rather than the morphology of surface and below ground remains, as at Dolaucothi. The Roman conquest of west Wales began *c.* AD 73/74 and was largely complete by the early-second century with the military withdrawing between AD 110 and AD 150 (Burnham and Davies 2010, 42–52). However, as noted above, the radiocarbon dates from Llangynfelyn are not sufficiently precise to determine whether the lead smelting began in the late Iron Age and was developed during the Roman Period, almost certainly under the military, or whether production began when the military moved into the area and ceased when the army withdrew. Whatever the date of the beginning of lead smelting it is clear that maximum production was during the Roman military occupation of the area and that Erglodd fortlet, overlooking the lead smelting site, would have had a key role in controlling the production of lead. Unfortunately, the small-scale excavations so far undertaken at Erglodd have not been sufficient to determine exactly what this role was (Davies 1980).

THE TRACKWAY

The palaeoenvironmental study by Astrid Caseldine, Catherine Griffiths and John Crowther below indicates that following the reduction in woodland by cal. AD 860–1010 (Beta-235893) a largely open agricultural landscape prevailed in the area. Pastoral activity dominated but there was some cereal cultivation. The trackway was constructed in the early to mid eleventh century during this pastoral farming phase. This palaeoenvironmental study, the report on plant macrofossils by Caseldine and Griffiths below, and the insect report by Smith *et al.* below suggest that the trackway was constructed over a varied wetland landscape encompassing wetland grasses, reed, sedges, heather and cotton grass with wetter pools containing pond weed. Bog myrtle, birch fenwood and alder carr would also have been growing in the area.

Alder was the main timber used in the track, with oak and other species also used, all of which were growing in the vicinity. Apart from a slight decline in alder in one of the pollen sequences, construction of the trackway had little impact on the surrounding woodland.

The trackway runs north for 800m from the south side of Cors Fochno (at SN 64869060) to the most southerly tip of Llangynfelyn ‘island’ (at SN 64789139). Its course shown on Figure 1 was plotted from a vertical aerial photograph taken in 1972.⁵ On the dry-land edge on the south side of Cors Fochno a linear earthwork up to 8m wide and 0.75m high marks the line of the track. As it runs to the north onto the bog the earthwork becomes less pronounced, but still visible as a slightly raised area and as a line of different vegetation. Approximately midway across the bog there is a dogleg in the track, after which the trackway resumes its northern course. The trackway is not traceable on the northern dry-land margin on Cors Fochno. Two modern lanes provide access onto Llangynfelyn ‘island’ from higher ground, one on the east

side and one on the north-east side, with the latter probably the more ancient route. The trackway would have provided a direct connection with the ‘island’ from the south, avoiding a 3- or 4-kilometre journey around the eastern fringe of Cors Fochno and onto the ‘island’ from the north-east. The excavation took place on the wetland/dry-land interface on the south side of the bog.

An evaluation (Trench 2) on the trackway was undertaken in March 2004, followed by more extensive excavation in July of that year when two areas were machine stripped, cleaned and hand excavated (Fig. 4). Trench 4 was located to investigate the junction of the trackway at the bog/dry-land interface, and Trench 5 was positioned on the bog where drainage works and other agricultural operations had disturbed the track. Trench 6 was opened in 2005 to reinvestigate the trackway and the underlying industrial deposits encountered in Trench 4, but not fully examined in 2004.

Trench 2

The basic structure of the trackway was revealed in this *c.* 10m by 1.6m evaluation trench (Fig. 7). A layer of angular stones, between which six roundwood stakes in two parallel rows had been driven into the underlying peat, was the earliest trackway element encountered. A radiocarbon date of cal. AD 890–1020 (Beta-191064) was obtained from one of the stakes. Within and alongside this layer were short pieces of roundwood and cut timber fragments (some showing evidence of tooling and working) thought to be waste from construction.

A layer of gritty gravel overlay the stone spread, and over the gravel was a decayed timber structure. This consisted of two parallel rails 1.5m apart running north to south. The east rail consisted of decayed



Fig. 7. Timber trackway in Trench 2 after the removal of the overlying layers of gravel and industrial waste. Scale 0.5m intervals.

roundwood, 1.4m long and *c.* 85mm diameter, from which a radiocarbon date of cal. AD 890–1030 (Beta-191065) was obtained. The west rail, also of decayed roundwood, had a maximum diameter of *c.* 175mm and was at least 2m long. The rails supported heavily decayed cross-timbers of complete and half-split roundwood, forming a ‘walkway’ surface *c.* 2.4m wide. A 0.1–0.15m thick layer of industrial waste overlay the timber structure, over which was a 0.15m thick deposit of gritty gravel. These two layers formed a distinct camber. Topsoil, 0.2m thick, overlay the gravel layer.

Trenches 4 and 6

The principal objective of Trench 4 was to define the nature of the trackway at the wetland/dry-land interface. Removal of a thin topsoil and turf revealed the surface of a pronounced camber, comprising a gravel and stone surface with a clay shoulder along its west side. In 2004, it was originally intended to fully hand excavate the trackway and any underlying deposits in this 25m by 10m trench. However, this was not practical owing to good survival of the timber elements of the trackway and the sheer volume of material involved. Instead, it was decided to excavate a more limited area at the southern end of the area (Trench 4a) and two 1m-wide cross-sections (Trench 4b and Trench 4c). Trench 4 was reopened in 2005 and a length of the trackway investigated as Trench 6 (Fig. 9).

Trench 4a measured 4.5m by 3m and was excavated to a general depth of between 0.20m and 0.40m. All that survived of the timber structure was a line of six stakes with pencil points driven into the underlying industrial deposits on the west side of the track. The trackway was constructed from layers of gravel, stone and waste material from the earlier lead smelting. The lower layer (1118) consisted of blue-grey fairly fine industrial waste, 70mm thick. The upper surface of the trackway (6) was 0.16m thick and consisted of buff gravel and larger stones forming a pronounced camber. A clay shoulder had been added to the west side, probably as a result of the slumping of this part of the trackway into a peat-filled hollow investigated in Trenches 4b and 6. There was no evidence here for the stone layer below the trackway recorded elsewhere, suggesting that the firmer nature of the ground at this point precluded the need for any support. Sometime after the trackway had been constructed a narrow trench (1016) was excavated along at least part of its eastern edge. The trench, which was also recorded in Trenches 4b and 6, contained bundles of small roundwood rods. The rods did not appear to form a structure, and it seems likely that they had been inserted as bundles into the base of the open trench, possibly to act as a drain.

Trench 4b, a 1m-wide cross-section, was located approximately midway along Trench 4 to investigate an area where the trackway seemed survived in good condition (Fig. 8). The excavation revealed that the trackway comprised the two upper gravel layers (6, 1118) noted in Trench 4a (Fig. 9), a timber structure (14) and the clay shoulder along the west edge (1119) also noted in Trenches 4a and 4c. In 2005, Trench 4b

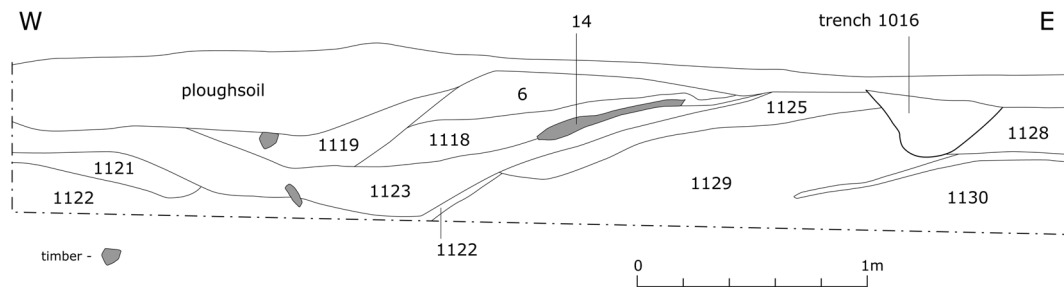


Fig. 8. Section of trackway in Trench 4b.

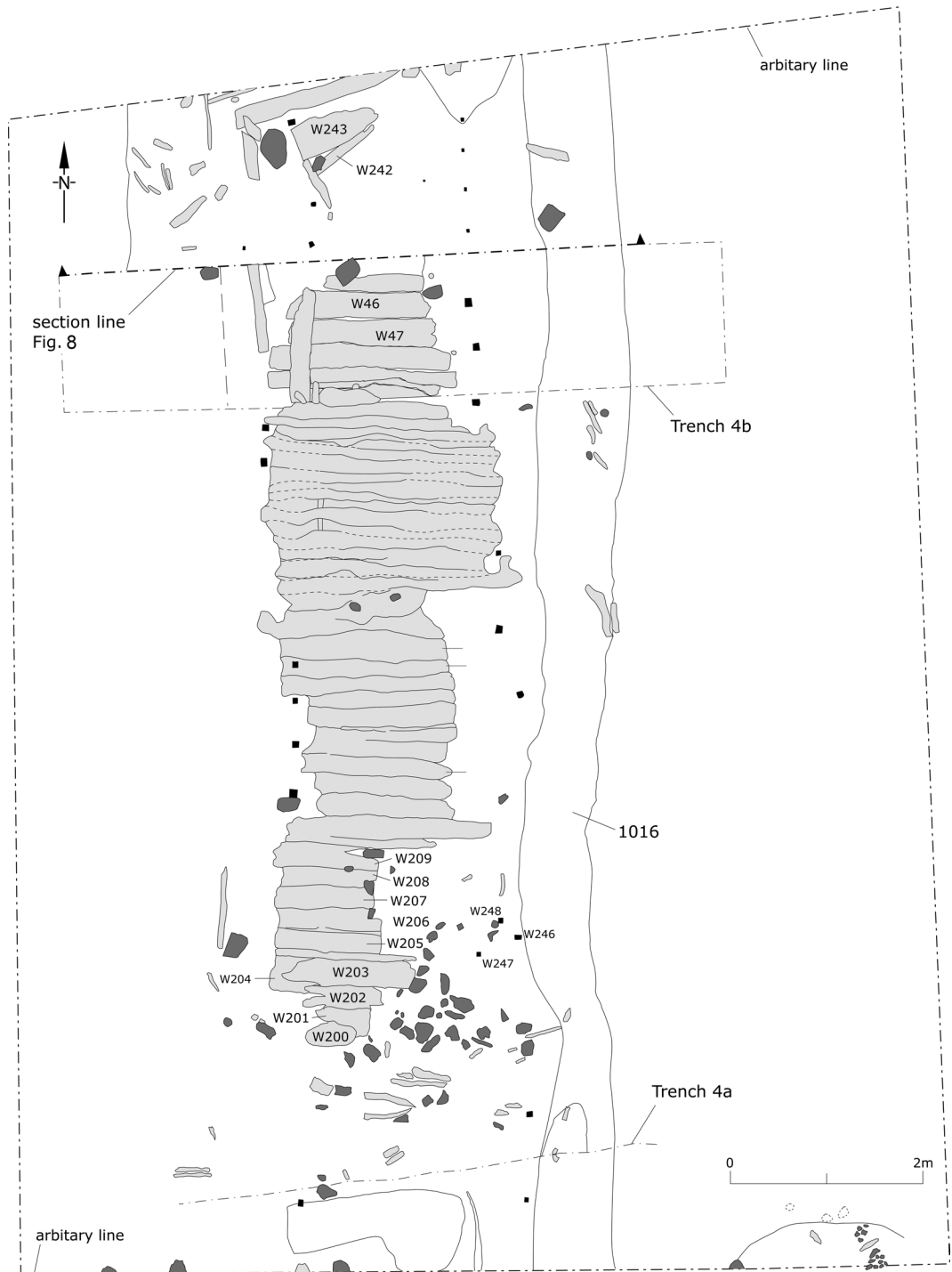


Fig. 9. Plan of timber trackway in the central section of Trenches 4b/6.

was extended as Trench 6 to the north and south to further investigate the timber trackway and underlying industrial deposits. Results from Trenches 4b and 6 are described together.

In Trench 4b the timber structure (14) consisted of side rails on the west side and cross-timbers with a number of upright stakes along the east side (Fig. 9). The stakes were small, roundwood timbers and appeared to have been driven into the underlying peat (1123) from the level of the timber structure, although it is possible that the tops had been lost. The stakes were presumably intended to prevent the lateral movement of the timber structure. Industrial deposits (1121–22, 1128–30) lay beneath the peat (1123). In the area of Trench 4b these industrial deposits, the peat and the trackway had slumped (Fig. 10), probably into a hollow formed in lower lying peat; this was not investigated.

Towards the southern end of Trench 6 the timber structure rested directly on industrial waste material, with no intervening peat deposit. The exact location of where the peat faded out was not investigated. The timber structure was, however, similar whether it overlay peat or industrial deposits, and in Trench 6 comprised close-packed cross-timbers, including half-round timbers and split planks. Rows of stake uprights ran along the line of the trackway and were for the most part below the cross-timbers. A single willow or poplar roundwood branch (not shown on Fig. 9) had been laid to act as the west side rail for some of the cross-timbers. There was no side rail on the east side.

A short length of at the extreme south end of the trackway in Trench 6 appeared to have been truncated on its eastern edge, but the timbers (W200–W209) were so degraded that no evidence of any saw or cut marks was visible. The area of truncation was filled with compacted gravel and industrial waste as a form of simple repair. The central section of the trackway in Trench 6 also appeared to be slightly truncated on



Fig. 10. Trench 4b taken during timber sampling, showing trackway slumping into hollow.

its east edge, possibly as a result of differential drying. The timbers at the northern end of Trench 6 along with those in Trench 4b sloped steeply to the west into the hollow described above.

Eighty-five wood samples were identified to species: these were 35 alder, 32 hazel, 12 oak, three willow, two ash and one Maloideae type. The stakes were all alder or hazel roundwood simply modified with either pencil or chisel points. The cross-timbers were a mix of alder and oak, but the timbers were in poor condition, heavily compressed and degraded, so that only approximately 40% of them were identified; several timbers survived as compressed bark only. The cross-timbers that were in a condition to be examined were a combination of tangential and radially split timbers. Most of the timbers appeared to have been laid with the split face downwards, so the bark (where present) and the round sides were uppermost.

Five timbers, all cross-timbers, were in a condition to allow dendrochronological analysis. Timber W202 was felled after AD 1069, W46 and W47 were felled after AD 1085, and W243 had a felling date between AD 1094 and 1130 AD. The third timber, W242, gave the closest reliable felling date of soon after AD 1136.

It seems likely that W242 and W243 were from the same parent tree and W202 is probably from the same parent tree as timbers W47, W56, W57 and W129 that were recorded in Trenches 5a and 5b.

The timber structure was overlain by a layer of blue-grey gravel and industrial waste material, 0.15m thick (1118), which was overlain by the upper gravel layer (6). Sometime after the trackway had been constructed a narrow trench (1016) was excavated along at least part of its eastern edge. This slot was also recorded in Trench 4a.

Trench 4c was hand excavated through the trackway to the top of the underlying peats at the northern end of Trench 4 in order to obtain a profile through the trackway that also included the deposits below and on either side.

The trackway had a foundation layer of large stones supporting a timber structure, consisting of side rails, cross-timbers and driven stakes, which was overlain by two gravel/industrial waste layers. The foundation layer comprised large irregular stones laid onto the surface of the underlying peat. Similar layers of stones were noted in other trenches below the track, and it is likely that they were dumped to fill wet hollows in the peat surface.

Overlying the foundation stones were very fragmentary remains of the timber structure, consisting of side rails supporting cross-timbers, similar to the trackway structure excavated in Trench 2. Three/four parallel rows of pointed driven stakes were noted within and under the stone foundation layer, aligned north-south along the track, and had presumably been intended to stabilize the peat surface and to stop lateral movement as the foundation stones were laid. The timber in this trench was very fragmented, desiccated and decayed and most of what survived had been squashed virtually flat, and so provided little opportunity for analysis. Above the timbers were two layers of gravel which formed a pronounced flattened camber, *c.* 4–5m wide and 0.4m high. The lower layer was a grey blue gravel and industrial waste material virtually identical to that seen in Trenches 2, 4a and 4b. The upper gravel layer contained a number of large stones, rounded and angular, which protruded through the trackway surface. The clay shoulder recorded along the west side of the trackway in Trenches 4a T4b and 6 was also present.

Trench 5

This trench was intended to investigate the condition and survival of the timber element of the trackway and to provide material for dating. It was positioned towards the northern end of the field in which drainage works were taking place and across an area of the trackway that had been disturbed by these works and other agricultural operations. This had resulted in the trackway being less pronounced than elsewhere excavated and the decision was taken to machine off surviving upper gravel layers in order to expose the

timber structure and foundation layer (Fig. 11). Trench 5 measured *c.* 35m by 10m and was sub-divided into four areas separated by 1m wide baulks (areas Trenches 5a–d).

The timber structure displayed variation among its surviving sections, with some side rails and cross-timbers substituted by longitudinal timbers. A number of driven stakes were recorded throughout Trench 5, although they were fairly randomly placed and there were no identifiable rows similar to those recorded in Trenches 2, 4 and 6. Timber was recovered from all four areas of Trench 5, although very few structural elements (a few stakes and one fragmentary cross-timber) survived in Trench 5c, the northernmost area, as it was located closest to a drainage ditch and had subsequently suffered the most from dewatering. Trench 5c had also been heavily disturbed by agricultural activities and the camber had been almost levelled in places. Therefore, the following descriptions concentrate on the sections recorded in Trenches 5a, 5b and 5d (starting from the southernmost trench, 5d), where the preservation of the timber was better and the trackway survived in a reasonable condition.

In Trench 5d, as with the other sections in Trench 5, the *c.* 0.2m of gravel was removed by machine to expose the timber structure. The southern end of the timber structure rested on a spread of large angular and sub-angular stones, similar to those recorded elsewhere, and which appeared to have been dumped to fill wet hollows in the peat surface. Gravel and industrial waste material recorded below the timber structure has been interpreted as having fallen through the degrading timber structure.



Fig. 11. Timber trackway in Trench 5 looking north.

The timber structure was similar to that recorded in Trench 5a (below), having a short length of side rails and transverse cross-timbers giving way to longitudinal timbers (Fig. 12). A total of 36 timbers were in a condition to allow lifting and identification. Of these the vast majority (30) were alder, with five oak timbers and one hazel timber also present. Two stakes were recorded below and alongside the structure, which suggests that the stakes recorded in other areas were not present in numbers along the whole of the track.

Timbers survived in fairly good condition, although only one east side rail (W101) survived: no west rails survived. The surviving side rail was a length of alder roundwood that had been simply modified by the removal of numerous side branches. Most of the cross-timbers were alder roundwood, suggesting that branch wood had been used with little or no modification, although all of the timbers were compressed and degraded, so it is possible that some detail of conversion was obscured. One of the oak cross-timbers (W90) had a through mortise at its east end, which could have been a stake hole used to anchor the timber in place, but there was no accompanying stake, and it may have been a piece of reused structural timber.

The longitudinal timbers included a massive tangentially split oak plank (W88), which was over 3m in length and almost 0.5m wide. The other longitudinal timbers were all alder roundwood. The southern end of W88 overlay cross-timber W90 and another oak cross-timber (W89). The longitudinal timbers appeared to bridge a *c.* 3m gap in the structure between two areas of side rails and cross-timbers, one of which extended into Trench 5a.

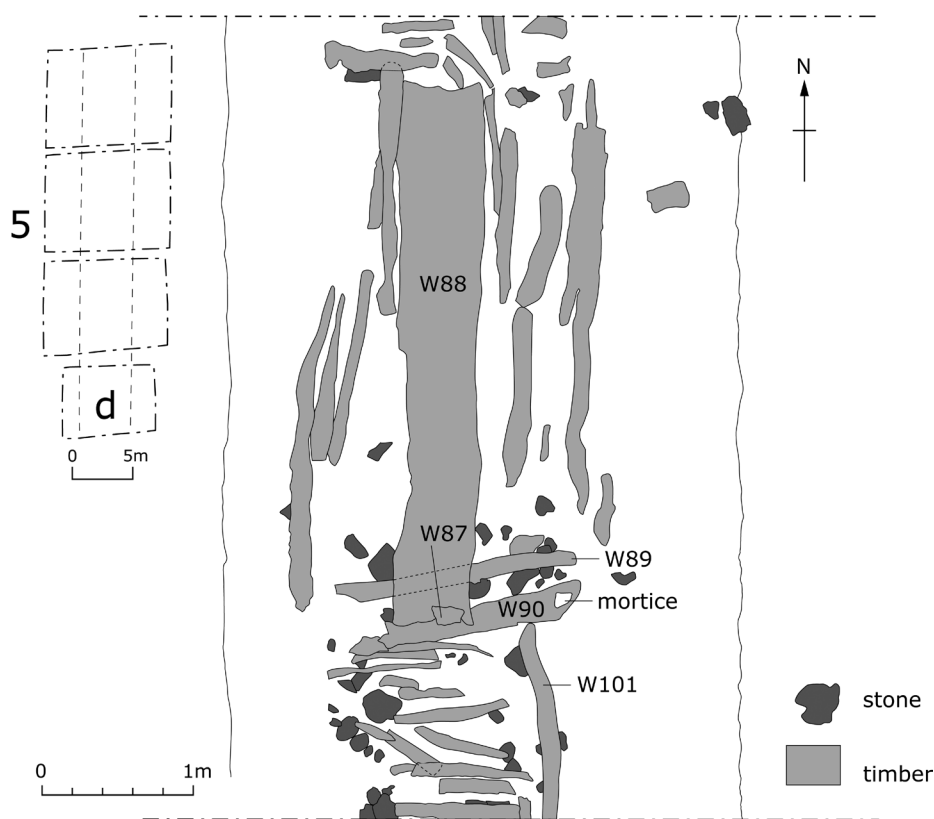


Fig. 12. Plan of surviving timbers in Trench 5d.

Four of the oak timbers (W87, W88, W89 and W90) in this section were sampled for possible dendrochronological dating, although, only three were able to provide any dates, and even these were not absolute, resulting in either felling date ranges and 'felling after' dates. Of these timbers one (W87) was a small fragment of oak that appeared to have been displaced and was recovered from above the southern end of W88, which adds to the uncertainty of this sample dated to after AD 1065. The two dates of AD 1076–1112? (W89) and after AD 1067 (W90) were obtained from cross-timbers. There was a sufficiently close correlation between the ring sequence of W80 in Trench 5a and W90 in Trench 5d to suggest that they may have derived from the same parent tree.

In Trench 5a, removal of the upper gravel surface exposed a fairly well preserved section of the timber structure, which consisted of a *c.* 3m length with side rails and transverse cross-timbers, which to the north gave way to a section comprising mostly longitudinal timbers. Underlying the timbers were patches of large rounded and sub-angular stones. Industrial material was also present below the timbers, as in Trench 5d.

The section of the timber structure that had been constructed using longitudinal timbers had been virtually lost through decay and desiccation: only three lengths of timber of any size and a few small fragments survived. Two of the surviving timbers (Fig. 13, W70 and W71) were alder roundwood and the third was an oak tangential split plank (W73). Other small fragments of oak were also evident in this part of the structure (W74 and W77). Some of the small fragments were too degraded to be samples for identification.

The side rail and cross-timber section of the structure survived in fairly good condition. It was 2.1m across. The west side rail was made up of three, possibly four lengths of radially split oak (W59, W60, W80 and W81). Dendrochronological analysis has suggested felling date ranges of AD 1085–1121 (W59) and AD 1020–1056 (W80) for two of the timbers.

Of the 26 cross-timbers, 19 were alder, 5 were oak and 2 were hazel. Dendrochronological analysis on two of the oak timbers indicated felling date ranges of after AD 1000 (W56) and after AD 1056 (W57). Both these timbers had been radially split, but were in fairly poor condition, and both, along with W47 from Trench 4b, W129 from Trench 5b and W202 from Trench 6, are thought to have been from the same parent tree.

The alder and hazel timbers were all roundwood, except for one alder timber that may have been half split. A few of the roundwood timbers had had side branches removed. There was little evidence of any major woodworking, and for the most part the structure was constructed using simply converted alder and hazel roundwood. The oak had been worked more, presumably to get the most from it, although the conversion into radially and tangentially split timbers was still straightforward.

In Trench 5b the timber structure survived in poor condition and the surviving elements consisted of side rails and fragmentary and poorly degraded cross-timbers. The stone spreads noted in Trench 4c and Trench 5a below the structure were also present in this area and, as with elsewhere on the site, appeared to have been dumped to fill hollows in the peat surface. A spread of gravel and industrial waste material was also present on the surface of the peat, as recorded elsewhere.

The surviving timber structure consisted of three side rails and a few fragmentary transverse cross-timbers (Fig. 14). Only eight timbers were in a condition to be examined and lifted. Of these five were oak, two were alder and one was hazel. The oak timbers were lifted for dendrochronological and other analyses, and only these are discussed here.

Three of the oak timbers had been used as the side rails (W129, W130 and W135) and the other two were cross-timbers (W131 and W132). The surviving length of the west side rail contained two radially split timbers W129 and W130, while the east side had one surviving timber (W135), which had been tangentially split. The two cross-timbers had been radially split.

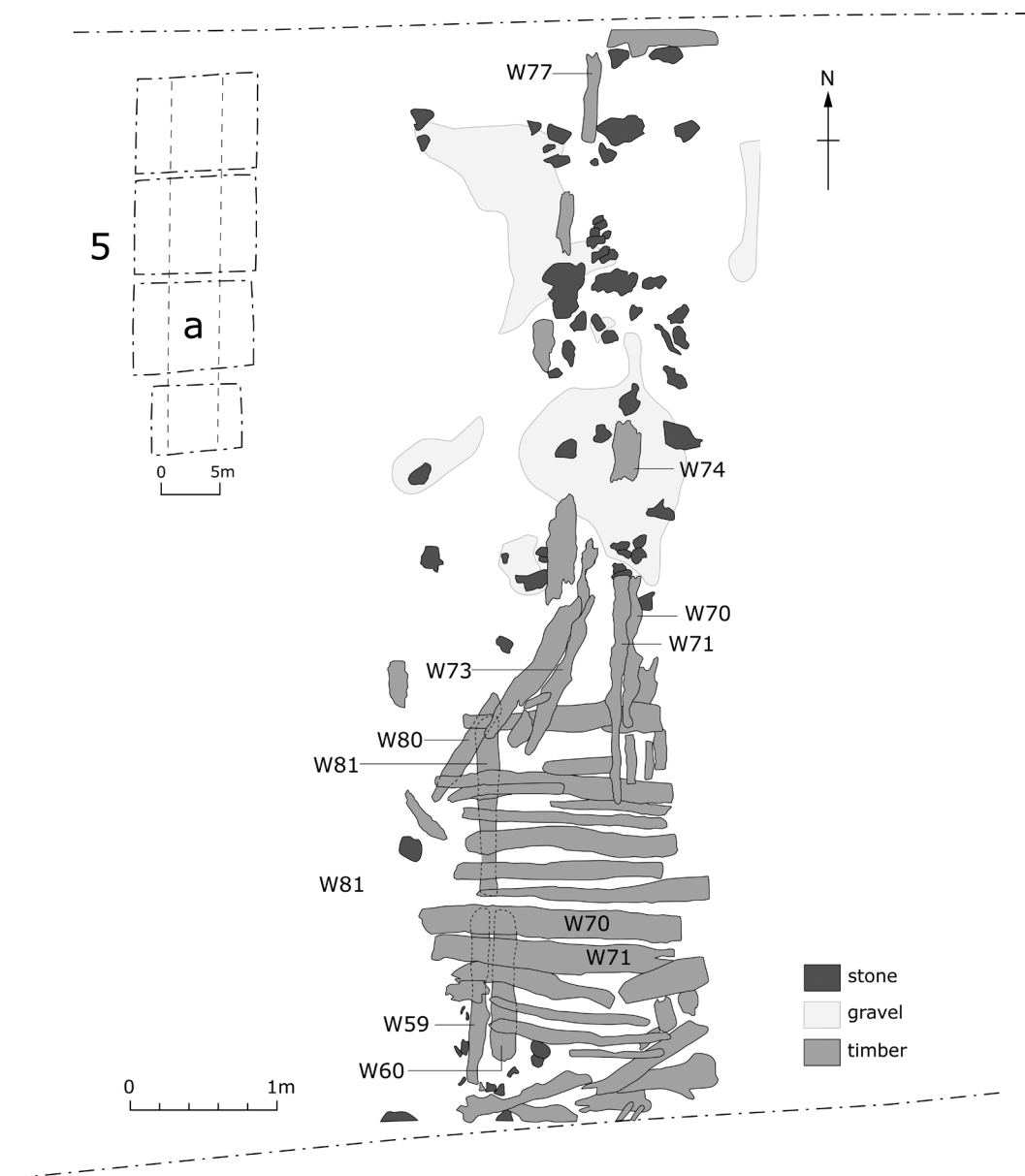


Fig. 13. Plan of surviving timbers in Trench 5a.

Only three of the timbers were dateable: the two side rails from the west side (W129 and W130) and one of the cross-timbers (W131). These were too degraded to produce an absolute felling date, but all were able to provide a felling date range; W129 was felled after AD 1026, W130 was felled after AD 1038 and W131 was felled after AD 1098.

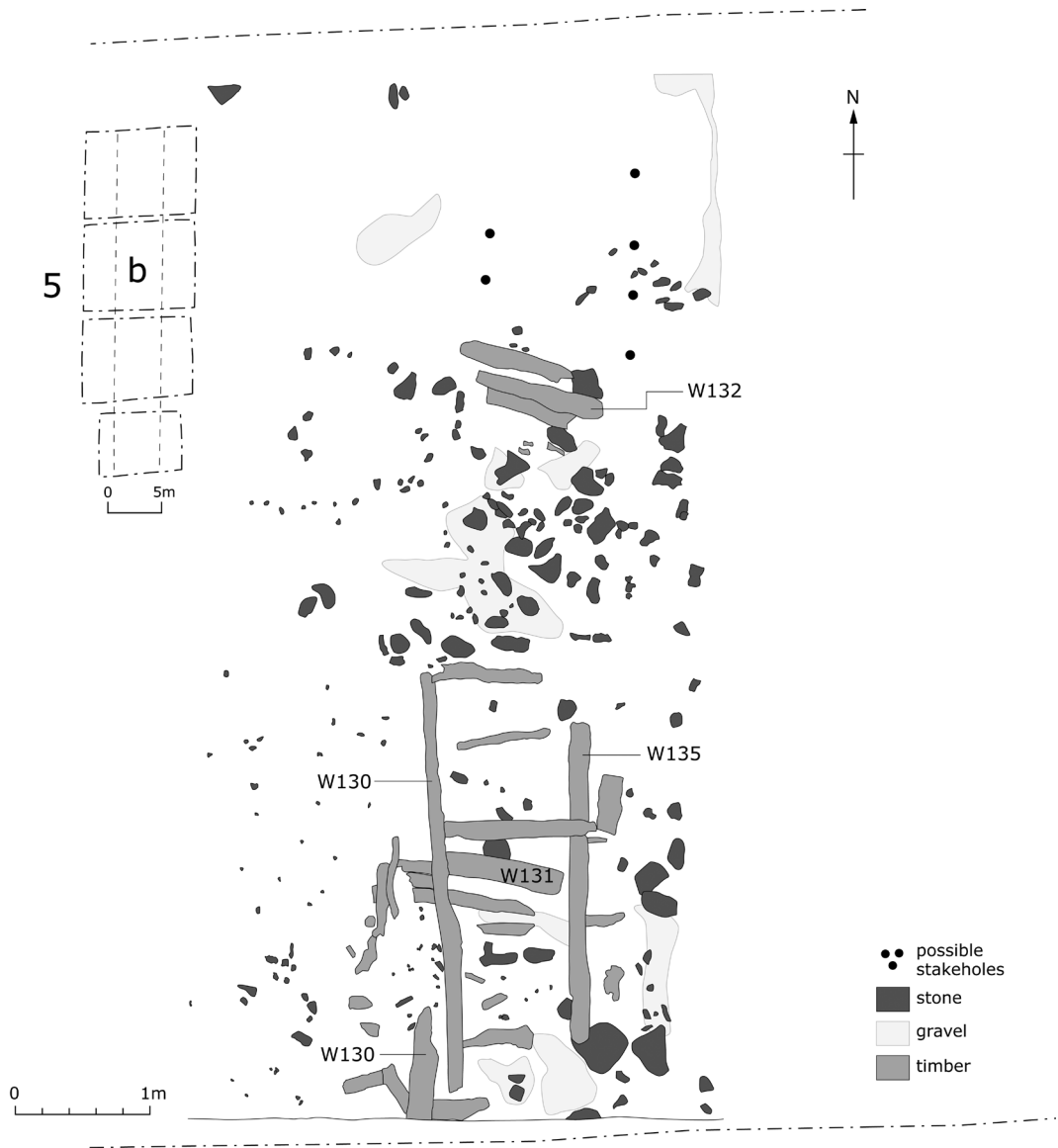


Fig. 14. Plan of surviving timbers in Trench 5b.

Dating the trackway

Dendrochronological analysis of the trackway timbers by Nigel Nayling (see below) suggests multiple phases of construction and/or repair for the timbers, with range of potential felling dates from after AD 1000 (W56) to soon after AD 1136 (W242).

Only the upper ranges of the two radiocarbon dates from the trackway of cal. AD 890–1020 (Beta-191064) and cal. AD 890–1030 (Beta-191065) overlap with the dendrochronological dates. As these dates were obtained from relatively slim roundwood stakes it cannot be argued that that these date ranges should

be adjusted beyond more than a decade or so to take account of heartwood being dated. If the radiocarbon dates are to be accepted, it suggests that the trackway was constructed in the early to mid eleventh century and that repairs to it were carried out over a century or so, as suggested by the dendrochronological sequence, with the last recognised repair dated to soon after AD 1136. It also means that the timbers were the only structural element of the trackway for a century or more, and that the layers of industrial waste and gravel forming a camber over the timbers were laid down after AD 1136. The precise date when the camber was constructed is unknown, but the apparent truncating of timbers at the south end of Trench 6 and their repair with gravel and industrial waste indicates a time span perhaps of decades between the laying down of timbers after AD 1136 and the construction of the first camber over them. Two phases of gravel/industrial waste camber were present, but there was no evidence to indicate the interval of time between them. It is also unknown when the trackway was abandoned, but it could have continued in use for several centuries after its construction.

Resources used for the construction of construction

Resources used for the construction of the trackway were all available from the bog margins and the dry ground on the surrounding slopes and so presented no particular problems of acquisition or transportation. Most of the timbers were alder, which the environmental analysis shows was growing on the wetland edge, with a high percentage of oak, available from nearby drier ground. Other species present were ash, willow, and hazel, also growing locally.

The timbers were, for the most part, in too poor a condition to reveal details of any woodworking technology, although it was possible to establish the method of conversion of some of the cross-timbers. The bottoms of the stakes survived in reasonably good condition, so it was possible to at least record the point type. They were a mix of pencil, wedge and chisel points, none of which required any specialist woodworking expertise, in fact there was no evidence to suggest that any great level of skill was required to construct the track.

One timber (W90) in T5d had a mortise at its eastern end and it may have been reused from an earlier structure. Unfortunately, its condition was too poor to allow survival of any evidence of woodworking technology of the mortise or the rest of the timber.

The stone used to fill the hollows in the surface of the peat was probably collected from close to site and may have been from the industrial deposits. The trackway camber was constructed from the smelting waste, which at the time may have still been visible as vegetation-free mounds along the southern edge of the bog.

Discussion of the trackway

Construction of timber trackways was a universal solution for crossing boggy ground, and examples, with varying degrees of sophistication, can be found in northern Europe from the Neolithic onwards (e.g. see Coles and Coles 1986; Coles and Orme 1986; and Godwin 1960). The Llangynfelyn trackway lies firmly within this tradition. Few examples are known from Wales, but the closest dated parallel to the Llangynfelyn trackway is at Llanaber, Gwynedd (Musson *et al.* 1989), which dates to late tenth to the late thirteenth century AD (cal. AD 990–1280). However, in character the Llanaber example is different, being little more than timbers thrown into a channel to form a rough bridge.

The Llangynfelyn trackway provides a route onto Llangynfelyn ‘island’ from the south of Cors Fochno, cutting 3 to 4 kilometres from a journey to get to the island from the east or north-east. The reason for construction is unclear, other than to avoid a longer journey, but it is likely to be the result of an increase in economic activity associated with expanding lead mining in the area as recorded in a peak in lead palaeo-pollution levels in the eleventh and twelfth centuries AD from samples taken from the centre of Cors

Fochno (Mighall *et al.* 2009). Once established the trackway was maintained and continued in existence for several centuries, but the reasons for its abandonment are not known.

RADIOCARBON DATES

Radiocarbon determinations are provided by Beta Analytic, Florida. Dates have been calibrated with the Radiocarbon Calibration Program CALIB rev 6.0.0 (Stuiver and Reimer 1993) using IntCal09 14c calibration data set and are quoted at 2 sigma.

TRENCH 1: TROUGH

Beta-189526, Radiometric
Material: oak timber
Radiocarbon age: 3210±60 BP
Calibrated range: 1630–1380 cal. BC

Beta-189527, Radiometric
Material: oak timber
Radiocarbon age: 3280±60 BP
Calibrated range: 1690–1430 cal. BC

TRENCH 2: TRACKWAY

Beta-191064, Radiometric
Material: roundwood timber stake
Radiocarbon age: 1070±30 BP
Calibrated range: cal. AD 890–1020

Beta-191065, Radiometric
Material: roundwood timber, c. 85mm diameter
Radiocarbon age: 1060±40 BP
Calibrated range: cal. AD 890–1030

TRENCH 4: LEAD SMELTING DEPOSITS

Beta-204040, AMS
Material: charcoal
Radiocarbon age: 1910±40 BP
Calibrated range: cal. AD 20–220

Beta-204041, AMS
Material: charcoal
Radiocarbon age: 1990±40 BP
Calibrated range: 90 cal. BC–cal. AD 90

TRENCH 5

Beta-235891, Radiometric
Material: peat, sample depth 17.5–18.5cm
Radiocarbon age: 1250±50 BP
Calibrated range: cal. AD 670–880

Beta-235892, Radiometric
Material: peat, sample depth 37.5–38.5cm
Radiocarbon age: 1390±70 BP
Calibrated range: cal. AD 530–780

Beta-222222, Radiometric
Material: peat, sample depth 53.5–54.5cm
Radiocarbon age: 1710±60 BP
Calibrated range: cal. AD 210–440

Beta-222223, Radiometric
Material: peat, sample depth 84.5–85.5cm
Radiocarbon age: 1960±60 BP
Calibrated range: 110 cal. BC–cal. AD 180

Beta-209007, Radiometric
Material: peat, sample depth 118.5–119.5cm
Radiocarbon age: 2200±50 BP
Calibrated range: 390–160 cal. BC

TRENCH 6

Beta-235893, AMS
Material: peat, sample depth 21.5–22.5cm
Radiocarbon age: 1120±40 BP
Calibrated range: cal. AD 860–1010

Beta-235894, AMS
Material: peat, sample depth 33.5–34.5cm

Radiocarbon age: 1230±40 BP
Calibrated range: cal. AD 680–890

Beta-235895, AMS

Material: peat, sample depth 46–46.5cm
Radiocarbon age: 1620±40 BP
Calibrated range: cal. AD 340–540

TRENCH 11

Beta-241084, AMS

Material: organic clay, sample depth 23.5–24.5cm

Radiocarbon age: 2260±40 BP
Calibrated range: 400–340 cal. BC and 320–200 cal. BC

TRENCH 15

Beta-241085, AMS

Material: peat, sample depth 5.5–6.5cm
Radiocarbon age: 310±40 BP
Calibrated range: cal. AD 1470–1650

DENDROCHRONOLOGICAL ANALYSIS

By Nigel Nayling

A full report on the dendrochronological analysis of the timbers of the trackway is lodged in the excavation archive (Nayling 2008). The following catalogue gives a summary of the results.

All samples were oak (*Quercus* spp.) with the exception of W132 which was ash (*Fraxinus excelsior*). Some timbers were from the same source: W47, W56, W57, W129, W202 being from one parent tree (tree 1), and W89, W90 being from another parent tree (tree 2).

If identifications of the heartwood/sapwood boundaries on timbers are correct (particularly with reference to W80, W89 from tree 2, and W59 and W243) then the implication is that the trackway has multiple phases of construction and/or repair. It should be stressed, however, that preservation of many of the timbers was far from perfect and sapwood was rarely observed in the field and present on only one of the 22 samples subjected to dendrochronological analysis. This makes identification of the boundary more difficult. It may be that degradation has led to loss of sapwood alone but loss of outer heartwood may also have occurred. Most of the samples where such a boundary was suspected in the field were radial splits. It is possible that sapwood was removed from these timbers (along with some outer heartwood rings) by secondary splitting by the builders during construction. Hence apparent heartwood/sapwood boundaries might be a reflection of woodworking practice and have no chronological implications. In this case, dating the trackway would necessarily focus on the sample from W242, which retained near complete sapwood. Again, preservation was not perfect but there is perhaps only the loss of a couple of outermost rings due to degradation and it would be reasonable to suggest that the parent tree had been felled soon after AD 1136.

The following catalogue contains only the timbers that have been dated absolutely by dendrochronology. Timbers from common parent trees are as follows: tree 1, W47, W56, W57, W129, W202; tree 2, W89, W90.

Sample W46

Context: Trench 4b, cross-timber

Cross-section: tangential

Dimensions (mm): 150 × 80

All measured rings: 123

Sapwood: –

Average ring width (mm/year): 0.95

Date of sequence: AD 953–1075

Felling date ranges: after AD 1085

Sample W47

Context: Trench 4b, cross-timber

Cross-section: tangential

Dimensions (mm): 115 × 85

All measured rings: 108

Sapwood: –

Average ring width (mm/year): 1.27

Date of sequence: AD 968–1075

Felling date ranges: after AD 1085

Sample W56

Context: Trench 5a, Cross-timber

Cross-section: tangential

Dimensions (mm): 145 × 36

All measured rings: 74

Sapwood: –

Average ring width (mm/year): 1.79

Date of sequence: AD 917–990

Felling date ranges: after AD 1000

Sample W57

Context: Trench 5a, cross-timber

Cross-section: radial

Dimensions (mm): 205 × 100

All measured rings: 132

Sapwood: –

Average ring width (mm/year): 1.57

Date of sequence: AD 10–1041

Felling date ranges: after AD 1051

Sample W59

Context: Trench 5a, side rail

Cross-section: radial

Dimensions (mm): 125 × 55

All measured rings: 126

Sapwood: + heartwood/sapwood boundary

Average ring width (mm/year): 0.98

Date of sequence: AD 950–1075

Felling date ranges: AD 1085–1121

Sample W80

Context: Trench 5a, side rail

Cross-section: radial

Dimensions (mm): 165 × 110

All measured rings: 88

Sapwood: + heartwood/sapwood boundary

Average ring width (mm/year): 1.82

Date of sequence: AD 923–1010

Felling date ranges: AD 1020–1056

Sample W87

Context: Trench 5d, displaced timber

Cross-section: radial

Dimensions (mm): 96 × 34

All measured rings: 89

Sapwood: –

Average ring width (mm/year): 1.04

Date of sequence: AD 967–1055

Felling date ranges: after AD 1065

Sample W89

Context: Trench 5d, cross-timber

Cross-section: radial

Dimensions (mm): 124 × 40

All measured rings: 122

Sapwood: + heartwood/sapwood boundary?

Average ring width (mm/year): 0.91

Date of sequence: AD 945–1066

Felling date ranges: AD 1076–1112?

Sample W90

Context: Trench 5d, cross-timber

Cross-section: radial

Dimensions (mm): 163 × 75

All measured rings: 156

Sapwood: –

Average ring width (mm/year): 1.14

Date of sequence: AD 902–1057

Felling date ranges: after AD 1067

Sample W129*Context:* Trench 5b, side rail*Cross-section:* radial*Dimensions (mm):* 175 × 80*All measured rings:* 110*Sapwood:* –*Average ring width (mm/year):* 1.50*Date of sequence:* AD 907–1016*Felling date ranges:* after AD 1026**Sample W130***Context:* Trench 5b, side rail*Cross-section:* radial*Dimensions (mm):* 90 × 70*All measured rings:* 100*Sapwood:* –*Average ring width (mm/year):* 0.79*Date of sequence:* AD 929–1028*Felling date ranges:* after AD 1038**Sample W131***Context:* Trench 5b, cross-timber*Cross-section:* radial*Dimensions (mm):* 195 × 57*All measured rings:* 110*Sapwood:* –*Average ring width (mm/year):* 1.70*Date of sequence:* AD 979–1088*Felling date ranges:* after AD 1098**Sample W202***Context:* Trench 6, cross-timber*Cross-section:* radial*Dimensions (mm):* 190 × 50*All measured rings:* 118*Sapwood:* –*Average ring width (mm/year):* 1.38*Date of sequence:* AD 942–1059*Felling date ranges:* after AD 1069**Sample W242***Context:* Trench 6, cross-timber*Cross-section:* radial*Dimensions (mm):* 254 × 54*All measured rings:* 194*Sapwood:* 24*Average ring width (mm/year):* 1.23*Date of sequence:* AD 943–1136*Felling date ranges:* AD 1136?**Sample W243***Context:* Trench 6, cross-timber*Cross-section:* tangential*Dimensions (mm):* 275 × 70*All measured rings:* 89*Sapwood:* + heartwood/sapwood boundary?*Average ring width (mm/year):* 0.74*Date of sequence:* AD 996–1084*Felling date ranges:* AD 1094–1130?

MINERALOGICAL AND TEXTURAL ANALYSIS OF THE SEDIMENTS ASSOCIATED
WITH LEAD SMELTING

By Simon Timberlake

Introduction

Seven samples were examined, representing a range of different types of potential processing or waste sediments across the site. These included four samples from Trench 21, where the only furnace was located, plus single samples from Trench 12, a short distance to the west, Trench 6, the largest excavated area where dumped industrial sediments and charcoal layers underlay the medieval track, and Trench 17, furthest away from the core area of the site, a location it was believed might provide information on the disposal of waste material. Sub-samples from these same contexts were taken for the purposes of carrying out metallographic work on the slag and furnace fragments (Anguilano 2007) with a view to interpreting the type of smelting process employed.

Trench 21, layer 1109

Out of all the samples looked at, this was the sediment richest in the evidence for nearby metallurgical activity. It appears that this context lay just to the side of the furnace. Proximity, however, was not suggested by the presence of any part-smelted ore (galena) or even droplets of lead metal, a factor which suggests a fairly efficient and thorough process (considering the primitiveness of the furnace). It was suggested instead by the profusion of slag, and slag fragmentation material, from coarser through to the finer sediment fractions, and by the overall freshness of the slag; all of these being good *in situ* indicators. Crushing of this slag is clearly indicated, perhaps on the spot or close by, much of it being crushed quite finely, perhaps by hand querns, but certainly not intentionally much finer than the 5–2mm. Whilst crushing may have been undertaken to release prills of metal, such an inefficient labour-consuming process does not seem likely, given that the slag itself seems to be lead-poor, something which also implies effective smelting conditions. The reasons for this are not entirely clear. However, fragmentation of the slag may have been achieved by dousing it in water, this might explain the presence of very fine glass shards from the slags, as well as greater amounts of burnt rock fragments, or dusts, within the smaller fractions. Some of the crushed/fragmented slag could have been reused as a grog in pottery, or else as a flux. These conglomeratic slags are very typical of this smelting site; they contained large inclusions of often un-reacted quartz and rock, suggesting perhaps that excess amounts of silica were intentionally being added as a flux in order to aid slag separation. The incidence of slag-coated fragmented rock surfaces amongst the coarser fractions (e.g. >10mm) provides the best evidence yet for the fragmentation or breaking up of a stone hearth surround nearby. In addition, the incorporation of some soil-derived shale clasts within the sediment suggests the scraping up of material from the underlying ground surface along with the slag, perhaps when incorporating this into a shallow waste mound.

Trench 21, layer 1091

A layer immediately overlying and either side of the hearth. Much of this consists of charcoal, at least within the fractions >1mm (70%), although the very largest fractions include a mixture of broken and mixed up waste material, including fewer pieces of heat-altered rock and mineral and the same crushed or pounded black glassy ‘conglomeratic slag’ as found in profusion within layer 1109 (although any indications of oxidised lead metal droplets or un-reacted ore within this are rare). The smaller proportion of broken (but heat unaffected) shale plus waterworn clasts present within this (alongside the slag) suggests re-deposition. This probably took the form of ‘raking out’ the unburnt wood and charcoal, and following that, the inadvertent mixing of this with the soil, before the dumping of the charcoal fines around the furnace site. The increased percentage of grains of what may be heat-decrepitated rock within the sub-2mm fractions is a good indication of the existence of a partly open hearth (or bole furnace).

Trench 21, layer 1085

There existed several different kinds of slag within this dry gravel layer of ‘crushings’, for instance the ‘drip slag’ coating the rock hearth surround, plus the ‘conglomeratic slag’, the latter once perhaps a molten layer which formed above the metal in the furnace, which was then tapped or ladled off. The presence of these gravel ‘crushings’ suggests a layer or lens formed from the mechanical reprocessing of this material, perhaps milling carried out to extract previously formed lead, or incompletely smelted ore. The much smaller percentage of burnt or fired country rock supports this, as does the suggested presence of powdered ‘slag dust’ (from crushing) within the finest fractions, along with the smaller amount of charcoal. The suggestion from the excavation notes that this had been lain down in order to create a level flat surface or base for something (perhaps another hearth), has at least some validity, given the thickness of poorly consolidated charcoal sediment.

Trench 21, layer 1093

This layer, evidently richer in charcoal, and also fresher-looking black glassy vesicular slag containing small traces of oxidised lead within it, might perhaps be part of a lobe of dumped furnace charcoal and the remnants of smelting waste. Such a sediment lens could be interpreted as 'spilling over' from a deposit up-slope of this site, perhaps one associated with another smelting hearth. This also makes sense with the higher incidence of burnt rock fragments and grains formed from the rapid weathering/ disintegration of these rocks.

Trench 12, layer 1119

A small fragment of slag-adhered stone (shale) hearth lining with traces of oxidised lead on it, alongside what are very clearly large (>10mm) crushed pieces of dull-black/red glassy slag, evidently slightly more weathered and devitrified, implies the presence of other, possibly earlier furnaces in this area. The changing ratios of charcoal, burnt rock fragments, mineral vein and slags, suggest that these furnaces are unlikely to be that close by.

Trench 6, layer 1129

The absence of crushed slag within the largest (>10 mm) fraction, and also its presence as sub-4mm size pieces of slightly devitrified, non-fresh looking material, implies an increasing distance from source. The very similar percentage equivalent amongst the larger size fractions between crushed slag, soil-derived rock clasts, and the angular shale rock (at 30% each), and the rising percentage of natural components amongst the smaller (sub-2mm) fractions, suggests that some of the redeposition processes involved at the bog margin may be partly natural.

Trench 17, layer 1115

This is distinctive and contrasting sediment, consisting largely of fresh lumps of oak charcoal, some up to 25mm in diameter, with no evidence for slag, and very little evidence for burnt rock. Some small fragments of completely unburnt wood chips survive, whilst the increasing amount of burnt shale flecks and sand, silt and clay, suggest the presence of at least one hearth (though not a mineral/smelting hearth) nearby. In the absence of any other sampling, this evidence might be taken to imply the existence of another related activity producing charcoal within this part of the site, perhaps even charcoal clamps to produce charcoal fuel for smelting. However, it remains uncertain as to how representative this sample is of the deposit.

Conclusions

Whilst a basic visual identification of sediment lithic/mineral/slag/organic components and size fraction analysis for each of the representative samples has been achieved, the interpretations of these deposits and the industrial processes which produced them are indicative, since comprehensive sediment sampling data has not been undertaken on what are very extensive industrial deposits.

Sediment analysis supports the following scenarios, although other interpretations may equally be valid:

- Lead ore (galena) was smelted at a number of different locations along the base, and possibly a little further up the slope above the bog margin.
- The ore was probably smelted in small, open-hearth, ephemeral bole furnaces. These may have been cut into the ground surface or into existing charcoal/slag deposits and were lined with stone (shale or sandstone) and possibly cemented in place using clay and gravel.

- The smelting process was efficient. Crushed quartz and rock may have been added as a flux, this formed a lead-poor slag of typical black glassy ‘conglomeratic’ appearance.
- The slag seems to have been broken up more or less *in situ*, then crushed or shattered to a minimum of <5mm >2mm, possibly to remove entrapped lead metal. This may have been undertaken by hand using querns, or possibly there was a mill on site.
- Layers of crushed slag may have been reused as level layers for the construction of new hearths. Large amounts of it were moved, along with the charcoal sediments, and dumped along the bog margin. However, a certain amount of re-deposition seems to be due to natural processes.
- Vast amounts of charcoal were raked out from the hearths. This became mixed with the slag, soil and sub-soil in varying proportions.
- Charcoal burning may have taken place on-site.

PALAEOENVIRONMENTAL INVESTIGATIONS

By Astrid E. Caseldine, Catherine J. Griffiths and John Crowther

There is a long history of palaeoenvironmental work in the area of Cors Fochno beginning in the late 1930s by Godwin (Godwin and Newton 1938; Godwin 1943; 1981) and others (Williams-Parry and Parker 1939; Slater 1972). Since then the raised bog, the submerged forests on the foreshore at Borth and Ynyslas, and the Dovey Estuary have been the subject of a number of palaeoenvironmental investigations (Moore 1963; 1966; 1968; Taylor 1973; Wilks 1979; Heyworth 1985; Shi and Lamb 1991; Hughes 1997; 2000; Hughes and Schulz 2001; Schulz 2002; Tetlow *et al.* 2007; Mighall *et al.* 2009).

Much of the work has been to do with the development of the bog itself, or to do with its relationship with the submerged forest, but Moore’s (1966; 1968) work was particularly concerned with the evidence for anthropogenic activity in the area. This current investigation again focuses on the palaeoenvironmental evidence for human activity, but specifically on the time period from the Iron Age, prior to the industrial activity at Llangynfelyn, through to the construction of the medieval track.

In recent years, it has been increasingly realized that peats provide an archive of palaeopollution as well as vegetation change in the past (Mighall *et al.* 2006). Chambers (2003) has described metal mining landscapes as a palimpsest of human activities in which there have been complex interactions between agriculture and industry. Hence one of the main aims of the palaeoenvironmental investigations at Llangynfelyn was to see if it was possible to identify the impact of industrial activity, especially that associated with the lead smelting site, on the surrounding environment as well as evidence for changes brought about by agriculture. A second aim was to determine the environmental conditions and impact of human activity around the time of trackway construction. With these aims in mind an extensive palaeoenvironmental sampling programme was undertaken which included sampling for pollen, plant macrofossils, insects, wood, charcoal and geochemical analyses. The geochemical analyses directly related to the pollen study are considered here, whilst the other analyses are considered separately.

POLLEN

Samples were taken using monolith tins from a number of locations from which samples were then selected for analysis. The samples examined include pollen columns (Trenches 11, 17, 20) at the dry-land/wetland interface, which included the record shortly before deposition of the industrial deposits and the industrial deposits themselves; a pollen column (Trench 6) through deposits between the industrial deposits and the

trackway terminal deposits; a pollen column (Trench 15) post-dating the industrial deposits and not sealed by the track; and a pollen column (Trench 5a) from beneath the track. The location of the pollen columns/excavation trenches is shown in Figure 4, and the results are presented in Tables 1–6 and Figs 15–20.

The pollen column stratigraphies are as follows:

Trench 5a

0–15cm Stony silty humified peat with less humified peat with monocotyledon remains *c.* 11–13cm Charred *Calluna* and *Erica* remains and uncharred *Erica* remains present. **15–24cm** Humified peat with monocotyledon remains. *Erica* seeds and leaf. **24–27cm** *Eriophorum* peat. **27–41cm** Less humified herbaceous peat with monocotyledon remains. *Carex* and *Juncus* seeds and occasional *Betula* and *Erica* seeds. *Calluna* stems present. **41–48cm** More humified herbaceous peat with monocotyledon remains and wood fragments including *Betula* bark. **48–50.5cm** Humified peat with wood fragments. *Betula* seeds. **50.5–100cm** Fibrous herbaceous peat with wood fragments. *Eriophorum*, *Calluna* remains and *Erica* remains present throughout. Occasional *Carex* seeds. *Myrica gale* present *c.* 65–68cm and 80cm. *Alnus* *c.* 100cm. **100–120cm** Herbaceous peat with monocotyledon remains and wood fragments. *Myrica gale* present *c.* 103cm and 112cm. *Calluna*, *Erica*, *Eriophorum* and *Sphagnum* remains present. Occasional *Betula*, *Carex* and Poaceae seeds.

Trench 6

0–3cm Gritty organic clay with sand, gravel and small stones. **3–9cm** Gritty humified silty peaty clay. *Juncus* seeds. Charred *Calluna* flower and leaf and moss stems. **9–18cm** Gritty humified silty peat clay with wood present *c.* 11–14cm. *Juncus* seeds. **18–21cm** Humified silty peat with some monocotyledon remains and minerogenic material visible. Charred *Erica* leaves. **21–27cm** Humified silty peat with some gritty minerogenic material visible. Charred *Erica* leaf. **27–30cm** Humified silty peat. **30–38cm** Less humified silty peat with monocotyledon remains. *Carex* seeds *c.* 32cm. **38–47cm** Silty peat with fresh, unhumified small monocotyledon stems and rhizomes. Poaceae seed, *Calluna* flower and stem fragment *c.* 40cm. **47–50cm** Grey gritty clay with sand and gravel.

Trench 11

0–2cm Silty clay with abundant charcoal. **2–25cm** Dark brown organic silty clay with gravel becoming stonier with depth. *Juncus* seeds present. **25–31cm**. Very stony silty clay with sand and gravel.

Trench 15

0–30cm Dark brown silty clay peat with fine monocotyledon rootlets. *Juncus* seeds present. **30–50cm** Dark brown silty clay peat with gritty material including gravel and charcoal. *Juncus* and Poaceae seeds and occasional wood fragment present.

Trench 17

0–3cm Topsoil. **3–6cm** Silty clay. **8–11cm** Organic silty clay. **11–14cm** Peaty silty clay. **14–16cm** Silty clay with charcoal. **16–20cm** Gritty clay with abundant charcoal. **29–37cm** Clay with charcoal interspersed through it. **37–39.5cm** Peat clay with wood fragments. **39.5–50cm** Silty wood peat with large fragment of *Salix*. *Juncus* seeds present.

Trench 20

0–3cm Silty clay. *Juncus* seeds. **3–6cm** Gritty silty clay with wood fragments including *Alnus*. *Rubus* and *Juncus* seeds. **6–21cm** Gritty silty clay with sand, gravel and charcoal. *Juncus* and *Carex* seeds.

21–24cm Silty clay with gritty material. **24–30cm** Monocotyledon remains interleaved with silty clay. Abundant monocotyledon remains at 28cm. *Juncus*, *Carex* and *Plantago major* seeds. **30–43cm** Organic clay becoming increasingly peaty with depth, particularly from 41cm. Wood fragments and monocotyledon remains. 30–32cm *Carex* and *Rubus* seeds and thorns. **43–50.5cm** Woody peat. *Alnus* and *Carex* seeds and *Calluna* flower. **50.5–86cm** Woody peat with large wood fragments. *Alnus*, *Betula*, *Carex* and *Callitriche* seeds present. **86–93cm** Woody peat with monocotyledon remains and minerogenic material. *Betula* seeds. **93–100cm** Woody peat. *Alnus*, *Betula*, Poaceae and *Ranunculus* seeds.

Methods

Sub-samples were taken from the pollen columns and prepared following standard procedures (Moore *et al.* 1991). These included acetolysis to remove cellulose as well as treatment with hydrofluoric acid and fine sieving to remove minerogenic material. *Lycopodium* spores were added to enable concentrations to be calculated. Pollen and spores were identified using the keys in Moore *et al.* (1991) and Andrew (1984) as well as a modern reference collection. A minimum sum of 300 land pollen grains was counted. Results are shown as percentage total land pollen (TLP) for land pollen types and aquatics and spores are shown as percentage TLP plus the respective group. In addition, selected fungal spores and testate amoebae were recorded and are expressed as percentage TLP. Charcoal was counted and is expressed as concentration data. In addition charcoal in the pollen sievings was counted and is included in the pollen diagrams. The pollen sievings were also examined for plant macrofossil remains and this information is included in the stratigraphic descriptions and text. Pollen nomenclature is modified from Moore *et al.* (1991) using Bennett (1994; Bennett *et al.* 1994). The diagrams were prepared using TILIA and TGVIEW.⁶ The results are given in Figs 15–20.

Loss-on-ignition (LOI)

The organic content of the samples was assessed using loss on ignition. Samples were dried at 40°C then ground up and oven-dried at 105°C for 12 hours. The samples were ignited at 550°C for 12 hours. The results are included in the pollen and sediment chemistry diagrams (Figs 15–21) and discussed in the main text.

Sediment chemistry

Atomic absorption spectrophotometry was used to determine metal concentrations from two sediment columns (Trench 5a and Trench 20). Sub-samples of 1cm thickness were taken from the columns and oven dried at 40°C. Analysis was undertaken on the fine earth fraction (i.e. < 2mm) of the samples. Extraction was by boiling with aqua regia (a 1:3 mixture of concentrated HNO₃ and HCl). Concentrations of lead, zinc, copper and silver were measured using a Philips PU9100X atomic absorption spectrophotometer. The results are presented in Fig 21.

Radiocarbon dating

Five conventional radiometric dates were obtained for peat samples from pollen columns Trench 5a, Trench 17 and Trench 20, whilst AMS dates were obtained for peat samples from pollen columns Trench 6, Trench 11, and Trench 15. Three charcoal samples from Trench 17 and Trench 20 were also dated using AMS. The results are summarised in a section above.

Results

The pollen zone characteristics are summarized in Tables 1–6. Where possible an estimated calibrated age for the zones is included in the tables. The ages should only be considered as an approximation

given possible variations in sedimentation and wiggles in the calibration curve (cf. Telford *et al.* 2004). The estimated age for pollen zones in Trench 5a and Trench 6 is based on the mid point of the 2 sigma age range of the calibrated dates and the dendrochronological date for the track. The age of zones in Trench 15 is based on one radiocarbon date and correlation of the zones with pollen zones in Trenches 5a and 6.

Sediment chemistry

The samples analysed from Trench 5a were from peat deposits whereas those from Trench 20 included both industrial minerogenic deposits, organic clays and peat deposits. The upper levels from Trench 5a were not analysed as the upper deposits included earlier industrial material which had been used to make the track.

As might be expected in view of the different nature of the deposits examined and the distance of Trench 5a from the industrial site, the metal concentrations are generally lower in Trench 5a than in Trench 20. Indeed, at Trench 5a there is no evidence of copper enrichment (maximum, $9 \mu\text{g g}^{-1}$) and Ag concentrations are below detection level ($< 2 \mu\text{g g}^{-1}$).

However, both the lead and zinc data do show clear signs of enrichment. The geometric mean for lead concentrations for soils in England and Wales is $30 \mu\text{g g}^{-1}$ (Reaves and Berrow 1984), whilst the concentration in soils in a nearby valley was found to be $42 \mu\text{g g}^{-1}$ (Alloway and Davies 1971). The average continental crust concentration for lead is $14.8 \mu\text{g g}^{-1}$ and for zinc is $65.5 \mu\text{g g}^{-1}$ (Wedepohl 1995). Clear peaks in lead occur at 64–74cm (maximum values 70–72cm), although a gradual increase begins earlier, and 48–52cm. Zinc peaks at a number of levels with major peaks at 74–78cm and 48–52cm.

Extremely high lead concentrations ($27,600\text{--}37,200 \mu\text{g g}^{-1}$) and relatively high concentrations of copper ($749\text{--}3,760 \mu\text{g g}^{-1}$) from the minerogenic deposits at Trench 20 confirm metal-processing activity. The average concentration in the earth's crust for copper is $25.9 \mu\text{g g}^{-1}$ (Wedepohl 1995). Silver is also present in appreciable concentrations ($49\text{--}168 \mu\text{g g}^{-1}$). The typical concentration of silver in the earth's crust is 70ng g^{-1} (Wedepohl 1995).

Very high concentrations of lead are also evident in the organic clays and upper peats, especially in the samples from 32–52cm (range $15,800\text{--}28,700 \mu\text{g g}^{-1}$), but extending down to 64cm. However, the difference in the nature of the deposits means that these values are exaggerated because of the much lower density of peat compared with the industrial deposits. Nevertheless, these values are high compared with those from Trench 5a. A small peak in lead values occurs at 80cm ($786 \mu\text{g g}^{-1}$). Some degree of copper enrichment is also evident in the upper peats, along with traces of silver in some samples. Extremely high zinc concentrations are recorded in the upper peat layers, with a maximum of $22,500 \mu\text{g g}^{-1}$ at 50cm. High zinc concentrations also persist through the lower peats.

Interpretation

Ombrotrophic peats have been widely used to reconstruct evidence of past metal mining (Mighall *et al.* 2006). Peat bogs are considered to provide an archive of atmospheric metal deposition (Shotyk 1996). It is argued that post-depositional migration of lead in peat bogs is not supported by recent studies, including the comparison of lead concentrations in bogs and lake sediments (Shotyk *et al.* 1997a; 1997b). However, the behaviour of zinc in peat is more problematical. The distribution can show great variability (Shotyk 1988) and most sub-surface peaks have not been adequately explained (Mighall *et al.* 2004). Zinc is considered to be mobile in peat and susceptible to leaching (Livett *et al.* 1979; Livett 1988) and hence peaks have been interpreted as the result of downward translocation of zinc (Mighall *et al.* 2004; 2008). It has been proposed that zinc may precipitate as a carbonate or sulphide in the water-table zone, be due to ash enrichment, or result from some unknown process (Shotyk 1988; Jones and Hao 1993).

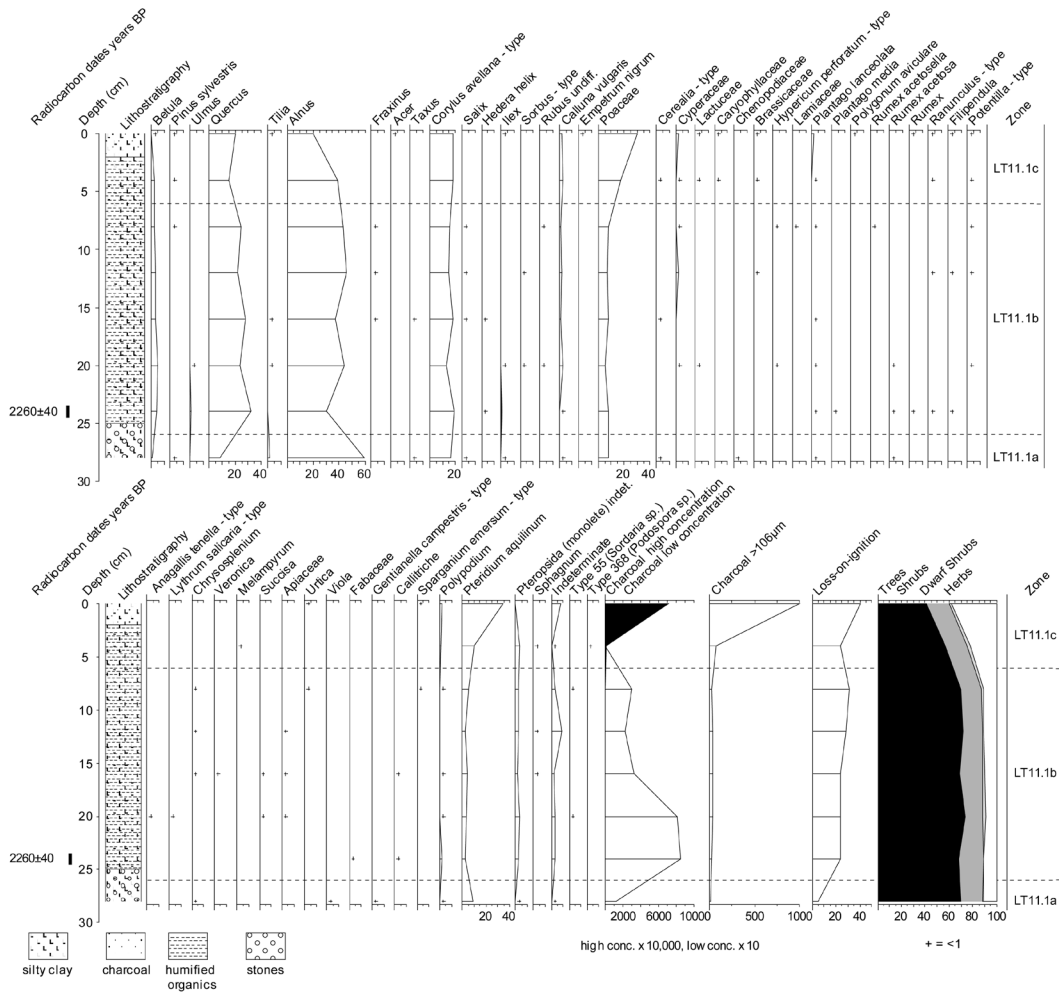


Fig. 17. Percentage pollen diagram for Trench 11.

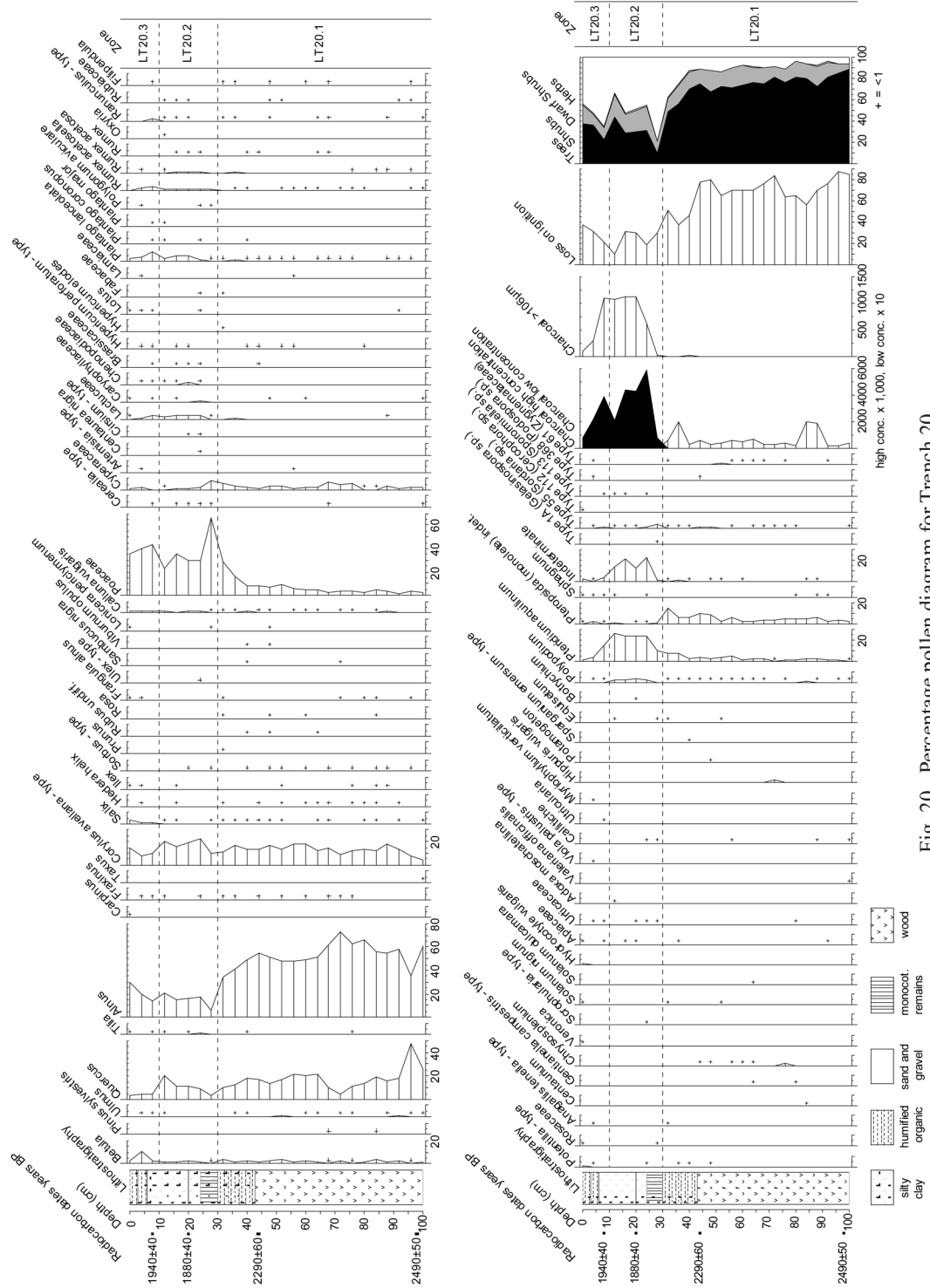


Fig. 20. Percentage pollen diagram for Trench 20.

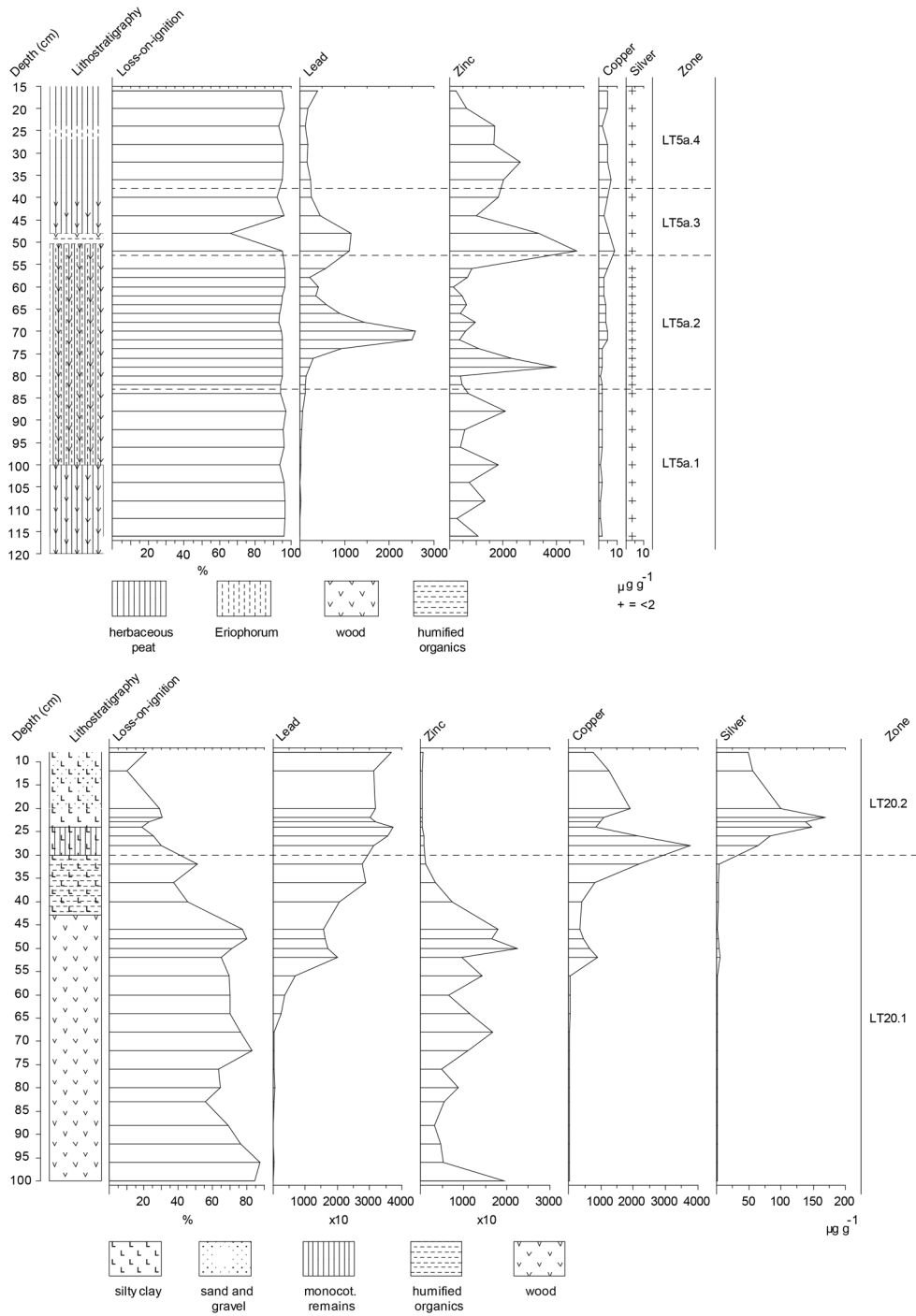


Fig. 21. Geochemical data for Trenches 5a (top) and Trench 20 (bottom).

Table 1: Zone characteristics for pollen column LT5A

Zone	Depth (cm)	Estimated Age c. cal. BC/AD	Characteristics
LT5a.1	120–83	c. 285 BC–AD 65	<i>Corylus avellana</i> type and other arboreal pollen types dominate. <i>Calluna</i> pollen is quite frequent. Poaceae and Cyperaceae occur in low amounts. <i>Plantago lanceolata</i> and other herbs occur throughout the zone. <i>Plantago</i> spp. peak mid-zone. <i>Sphagnum</i> spores are relatively frequent. Microscopic charcoal is scarce until the end of the zone.
LT5a.2	83–53	c. AD 65–365	Arboreal pollen values are lower but <i>Salix</i> increases slightly. Ericaceae and Poaceae values are higher. <i>Plantago lanceolata</i> is more abundant than previously and other herb taxa, notably <i>Rumex</i> spp. and Lactuceae, are more frequent. Cerealia type pollen is present in noticeable amounts. <i>Lotus</i> pollen peaks towards the end of the zone. <i>Pteridium</i> spores increase. Microscopic charcoal values rise with a marked increase mid-zone.
LT5a.3	53–38	c. AD 365–655	<i>Betula</i> and <i>Alnus</i> dominate. <i>Calluna</i> pollen is scarce. Poaceae values are low then increase. Herb pollen is rare. Pteropsida monolet spores are relatively frequent. Microscopic charcoal is present.
LT5a.4a	38–14	c. AD 655–860	<i>Betula</i> values fall. <i>Corylus avellana</i> type pollen increase. <i>Quercus</i> and <i>Alnus</i> increase then decline. Ericaceae pollen gradually increases. Poaceae values decrease. Cyperaceae pollen increases. <i>Plantago lanceolata</i> pollen is consistently present. Herb pollen is more plentiful. <i>Sphagnum</i> spores are abundant.
LT5a.4b	14–0	c. AD 860–?1136	<i>Quercus</i> , <i>Alnus</i> and <i>Corylus avellana</i> type values are lower than previously. <i>Calluna</i> and Cyperaceae values are consistently higher. Poaceae values remain constant. <i>Plantago lanceolata</i> representation is similar to previously. Herb pollen is relatively frequent. Cerealia type pollen is present. Microscopic charcoal increases.

Table 2: Zone characteristics for pollen column LT6.

Zone	Depth (cm)	Estimated Age c. cal. BC/AD	Characteristics
LT6.1	50–42	c. AD 325–555	Poaceae pollen dominates. Herb taxa decrease, notably <i>Plantago lanceolata</i> , <i>Rumex</i> spp. and Lactuceae values. Arboreal values are low. Microscopic charcoal declines from high values.
LT6.2	42–34	c. AD 555–785	Arboreal values increase, particularly <i>Betula</i> and <i>Alnus</i> . Poaceae pollen declines but remains frequent. Herb pollen is rare. <i>Calluna</i> pollen increases. Microscopic charcoal is scarce.
LT6.3	34–22	c. AD 785–935	<i>Betula</i> decreases whilst <i>Corylus avellana</i> type and <i>Quercus</i> increase. Poaceae pollen is relatively frequent but fluctuates and Cyperaceae pollen increases. <i>Calluna</i> pollen is scarce. Herb taxa increase, especially <i>Plantago lanceolata</i> and <i>Potentilla</i> type pollen. <i>Pteridium</i> spores increase.
LT6.4a	22–6	c. AD 935–?1136	<i>Quercus</i> and <i>Corylus avellana</i> type, followed by <i>Betula</i> , decline and Poaceae increases. Herb pollen continues to be frequent. Microscopic charcoal increases.
LT6.4b	6–0	c. AD 1136–?	<i>Quercus</i> , <i>Betula</i> and <i>Corylus avellana</i> type increase very slightly, whilst Poaceae and herb taxa decrease. Microscopic charcoal is frequent.

Table 3: Zone characteristics for pollen column LT11

Zone	Depth (cm)	Estimated Age c. cal. BC/AD	Characteristics
LT11.1a	30–26	<(?)370 BC)* or ?260 BC	The assemblage is dominated by arboreal pollen, principally <i>Alnus</i> . <i>Corylus avellana</i> type pollen values are around 15% TLP. Poaceae values are low. Herb taxa are scarce but include <i>Plantago lanceolata</i> and Chenopodiaceae. Microscopic charcoal is present.
LT11.1b	26–6	(c. 370 BC)* or c. 265 BC– <c. AD 35–140	<i>Alnus</i> declines and <i>Quercus</i> increases. <i>Corylus avellana</i> type values remain fairly constant. Herb taxa include <i>Plantago</i> spp, <i>Rumex</i> spp. and <i>Succisa</i> . Microscopic charcoal peaks initially.
LT11.1b	6–0	<c. AD 35–140– c. AD 35–140	Poaceae pollen increases from around 10% TLP to around 30% TLP. Herb taxa increase in frequency. <i>Quercus</i> declines followed by <i>Alnus</i> . <i>Pteridium</i> spores are more abundant. Microscopic charcoal shows a sharp increase.

*(lower probability)

Table 4: Zone characteristics for pollen column LT15

Zone	Depth (cm)	Estimated Age c. cal. BC/AD	Characteristics
LT15.1	50–30	c. AD 600–?900	<i>Alnus</i> and <i>Betula</i> dominate the arboreal assemblage. <i>Quercus</i> and <i>Corylus avellana</i> type occur in relatively low amounts. <i>Salix</i> is present at more than 1% TLP. Poaceae pollen values are relatively high and herb pollen is plentiful. Microscopic charcoal is abundant.
LT15.2a	30–18	c. AD 900–1100	Poaceae pollen dominates. <i>Betula</i> pollen shows a noticeable decrease whilst <i>Quercus</i> , <i>Alnus</i> and <i>Corylus avellana</i> type values also fall slightly. Herb pollen continues to be quite well represented. Microscopic charcoal values decline.
LT15.2b	18–6	c. AD 1100–1560	Poaceae values are marginally lower. Herb taxa remain relatively frequent. <i>Betula</i> and <i>Quercus</i> show a minor recovery.
LT15.2c	6–0	c. AD 1560–?	Poaceae pollen declines slightly and herb taxa are scarcer. <i>Corylus avellana</i> type and <i>Alnus</i> increase. Microscopic charcoal increases.

Table 5: Zone characteristics for pollen column LT17

Zone	Depth (cm)	Estimated Age c. cal. BC/AD	Characteristics
LT17.1	50–38	<c. AD 10– >c. AD 20 or (AD 110)*	Arboreal pollen values are high, notably <i>Alnus</i> and <i>Quercus</i> , but decline. <i>Salix</i> is well represented. Poaceae, Cyperaceae and herb taxa such as <i>Rumex acetosa</i> , <i>R. acetosella</i> and <i>Potentilla</i> type increase towards the end of the zone. <i>Potamogeton</i> peaks at the end of the zone. Microscopic charcoal values rise towards the end of the zone.
LT17.2	38–14	>c. AD 20 or (AD 110)*– >c. AD 45–145	After an initial decline, arboreal pollen increases. Poaceae pollen is frequent and herb taxa are relatively well represented, especially <i>Plantago lanceolata</i> , Lactuceae and <i>Rumex</i> spp. <i>Pteridium</i> spores are abundant. Indeterminate pollen is frequent. Microscopic charcoal values are high.
LT17.3	14–10	>c. AD 45–145–?	Poaceae pollen increases further. <i>Quercus</i> and <i>Corylus avellana</i> type decline but <i>Alnus</i> values remain high. Herb pollen continues to be quite frequent. <i>Pteridium</i> spores decrease. Microscopic charcoal values fall.

*(lower probability)

Table 6: Zone characteristics for pollen column LT20

Zone	Depth (cm)	Estimated Age cal. BC/AD	Characteristics
LT20.1	100–30	c. 630 BC or (440 BC)*–>c. 355 BC	Arboreal pollen values are high, with <i>Alnus</i> dominating, before a decline at the end. <i>Quercus</i> values fluctuate. <i>Corylus avellana</i> type values are relatively constant and <i>Betula</i> values are low. A wide range of shrub taxa is present. <i>Calluna</i> pollen is scarce. Herb pollen is consistently present in low quantities. Pteropsida monoletes and <i>Pteridium</i> spores occur in noticeable amounts as does microscopic charcoal.
LT20.2	30–10	>c. 355 BC–c. AD 45–145	Poaceae values increase markedly to c. 60% TLP before falling back to c. 25–35% TLP. <i>Alnus</i> and <i>Quercus</i> increase from minima at the opening of the zone. <i>Corylus avellana</i> type also increases. Representation of herb pollen is stronger, especially <i>Plantago lanceolata</i> , <i>Rumex acetosella</i> , <i>R. acetosa</i> , Lactuceae and Chenopodiaceae. <i>Pteridium</i> spores increase in abundance, as do <i>Polypodium</i> spores. Indeterminate pollen values are high. Microscopic charcoal values are high.
LT20.3	10–0	c. AD 45–145–?	Arboreal pollen values fall before an increase in <i>Betula</i> , <i>Alnus</i> , <i>Salix</i> and then <i>Corylus avellana</i> type. Poaceae pollen is more frequent and herb taxa continue to be well represented. <i>Pteridium</i> and <i>Polypodium</i> spores decline. Microscopic charcoal, although still frequent, decreases.

*(lower probability)

At Llangynfelyn analyses included investigation of a range of deposits, including different peat types and industrial deposits, and therefore some of the results must be treated with caution. However, the mining and smelting of lead is likely to have resulted in the release of large amounts of lead into the surrounding environment and probably accounts for peaks in lead in the peat deposits at Trench 5a. A distinct peak in lead with maximum values at 70–72cm clearly reflects contemporary mining/smelting activity. This coincides with an expansion in raised bog vegetation, notably heather, locally. The maximum occurs approximately midway between dates of 110 cal. BC–cal. AD 180 (Beta-222223) and cal. AD 210–440 (Beta-22222) although there is slight enhancement from shortly after 110 cal. BC–cal. AD 180 (Beta-222223). This enhancement could, however, simply reflect some movement down the profile. A second distinct lead peak, c. 48–52cm, may indicate a further period of activity, although not as intensive, shortly after cal. AD 210–440 (Beta-222222). The occurrence of minerogenic input at 48cm, reflected in the LOI values, may indicate an inwash of eroded material from the industrial site or other mining/smelting sites in the area. This also coincides with an expansion in fen woodland locally and change in peat deposits.

The interpretation of zinc values in peat deposits, as already mentioned, is difficult and zinc shows peaks at several levels in Trench 5a. Comparatively low zinc values coincide with the earlier peak in lead values but peak just below, while high zinc values coincide with the later peak in lead. Although zinc was not deliberately exploited at this time large amounts of it may have been released into the environment when galena was crushed (Mighall *et al.* 2008). This would then have been leached out or blown in the atmosphere from exposed spoil tips. It has also been suggested that smelting may preferentially concentrate the more volatile metals, including zinc, compared with lead and copper within the atmospheric fallout (Jenkins and Timberlake 1997; Mighall *et al.* 2009). Hence, although some downward translocation of zinc might have occurred, it is possible that the peaks in zinc closely related to the lead peaks might reflect smelting/mining activity in the area.

Very high concentrations of lead occur in the industrial deposits at Trench 20, confirming lead smelting activity at the site. Enhanced copper and silver values also occur in the industrial deposits. However, concentrations of lead and copper are also high in the underlying minerogenic and upper woody peat deposits (LOI results indicate the peats also contain inwashed minerogenic material). Although these high values could be interpreted as earlier activity at the site, this column was from the wetland/dry-land edge and the deposits are likely to have been subject to a fluctuating water-table. It therefore seems likely that the high concentrations of metals in the organic clays and upper peats at Trench 20 may reflect downward movement of metal pollution from the overlying deposits, rather than earlier activity. The occurrence of higher zinc values in the deposits beneath the industrial deposits rather than in the industrial deposits themselves is also consistent with the leaching of zinc downwards, although other processes may have been operating as well.

While the results from Trench 20 are certainly indicative of lead-related activity at the site, the concentrations of copper and silver and zinc in the minerogenic sediments could simply reflect the presence of these metals in the lead-rich ores and rocks that were being used. This is also suggested by the analysis of slag samples by Anguilano (2007) who concluded that the main ore used at the site was galena (lead sulphide) and that this was associated with other minor sulphides and the arsenides of antimony, copper, iron, nickel and zinc. Equally, the silver concentrations at Trench 20 are consistent with the silver-rich phase found in one of the slag samples which suggests that possibly some of the veins exploited were argentiferous.

The environmental impact of human activity at Llangynfelyn

The main focus of the pollen sites investigated in this study is the effect of human activity on the environment from the Iron Age through to the medieval period, and especially that associated with late Iron Age/Roman industrial activity. However, the recovery of a wooden trough dating to the Middle Bronze Age demonstrates earlier activity in the area of the site. This is consistent with the pollen evidence from other sites on Cors Fochno (Moore 1968; Mighall *et al.* 2010), which indicate the impact of human activity on the surrounding vegetation during the Bronze Age. There is also geochemical evidence which suggests mining activity during the Bronze Age, pre-dating that at Llangynfelyn (Mighall *et al.* 2009.).

Iron Age and Roman activity

The earliest evidence from this investigation commences during the early Iron Age, between 780–480 cal. BC and 470–410 cal. BC (Beta-222224) at Trench 20, and demonstrates the presence of alder carr growing along the wetland margin with oak woodland towards the dry land. Ribwort plantain and other herbs, as well as fungal spores indicative of dung (van Geel 1978; van Geel *et al.* 1981; 2003, Buurman *et al.* 1995), indicate a low level of agricultural activity, largely pastoral, although this might be underrepresented because of the abundance of alder. Microscopic charcoal suggests fire events that might relate to domestic fires at settlement sites or fires associated with clearance and agriculture or, possibly, industrial activity in the wider region, albeit the possibility of natural fires cannot be totally ruled out. From around 510–200 cal. BC (Beta-211077) alder declines, accompanied slightly later by a decline in oak, and an increasingly open environment is evident at Trench 20. There is also some limited pollen evidence for increased agricultural activity as well as evidence for increased soil erosion, probably related to this activity.

The pollen records from two other sites, Trench 11 and Trench 17, at the dry land/wetland interface, provide further evidence for the composition of woodland around this time and possible clearance activity. At Trench 11, a site nearer to the dry land edge than Trench 20, a decline in alder between 400–340 cal. BC and 320–200 cal. BC (Beta-241084) is accompanied by an increase in oak, suggesting an expansion in oak woodland or increased representation. High microscopic charcoal values coincide with the decline

in alder and, slightly later, minor falls in hazel and oak. Charred alder and hazel wood were found at this level at the site and suggest Iron Age activity at the wetland edge. Further to the north-east along the wetland edge, at Trench 17, there is evidence that willow, as well as alder, was a significant component of the carr woodland.

By 110 cal. BC–cal. AD 130 (Beta-211076) there is evidence for a marked impact on oak and alder woodland at all three sites (Trenches 11, 17, 20). This clearance activity immediately precedes and is contemporary with the beginning of industrial activity at the site. Small peaks in microscopic charcoal and an increase in agricultural indicators, most noticeably at Trench 17, immediately prior to the industrial phase suggest Late Iron Age activity in the local area. Cereal type pollen and weed taxa suggest mixed farming, although with pastoralism predominating.

A slightly more detailed and regional picture of the vegetation changes taking place from 390–160 cal. BC (Beta-209007) is evident at Trench 5a, about 100 metres from dry land, where the pollen record is less influenced by local alder carr than at the wetland fringe. Alder carr dominated at Trench 2, approximately midway between Trench 5a and dry land. Initially evidence for agricultural activity in the area is also comparatively limited. There appears to be a period of oak regeneration, probably the same event as recorded at Trench 11, before a decline in oak woodland, after which there is a more consistent record for agricultural activity, mainly livestock farming. Towards the end of this phase the charcoal record indicates fires in the area and by 110 cal. BC–cal. AD 180 (Beta-222223) oak woodland appears to have been significantly reduced. There follows a brief period of oak regeneration but whether this represents recolonisation following total clearance or whether the regeneration represents oak that had regrown from oak that had been deliberately coppiced or had coppiced naturally is unclear. There is, however, no evidence of a coppice cycle. An increase in bracken accompanies the regeneration. Microscopic charcoal is largely absent which suggests a period of reduced fire activity but the presence of cereal type pollen and an increase in weed taxa suggests an expansion in agricultural activity. From the radiocarbon evidence, this activity occurred during the Late Iron Age or Roman period. Although the decline in woodland may be a result of clearance for agriculture, it is also possible that it could relate to clearance associated with Roman military activity in the area.

A slight increase in lead values occurs during this period and might indicate a very low level of mining or smelting activity at this time, although some movement of lead down the profile may be more likely. Zinc levels are high and probably represents leaching of zinc down the profile rather than contemporary activity.

Following the minor regeneration episode there is clear evidence for renewed human impact on oak woodland in the area with a fall in oak values to a minimum. This coincides with maximum lead values and suggests that the decline in oak is directly related to activity at the industrial site, although the high lead values and decline in oak could also reflect activity associated with mining in the wider area. However, the former seems probable given the close proximity of the pollen site to the smelting site. During this period charcoal values also increase and decreasing alder and birch values indicate the exploitation of local carr woodland as well as oak woodland. This is borne out by charcoal identifications from the smelting site (see Caseldine and Griffiths below). Although there is then a slight recovery in oak and birch woodland, maximum lead values are maintained. After this lead values fall and small declines in oak and birch and fluctuations in alder suggest impact on the local woodland was at a reduced level as industrial activity declined. Although the main phase of industrial activity could have lasted as short a period as 20 years, it is possible that industrial activity continued until the end of the second century AD, or later. Throughout this phase there is evidence for continued agricultural activity, including cereal cultivation as well as pastoral farming. This is especially noticeable immediately prior to and during the industrial period. The industrial activity may

have stimulated the agricultural economy. A small peak in cereal cultivation is recorded initially and weed taxa are well represented, suggesting an intensification of farming. Albeit some of the weed pollen could derive from disturbed ground habitats associated with the lead smelting site or similar sites in the area, as could frequent bracken spores. Vegetation would have been sparse on the most toxic areas of the site but common sorrel and certain grasses have strains that are tolerant of heavy metals (Rodwell 2000). On less contaminated ground species such as ribwort plantain and bird's-foot-trefoil would have occurred and were probably more influenced by grazing.

It is possible that some grazing was also taking place on the wetland at this time. Whilst alder carr fringed the dry land, further out into the wetland the woodland gave way to more open bog conditions with less alder and birch. As well as bog myrtle, the vegetation would have included grasses, sedges, heather, cross-leaved heath and cotton grass. The presence of charred heather remains, coinciding with high charcoal values, suggests that some of the charcoal was from local burning of the bog. This could have occurred accidentally, perhaps because of the nearby industrial activity, or could reflect a deliberate attempt to increase browse. There is some insect evidence (see Smith *et al.* below) that could indicate grazing animals, as well as fungal spores frequently associated with dung. Burning and grazing would have helped prevent or limited woodland regeneration.

The palaeoenvironmental record from the industrial site itself complements the evidence from Trench 5a. The pollen records (Trenches 17, 20) from the wetland edge also indicate the exploitation of oak, alder, birch and hazel for use at the lead smelting site. This is confirmed by charcoal identifications from the industrial deposits (see Caseldine and Griffiths below) which indicate that these were the main species, especially oak, used as fuel at the site. Charcoal production may have taken place at Trench 17 (see Timberlake above) and the environmental evidence suggests this area of the site was possibly chosen for this purpose because of the close proximity of standing water, a necessary requirement in case the charcoal accidentally caught fire.

Following a decline in woodland, dated to 80 cal. BC–cal. AD 120 (Beta-211076) at Trench 17, arboreal pollen increases at both Trench 17 and 20. This is similar to the record from T5a and suggests that, following an initial decline, there was some woodland regeneration in the area. It is possible that there was some attempt at woodland management in the area to ensure there was a supply of wood at the smelting site but neither the pollen nor the charcoal records confirm this. Also, the increased arboreal pollen values at the industrial site might be at least partly attributable to the presence of older, redeposited pollen from woodland soils in the minerogenic sediments. High levels of indeterminate pollen and a poorer state of preservation tend to support this. Another possibility is that some of the pollen incorporated within the deposits was brought onto the site along with wood used for fuel. The date of cal. AD 50–240 (Beta-238739) from industrial deposits in Trench 20 agrees well with the evidence for maximum industrial activity represented at Trench 5a which occurred midway between dates of 110 cal. BC–cal. AD 180 (Beta-222223) and cal. AD 210–440 (Beta-222222), although an earlier date of 40 cal. BC–cal. AD 130 (Beta-238738) was also recovered from industrial deposits at Trench 20. The two dates from Trench 20 are inverted, possibly providing further evidence for reworking and redeposition of pollen and sediments at the site. Inverted dates were also recovered from deposits in Trench 4.

The range of radiocarbon dates from the industrial site suggests that industrial activity was taking place at the same time as either the clearance episode dated to 110 cal. BC–cal. AD 180 (Beta-222223) or the later clearance episode estimated lying midway between this date and cal. AD 210–440 (Beta-222222) at Trench 5a, or both. However, the geochemical evidence associated with the earlier clearance is slight, suggesting either that the industrial pollution was at too low a level to register significantly or that this episode pre dates the industrial activity. The geochemical evidence associated with the second clearance episode suggests that this episode relates to the industrial activity. Given the range of dates

from the industrial site and the limitations of radiocarbon dating, it is possible that the minor intervening regeneration episode at Trench 5a was short lived and is possibly represented in the reworked industrial deposits. As discussed above, the first clearance episode could represent clearance associated with late Iron Age activity and/or the arrival of a Roman military presence in the area and the construction of the Roman road and the fort at Erglodd. The second clearance episode could represent either Roman military activity and/or industrial activity.

The very high lead values from industrial deposits at Trench 20 are consistent with the other evidence from the site for lead smelting and the presence of silver in the deposits indicates the presence of silver within the ore. An expansion in the agricultural economy, along with the industrial activity, is borne out by frequent weed taxa and the presence of cereal type pollen, indicating mixed farming, in the records (Trenches 17, 20) from the wetland edge as well as Trench 5a. Fungal spores indicative of dung support the pollen evidence for livestock grazing in the area, as does the beetle evidence at Trench 5a (see Smith *et al.* below). Plant macrofossils from the industrial deposits, including glume bases of spelt wheat as well as seeds such as fat hen, oraches, sheep's sorrel, docks, common nettle, buttercup and grasses and bracken and bramble remains, confirm cereal cultivation in the vicinity of the site as well as grassland and waste and disturbed ground habitats (see Caseldine and Griffiths below).

The lead pollution evidence from Trench 5a suggests that at least the main period of industrial activity occurred over a relatively short period. The lack of evidence for woodland management from the charcoal record (see Caseldine and Griffiths below) might also support this. As industrial activity declined, cereal production also appears to have declined and pastoral activity, especially on the wetland, may have reduced.

Post-Roman activity

A date of cal. AD 340–540 (Beta-235895) from immediately above industrial deposits at Trench 6 at the smelting site suggests that activity had ceased by that date, if not earlier. Oak woodland was scarce in the area but there is some evidence for an increase in alder carr. A reduction in weed taxa at Trench 6 at this time could reflect a decrease in disturbed ground with abandonment of the site, a reduction in agriculture or simply the effect of local grass communities masking weed pollen representation. The latter is most likely given that weed taxa remain frequent at Trench 20. Shortly after this, both at wetland edge sites (Trenches 6, 15, 20) and at Trench 5a, there is, however, some evidence for an increase in birch woodland in the area. Although this could indicate regeneration of birch on the dry land, it is most strongly represented at Trench 5a where a phase of local birch and alder woodland occurred between cal. AD 210–440 (Beta-222222) and cal. AD 340–540 (Beta-235892). The expansion in woodland might be at least partly due to a reduction in grazing on the wetland, allowing trees to regenerate, as well as hydrological changes. Weed taxa are largely absent, which again suggests a reduction in agriculture in the area, but their absence could at least be partly due to the filtering effects of local woodland. The stronger representation of weed taxa at the wetland edge sites compared with at Trench 5a may signify the closer proximity of these sites to more localised farming activity.

A peak in lead values occurs soon after cal. AD 210–440 (Beta-222222) at Trench 5a which may represent a further episode of mining or smelting activity in the area, although an increase in minerogenic sediment during this period could indicate eroded, older material from the smelting site or elsewhere. The date of cal. AD 340–540 (Beta-235895) from peat deposits overlying industrial deposits at Trench 6 at the smelting site suggests that activity had ceased and there are no other dates that indicate a continuation or renewal of activity. Hence, if the activity is contemporary, it was taking place elsewhere in the area.

Although the timing varies, cal. AD 530–780 (Beta-235892) at Trench 5a and slightly later, cal. AD 680–890 (Beta-235894), at Trench 6, perhaps because of the persistence of local birch near the industrial

site influencing pollen representation, there appears to be an increase in oak woodland in the area. This again suggests some land may have gone out of agricultural production, although agricultural indicators demonstrate mixed farming continued in the area. A date of cal. AD 670–880 (Beta-235891) at Trench 5a suggests a renewed impact on the oak woodland in the wider area, whilst it remained in the area of the industrial site (Trenches 6, 15). However, even here by cal. AD 860–1010 (Beta-235893) clearance of oak and possibly birch was taking place, but alder woodland seems little affected throughout this period. The reduction in woodland was possibly the result of deliberate clearance, or sustained grazing activity in the area might have prevented regeneration.

The trackway period

Following the reduction in woodland, especially of oak, a largely open agricultural landscape prevailed in the local area. Pastoral farming dominated but there was some cereal cultivation. During this phase, the trackway was constructed. Radiocarbon dates and dendrochronological analysis (seen main report above) suggest that timber trackway was built in the early to mid eleventh century and that repairs to it were carried out over a century or so. Later the timber trackway was covered by a stone trackway made from mainly smelting waste. The impact of trackway construction on the woodland communities is, however, difficult to detect clearly.

Oak was one of the principal species used, although not to the same extent as alder, which was the main wood employed (see Caseldine and Griffiths below). Hazel was more widely used for stakes and posts nearer the dry land, where it was more likely to be growing. Other species such as ash, holly, willow/poplar, cherry and hawthorn type were present in low amounts and also largely occurred towards the dry land. All these taxa occur in the pollen records around the time of trackway construction and initial use, demonstrating their presence in the surrounding woodland communities.

It is possible that a decline in alder towards the end of zone LT6.4a could relate to felling of alder to make the track. Otherwise, there is little evidence to indicate impact on the surrounding woodland. Indeed there appears to be a small recovery in oak, birch and hazel woodland at the beginning of zones LT6.4b and LT15.2b, although there is a slight decline in alder. The limited evidence for human impact on the woodland in the area might be because the amount of wood used in making the trackway had little effect on the overall woodland communities in the pollen catchment, because the woodland exploited was some distance from the trackway or because the clearance episode was extremely brief. Equally, older pollen from industrial deposits used in making the trackway may have masked changes in the contemporary woodland.

The pollen, plant macrofossil and insect evidence suggests that the trackway was constructed over a varied wetland landscape encompassing wetland grasses, reed, sedges, heather and cotton grass with wetter pools containing pond weed (see Caseldine and Griffiths and Smith *et al.* below). Bog myrtle, birch fenwood and alder carr would also have been growing in the area.

Apart from a limited increase in woodland, the local landscape seems to have altered little up cal. AD 1470–1650 (Beta-241085). Shortly after this there was slight expansion in hazel and/or bog myrtle communities and alder carr. Agricultural activity also appears to have diminished. After this, the record ceases as a result of recent farming activity.

The local Late Iron Age/Roman landscape and archaeology

The pollen and palaeopollution evidence from Llangynfelyn demonstrates that both agriculture and lead processing/mining activity had a significant impact on the environment during the late Iron Age/Roman period. The pollen records clearly indicate a marked impact on the local woodland, notably oak. A first phase of activity is dated to 110 cal. BC–cal. AD 130 (Beta-211076) and 110 cal. BC–cal. AD 180

(Beta-222223). At the same time there is an expansion in agriculture. This activity could be related to the presence of a possible Iron Age enclosure close to the dry land edge at Ynys Capel, about 650m from the industrial site. The construction of this settlement, as well as clearance for agriculture, would have contributed to a reduction in the local woodland. Equally, the construction of the nearby Roman road, including clear ways on either side, would have resulted in woodland clearance, whilst the construction of the Roman fortlet at Erglodd, around 500m from Llangynfelyn, would also have required timber.

As already discussed, the arrival of a Roman military presence in the area could, alternatively, be represented by the second phase of clearance activity identified at Trench 5a. This second phase coincides with evidence for palaeopollution at Trench 5a. The close proximity of Trench 5a to the smelting site at Llangynfelyn suggests that this site was largely responsible for the palaeopollution recorded, although there is a possibility that the peak in lead could represent other mining or smelting activity in the region. Equally, some of the pollution may derive from the mining activity that provided the ore used at the site rather than the smelting activity; there are several post-medieval mines within the immediate area (Fig. 1) which perhaps might have commenced earlier. Overall it seems probable that the sharp decline in oak, as well as the decline in other tree species, was directly related to the exploitation of the local woodland for fuel at the smelting site. The use of wood at local mines, as well as for fuel for domestic fires and for other purposes at the nearby settlements, would also have contributed to the reduction in woodland.

The five radiocarbon dates from the industrial waste range from 90 cal. BC through to cal. AD 240, with all five dates overlapping between cal. AD 50–90. It seems probable that the first clearance episode occurred during the first century AD, shortly before or contemporary with the arrival of the Romans, and the industrial activity occurred at the end of the first century AD and/or during the second century AD, although the possibility of initial mining activity commencing during the late Iron Age cannot be ruled out, and there is the suggestion that from the lead/palaeopollution record from the central dome of Borth bog there could have been lead mining activity in the area as early as 384–203 cal. BC (Mighall *et al.* 2009).

The fortlet at Erglodd is considered to date to the Flavian period and was probably established sometime around AD 74, with occupation continuing into the second century AD. This is in agreement with the proposed period of main activity at the lead smelting site. The pollen and palaeopollution records support the suggestion that the fortlet was not only involved in the supervision of traffic along the road between the auxiliary forts at Pennal, to the north, and Pen Llwyn, to the south, but was also involved in the exploitation of local lead and, possibly, silver deposits.

A mixed farming economy appears to have prevailed throughout the period of smelting/mining activity. Cereal cultivation included the growth of spelt wheat and some grazing of stock may have occurred on the wetlands as well as on the dry land. By the end of the Roman period farming activity appears to have declined and there seems to be a renewed expansion in woodland during the early medieval period. Although agricultural activity may have been reduced, the palaeopollution record does indicate that there may have been some late Roman/early medieval industrial activity in the area.

Comparison with the wider environmental record during the Late Iron Age/Roman period

The results from Llangynfelyn are consistent with other evidence from Cors Fochno. Moore (1968; Moore and Chater 1969) also attributed evidence for increased clearance and agricultural activity at Borth to the Iron Age/Roman period, noting that Borth was close to the Roman fording point of the river Dovey (Moore and Chater 1969). In addition he assigned a period of woodland regeneration to the early medieval period, although the changes were undated. Recent work by Mighall and Timberlake (Mighall pers. comm.) has identified similar vegetation changes and palaeopollution in a core from the central dome of Borth Bog. A radiocarbon date of cal. AD 133–341 suggests that lead enrichment, coinciding with a woodland clearance episode, dates to the Roman period and reflects mining/smelting in the area

(Mighall *et al.* 2009). This event begins earlier than the dated horizon and again could indicate industrial activity prior to the arrival of the Roman military in the area. An earlier peak in lead could indicate lead mining activity in the area as early as 384–203 cal. BC in the Iron Age. A recovery in woodland occurs during the early medieval period followed by a clearance episode. These vegetation changes appear to be comparable to those identified at Erglodd, Llangynfelyn.

There is some evidence for the impact of lead mining during the Roman period from other sites in Wales. The nearest evidence is from the Ystwyth valley where a period of sustained woodland clearance is recorded during the Iron Age in the blanket peats at Copa Hill, Cwmystwyth (Mighall *et al.* 2006). This is attributed to an expansion in agriculture because of the absence of metal enrichment in the peat at this time. However, following a slight recovery, a subsequent decline in woodland, accompanied by an increase in lead concentrations, is considered to reflect Roman mining and smelting in the Ystwyth valley. As at Llangynfelyn farming continued throughout the Roman period with evidence both for cereal cultivation and livestock farming and, following cessation of mining, there was a recovery in woodland.

A rise in lead and zinc values dated to 1720±40 BP in a core from a blanket peat close to the former lead mine at Craig y Mwyn, Llanrhaeadr-ym-Mochnant, Powys, suggests that mining may have commenced in the Roman period (Mighall *et al.* 2008). The evidence for Roman mining activity from a blanket peat at the head of the Nant y Bai valley close to the mines at Rhandirmwyn (Pen Cerrig y Mwn and Nantymwyn mines), Carmarthenshire (*ibid.*) is less certain. A phase of small-scale activity might represent a phase of prospecting activity for gold rather than for lead (Timberlake 2003b) during the Roman period, but alternatively might represent small-scale mining during the Dark Ages (Mighall *et al.* 2008). Either way, mining activity had a limited impact. There is also some evidence for agriculture but not on a major scale.

As well as evidence from Wales for Roman lead mining activity, there is evidence from peats from south-west England (West *et al.* 1997). However, evidence from the North Pennine lead orefield is circumstantial (Mighall *et al.* 2006). Pollution records from peats in the area suggest that either local lead ores were not exploited or exploitation was on a scale that was insufficient to generate a pollution signal (Mighall *et al.* 2004). There are also metal pollution records from Europe which indicate lead mining during the Roman period (Görres and Frenzel 1997; Martinez Cortizas *et al.* 1997).

The expansion in clearance and agricultural activity at Llangynfelyn during the late Iron Age/Roman Period has been identified at other sites in Wales, for example Whitland (Caseldine *et al.* 2002), Cefn Gwernffrwd (Chambers 1982), Black Mountains (Price and Moore 1984), and Llangorse Lake (Jones *et al.* 1985; Chambers 1999). In the uplands of mid-Wales, although undated, it has been suggested that clearance evident in several diagrams, Plynlimon, Towy Valley UTV-5 and Llyn Gynon, was related to Roman activity (Moore 1966; Moore and Chater 1969). Plynlimon is close to the Roman fort of Cae Gaer and Towy Valley UTV-5 and Llyn Gynon not far from the Sarn Helen road. More recently radiocarbon dated diagrams from Craig y Dullfan, near Nant y Moch reservoir, confirm the evidence for Roman activity in the Plynlimon area (Caseldine and Griffiths 2009). At Bryniau Pica a short-lived decline in hazel has been dated to 1965±65 BP (AA-27632) (Buckley 2000; Buckley and Walker 2001), whilst at Carneddau an extensive period of deforestation occurred between *c.* 1960 BP and 1790 BP (Walker 1993).

A recent detailed study at the lowland raised bog Cors Caron (Tregaron Bog) charts the vegetation changes during the later Iron Age through to the medieval period (Morriss 2001; Lomas-Clarke and Barber 2007). The events relating to the Roman period are similar to those found at Llangynfelyn. From *c.* 100 cal. BC there was a period of substantial hazel scrub clearance, accompanied by an increase in mixed farming. This was followed by a further phase of increased agricultural activity dated to *c.* cal. AD 75 and cal. AD 375. It is suggested that this agricultural activity may be related to the construction of the Roman fort of *Bremia* at Llanio, Ceredigion. A decline in pastoral and arable activity and regeneration of woodland/scrub *c.* cal. AD 375 is considered to be linked to the withdrawal of the Romans.

The early medieval – medieval period

The regeneration of woodland observable at Llangynfelyn during the early medieval period is also recorded in other diagrams from Borth (Moore 1968; Moore and Chater 1969; Mighall *et al.* 2009), as is the continued presence of agricultural activity. A regeneration phase is observable at a number of pollen sites during this period, for example, Talley (Butler 1984), the Black Mountains (Moore *et al.* 1984), Waun Fignen Felen (Smith and Cloutman 1988), the Berwyns (Bostock 1980) and Preselis (Seymour 1985). By cal. AD 860–1010 (Beta-235893) at Llangynfelyn, apart from alder, most of the woodland had disappeared from the local area as a result of clearance for agriculture, the use of wood for construction, fuel or other purposes and/or as a result of grazing preventing regeneration. The beginning of a decline in woodland in the region, recorded in a diagram from the central dome, has been dated to cal. AD 1026–1177 and includes a decline in alder, oak and birch although hazel increases initially before declining (Mighall pers. comm.; Mighall *et al.* 2009). The evidence from the central dome suggests that woodland was more abundant in the wider region compared with the area around the smelting site prior to the decline, which then continues through, although with minor oscillations in woodland expansion and clearance, until woodland regeneration and planting in post-medieval and modern times.

The timber trackway at Llangynfelyn was constructed in the early to mid eleventh century with repairs taking place over a century afterwards, around the time, or soon after, the pollen records suggest that there was a slight recovery in woodland in the local area or, alternatively, they could be registering an increase in woodland in the wider region. There is some limited documentary evidence for woodland during the twelfth century. Giraldus Cambrensis during his tour of Wales in AD 1188 described the country as having extensive woods. Glanville Jones (Jones 1965) suggested that during the later part of the reign of Gruffydd ap Cynan (d. 1137) ‘the men of Gwynedd began to plant the old woods, to make orchards and gardens surrounded with walls and ditches, and to construct walled buildings’ (Musson *et al.* 1989). The slight increase in woodland broadly contemporary with the trackway at Llangynfelyn may indicate similar activity in the local area.

PLANT MACROFOSSIL EVIDENCE AND WOOD AND CHARCOAL IDENTIFICATIONS

By Astrid E. Caseldine and Catherine J. Griffiths

PLANT MACROFOSSIL EVIDENCE

Samples from both the Iron Age/Roman industrial deposits in Trenches 4a, 6, 12, 17 and 21 (Table 7) and from deposits directly beneath the medieval trackway in Trenches 5a and 6 (Table 8) were examined with the aim of gaining information about the local environment and, possibly, agricultural activity.

The Iron Age/Roman industrial deposits

The results from Trenches 4a and 6 are considered together as they are from the same area of the site. The archaeological remains consist of dumps of industrial deposits underlying the southern terminal end of the medieval timber trackway at the dry land/wetland interface. The plant remains recovered were uncharred, apart from a charred orache (*Atriplex* sp.) seed. The assemblage indicates a variety of habitats in the vicinity of the site at the time the industrial material was deposited.

Wet or damp ground conditions are suggested by the presence of rushes (*Juncus* spp.), sedges (*Carex* spp.), water-pepper (*Persicaria hydropiper*), marsh pennywort (*Hydrocotyle vulgaris*), blinks (*Montia fontana* ssp. *fontana*), celery-leaved buttercup (*Ranunculus sceleratus*) and crowfoots (*Ranunculus* subgenus *Batrachium*), probably reflecting the marshy conditions at the dry land edge where the deposits

Table 7. Plant macrofossils from the industrial deposits at Llangynfelin

Trench	4	4	4	4	6	6	6	6	12	12	12	12	12	17	17	21	21	21	21	
Context	27	69	70	1129	1130	1133	1098	1134	1098	1133	1098	1134	1116	1115	1116	1085	1091	1092	1093	1109
Weight (kg)	3	2.5	2.4	1	0.5	1	1	1	1	1	1	1	1	0.2	1	1	1	1	1	1
<i>Ranunculus repens</i> type (Creeping buttercups)	1	-	1	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
D, Du, F, Gw, Ss, W																				
<i>Ranunculus sceleratus</i> L. (Celery-leaved buttercup)	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gw, P, Ss																				
<i>Ranunculus</i> Subgenus <i>Batrachium</i> (DC) A. Gray (Crowsfoot) P, Ss	-	-	17	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Ranunculus</i> spp. (Buttercups) C, D, Du, F, G, Ss, W, o, w	1	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Urtica dioica</i> L. (Common nettle) C, D, F, W, n	10	-	8	6	1	-	-	3	-	-	-	-	-	-	-	-	-	1	1	-
<i>Chenopodium album</i> L. (Fat-hen) C, D	24	-	12	9	2	2	-	14	-	-	-	-	-	-	-	-	1	1	1	-
<i>Chenopodium</i> spp. (Goosefoots) C, D	-	-	2	6	2	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-
<i>Atriplex</i> spp. (Oraches) C, D, Sm	2	-	7	-	-	-	-	-	-	-	-	-	1	-	-	-	-	2	-	-
<i>Atriplex</i> spp. - charred	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1
<i>Montia fontana</i> ssp. <i>fontana</i> L. (Blinks) P, Ss, W	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Stellaria</i> spp. (Stitchworts) C, F, G, Ss, W, o, w	-	-	1	-	-	-	-	2	-	-	-	-	-	-	-	-	-	3	-	-
<i>Cerastium</i> cf. <i>arvense</i> L. (Field mouse-ear) G	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Persicaria lapathifolia</i> (L.) Gray (Pale persicaria) C, D, o, w	5	2	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Persicaria hydropiper</i> (L.) Spach (Water-pepper) P, w	7	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Persicaria</i> sp. (Knotweeds) C, D, Ss, o, w	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Rumex acetosella</i> L. (Sheep's sorrel) C, D, M, o	7	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Rumex</i> spp. (Docks) C, D, G, P, Ss, W, w	2	-	-	-	-	1	-	14	-	1	-	14	1	-	-	-	-	2	6	-
<i>Rumex</i> sp. - charred	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Viola</i> spp. (Violets) C D, Du, F, G, H, M, S, W	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Brassica</i> sp. / <i>Sinapis arvensis</i> L. (Cabbage/charlock) C, D, Sc, Ss	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Rubus fruticosus</i> agg. (Brambles) D, Du, G, H, M, S, W, o	-	-	-	3	-	1	-	3	-	-	-	-	-	-	-	-	-	-	27	1
<i>Rubus fruticosus</i> agg. - frags.	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Potentilla erecta</i> (L.) Raeusch (Tormentil) G, M	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Potentilla</i> spp. (Cinquefoil) D, Du, G, M, Wc	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
<i>Aphanes arvensis</i> L. (Parsley-piert) C, D	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Aphanes inexpectata</i> Lippert (slender parsley-piert) C, D	10	-	4	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rosaceae - thorn H, S, W	-	-	-	1	-	1	-	1	-	-	-	1	-	-	-	-	-	-	-	-
<i>Ulex europaeus</i> L. - spines (Gorse) G, M, Wo	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

continued

Table 7. Plant macrofossils from the industrial deposits at Llangynfelin *continued*

Trench	4	4	4	4	6	6	6	6	6	12	12	12	12	12	17	21	21	21	21	21
Context	27	69	70	1129	1130	1133	1098	1134	1115	1116	1085	1091	1092	1093	1109	1093	1109	1093	1109	
Weight (kg)	3	2.5	2.4	1	0.5	1	1	1	0.2	1	1	1	1	1	1	1	1	1	1	
<i>Hydrocotyle vulgaris</i> L. (Marsh pennywort) F, M, P	-	-	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Torilis nodosa</i> (L.) Gaertner (Knotted hedge-parsley) C, D	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Apium</i> sp. (Marshworts) F, P, Sm, Ss, o	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Solanum dulcamara</i> L. (Bittersweet) D, F, H, P, W	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Galeopsis tetrahit</i> L. (Common hemp-nettle) C, D, F, Wc, w	-	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Galeopsis</i> sp. (Hemp-nettles) C, D, Wc, w	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Prunella vulgaris</i> L. (Sefheal) D, G, Wc	1	-	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Mentha arvensis</i> L. / <i>aquatica</i> L. (Corn/water mint) C, Gw, P, Wc	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Salvia pratensis</i> L. (Meadow clary) D, G, S, Wc	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Lamiaceae</i> (Deadnettle) C, D, G, P, S, Wc, w	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Plantago major</i> L. (Greater plantain) C, D, o	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Cirsium</i> spp. (Thistles) C, D, F, G, H, Wo, w	1	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
<i>Leontodon</i> sp. (Hawkbits) G	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Sonchus asper</i> (L.) Hill (Prickly sow-thistle) C, D, F	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
cf. <i>Sonchus</i> sp. (Sow-thistles) C, D, Du, F, Ss	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Juncus</i> sp. (Rushes) F, G, M, P, Sm, Ss, Ww	-	-	1	>1000	-	-	>100	-	10	-	-	42	>100	-	-	-	-	-	-	-
<i>Juncus</i> sp. – capsule	1	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Schoenoplectus lacustris</i> (L.) Palla (Common Club-rush) F, P, Ss	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
<i>Carex</i> spp. – biconvex (Sedges) F, G, M, Ss, W, w	3	-	2	19	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-
<i>Carex</i> spp. – trigonous	1	-	2	14	1	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-
<i>Carex</i> spp. – trigonous charred	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
<i>Festuca</i> type (Fescues) G, H, M, Ss	9	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Triticum spelta</i> – glume base (Spelt wheat) C	2	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Poaceae (Grass) C, D, G, M	1	1	4	29	-	6	-	-	-	-	-	-	-	1	-	-	-	-	1	-
<i>Pteridium aquilinum</i> L. – leaf frags. (Bracken) M, W, G	3	-	2	4	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Tree buds	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bud scale	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Charred seed indet.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1

Ecology: C = cultivated; D = disturbed; Du = dunes; F = fens; G = grassland; H = hedges; M = bogs, heath, moors; P = ponds, lakes, ditches; S = scrub; Sm = saltmarsh; Ss = stream-sides; W = woods; Wc = woodland clearance, margin; n = nutrient enrichment; o = open ground; w = wet/damp ground.

Table 8. Plant remains associated with the medieval trackway at Llangynfelin

Trench	5	5	5	5	6	6
Sample	1	2	5	6	209	244
Volume (litres)	0.5	0.5	0.5	0.5	0.5	0.5
<i>Ranunculus repens</i> L. (Creeping buttercups)	–	1	–	–	–	–
D, Du, F, Gw, Ss, W						
<i>Urtica dioica</i> L. (Nettles) W, F, Cn	–	–	–	–	1	–
<i>Betula</i> spp. (Birch) W, w	2	1	4	–	1	2
<i>Corylus avellana</i> L. – nut shell frags. (Hazel) H, S, W	3	2	1	1	–	–
<i>Atriplex</i> spp. (Oraches) C, D, Sm	–	–	–	–	–	2
<i>Calluna vulgaris</i> (L.) Hull – semi-charred leaves (Heather) M	5	–	–	–	–	–
<i>Calluna vulgaris</i> – flower	4	–	–	–	2	–
<i>Calluna vulgaris</i> – charred flowers	17	4	13	31	–	2
<i>Calluna vulgaris</i> – shoot	1	–	–	–	–	–
<i>Erica tetralix</i> L. – leaf (Cross-leaved heath) M	1	–	–	1	–	–
<i>Erica tetralix</i> L. – shoot	–	–	–	2	–	–
<i>Erica tetralix</i> L. – semi-charred leaves	27	–	–	–	–	–
<i>Erica tetralix</i> L. – charred leaves	–	5	15	47	–	–
<i>Rubus fruticosus</i> agg. (Brambles) D, Du, G, H, M, S, W, o	–	1	3	–	1	2
<i>Potentilla</i> sp. (Cinquefoil) D, Du, G, M	4	1	–	1	1	8
Rosaceae type – thorn	–	–	–	–	2	–
<i>Linum catharticum</i> L. (Fairy flax) G, M	–	–	1	–	–	–
<i>Sambucus nigra</i> L. (Elder) H, W, Dn	–	–	–	1	–	–
<i>Eriophorum vaginatum</i> L. – sclerenchymatous spindles (Hare's-tail cottongrass) F, M	17	16	4	4	–	–
<i>Potamogeton</i> sp. (Pond weed) P	–	8	–	–	–	–
<i>Juncus</i> sp. (Rushes) F, G, M, P, Sm, Ss, Ww	–	1	–	–	1	1
<i>Luzula</i> cf. <i>campestris</i> (L.) DC. (Field wood-rush) G	–	–	–	–	–	4
<i>Rhynchospora alba</i> (L.) Vahl (White beak-sedge) M, w	–	–	1	–	–	–
<i>Carex</i> sp. – biconvex (Sedges) F, G, M, Ss, W, w	1	–	–	–	–	–
<i>Carex</i> sp. – biconvex charred	2	–	–	–	–	–
<i>Carex</i> sp. – trigonous	1	–	1	1	3	65
<i>Carex</i> sp. – trigonous charred	1	–	–	–	–	–
<i>Carex</i> sp.	3	–	–	–	–	2
<i>Festuca</i> type (Fescues) G, H, Ss	19	12	16	–	–	–
cf. <i>Phragmites australis</i> (Cav.) Trin. ex Steudel (Common reed) G, F	–	2	–	–	–	–
Poaceae (Grass) C, D, G, M	1	3	12	24	60	233
Poaceae – charred	1	–	–	–	–	–
<i>Typha latifolia</i> L. (Bulrushes) P	–	–	–	–	–	3
<i>Eriophorum vaginatum</i> L. – stem bases	+++	+++	++	++	–	–
Monocot. stems and roots	+++++	+++++	+++++	+++++	+++++	+++++
Thorn	–	–	–	–	+	–
Wood and bark fragments	+++++	+++++	+++++	+++++	+++++	+++++
Deciduous leaf fragment	–	–	+	–	–	–
Wood charcoal	++	++	+	+	++	++
<i>Sphagnum</i> spp. – leaves	–	+	+	+	+	+
Moss frags.	–	–	+	+	–	+
Stone/gravel/lead waste	+++++	+++++	+++++	+++++	++	++

Ecology: C = cultivated; D = disturbed; Du = dunes; F = fens; G = grassland; H = hedges; M = bogs, heath, moors; P = ponds, lakes, ditches; S = scrub; Sm = saltmarsh; Ss = streambanks; W = woods; Wc = woodland clearance, margin; n = nutrient enrichment; o = open ground; w = wet/damp ground.

+++++ = very abundant; ++++ = abundant; +++ = frequent; ++ = occasional; + rare

were dumped. Pale persicaria (*Persicaria lapathifolia*) is also typical of damp ground as well as waste and cultivated areas. Other weed species such as common nettle (*Urtica dioica*), fat-hen (*Chenopodium album*), parsley piert (*Aphanes arvensis*), slender parsley-piert (*Aphanes inexpectata*) and common hemp-nettle (*Galeopsis tetrahit*) could represent waste or bare ground associated with the site, or nearby cultivation. Local arable activity is confirmed by the presence of glume bases of spelt wheat (*Triticum spelta*). Bramble (*Rubus fruticosus* agg.) seeds and bracken (*Pteridium aquilinum*) leaf fragments provide further evidence for waste or abandoned ground as well as woodland edge habitats, whilst species such as sheep's sorrel (*Rumex acetosella*) could indicate cultivation or grassland. Grasses (Poaceae), selfheal (*Prunella vulgaris*) and creeping buttercup (*Ranunculus repens*) type, the last suggesting wet grassland, also indicate grassland habitats.

The plant remains from Trench 12 were from several layers of industrial waste. The only charred remains, aside from charcoal, were one charred orache seed and one charred dock seed from an ashy layer below a layer containing partly charred wood. The weed seeds probably became charred incidentally along with wood used for fuel. The other seeds from the ashy layer comprised grass and rush seeds indicating damp grassland.

Plant remains were also recovered from two silty soil layers (1133, 1134), which lay below a layer of ash, charcoal and clay (1061). Few remains were recovered from the upper silty soil layer, but they included dock, fat-hen, bramble and a thorn, again reflecting disturbed and rough ground. Rather more seeds were recorded from the lower silty soil, and, as well as species indicative of waste ground, sedge and common club-rush (*Schoenoplectus lacustris*) suggest wetter conditions nearby. Common club-rush is typically found in shallow water in rivers, ponds and lakes. The occurrence of the latter two species, and slightly greater abundance of seeds in the lower layer, suggests a wetter depositional environment and conditions more favourable for preservation when it was laid down than when the upper layer was deposited. The only seeds recovered from an industrial deposit of charcoal, grit and clay in Trench 17 were rush seeds.

Virtually all the plant remains recovered from contexts associated with the furnace in Trench 21 were uncharred. The uncharred remains could represent much later intrusive material but the assemblage is similar to that recovered from wetter contexts at the site and the high lead levels may have aided preservation. Two indeterminate charred seeds were recovered, as well as a charred orache and a charred sedge nutlet. The charred seeds were probably burnt incidentally along with wood or charcoal used for fuel. In general the uncharred remains were scarce but they included a range of weed species such as nettle, fat hen, thistle (*Cirsium* sp.) and docks suggesting disturbed or waste ground habitats at the site or, possibly, arable activity nearby. The presence of grasses, sedges and rushes indicate damp grassland, whilst blackberry remains could derive from disturbed ground or hedges and woodland in the surrounding area.

Discussion of the plant macrofossil evidence

The industrial activity would have had a considerable impact on the vegetation in the immediate area of the site. Large parts of the area would have been highly toxic and sparsely vegetated but certain taxa are tolerant of the extreme environmental conditions presented by soils rich in heavy metals. Fescue type grasses and docks are recorded from the site and sheep's fescue (*Festuca ovina*) and probably common sorrel (*Rumex acetosa*) have strains tolerant of heavy metals (Rodwell 2000, 447). Other species would have colonized around the periphery of the site where toxin levels were lower. Many of the seeds and other plant remains recorded probably reflect plants that grew around the edge of the site and were either washed into or blown onto the waste deposits. As well as plants typical of rough and disturbed ground, species indicative of wetter conditions are recorded from the deposits at the dry land edge and probably

are derived from the local area. However, as cultivated plants are susceptible to damage from heavy metals, it is likely that the spelt glume bases represent cultivation a little distance from the site itself.

The medieval trackway

Two of the samples were from beneath timbers in Trench 6 at the terminal end of the track, while the remaining four samples were from Trench 5, around 100m from dry land. The samples contained charcoal, stone and other minerogenic material, including lead waste, reflecting material dumped on the bog surface, as well as plant remains. Wood fragments from the trackway were also present.

Monocotyledon remains comprising stems, stem bases and rhizomes of grasses and sedges, dominate all the plant macrofossil assemblages but there are some differences between the samples from Trench 6 and Trench 5. Grass (Poaceae) seeds are particularly frequent in samples from Trench 6, suggesting wet grassland communities, whilst remains of hare's tail cottongrass (*Eriophorum vaginatum*) occur in Trench 5, reflecting the boggy conditions further into the wetland. Similarly, charred heather (*Calluna vulgaris*) and cross-leaved heath (*Erica tetralix*) remains are scarce or absent in the samples from Trench 6 compared with those from Trench 5. It seems likely that the charred ericaceous remains from Trench 5 represent burning of the contemporary bog surface rather than earlier industrial material, as these remains were not recorded from the industrial samples and semi-charred and waterlogged ericaceous remains are present. Indeed burning of the bog surface may have favoured the spread of cottongrass.

As well as large numbers of grass seeds, sedge (*Carex* sp.) nutlets are also abundant in Trench 6 and seeds of wood rush and bulrush are present. The occurrence of nettle (*Urtica dioica*) and orache (*Atriplex* sp.) in samples also from Trench 6 probably reflect disturbed ground habitats, although nettles are also found in fen. Occasional blackberry (*Rubus fruticosus*) seeds in samples from both trenches might also indicate waste ground in the area, but occur in a wide range of habitats. The occasional birch (*Betula* sp.) fruit might have been carried some distance by the wind but suggests birch woodland in the surrounding area, whilst hazelnut (*Corylus avellana*) shell fragments from Trench 5 probably reflect transport either by small mammals or humans, as well as demonstrating the presence of hazel woodland. Equally, small mammals or birds could have transported an elder (*Sambucus nigra*) seed. Wetter conditions and the presence of standing water in the vicinity of Trench 5, perhaps a pool, is indicated by pondweed (*Potamogeton* sp.) fruits. White beak-sedge (*Rhynchospora alba*) and possibly common reed (*Phragmites communis*) also suggest wet conditions.

Overall the evidence suggests wet grassland communities with sedges and rushes in the area of the industrial deposits at the terminal end of the trackway giving way to wet boggy ground with tussocks of cotton grass, grasses, heather and cross-leaved heath. Permanently waterlogged hollows and bog pools would have occurred amongst the drier hummocks. Some birch woodland may have been present in the area.

WOOD IDENTIFICATION

The majority of the wood identified from Llangynfelyn was from the medieval trackway but a small amount was identified from Trench 11 from below industrial deposits and from contexts associated with a furnace in Trench 12 (Table 9). The main aim was to determine the types of wood that had been exploited, particularly for the construction of the track, whilst the wood from the earlier contexts provided further information about woodland resources in late Iron Age/Roman times. Wood was also identified from the pollen columns and this is included with the pollen evidence. Most of the oak (*Quercus* spp.) was identified in the field by Nigel Nayling and it was largely the non-oak species that were identified in the laboratory.

Table 9: Wood identifications from Llangynfelyn

Trench	2	4a	4b	4c	5A	5a	5c	5d	6	11	12	Total
<i>Fagus sylvatica</i> L. (beech)	–	–	1	–	–	–	–	–	–	–	–	1
<i>Quercus</i> spp. (oak)	–	1	3	–	12	5	–	5	12	2	2	42
<i>Alnus glutinosa</i> (L) Gaertner (alder)	21	1	21	–	20	2	5	30	35	3	1	139
<i>Corylus avellana</i> L. (hazel)	6	2	–	1	1	1	1	–	32	2	2	48
<i>Salix/Populus</i> sp. (willow/poplar)	1	–	–	–	–	–	–	–	3	–	1	5
<i>Prunus</i> spp. (cherries)	–	–	1	–	–	–	–	–	–	–	–	1
Maloideae type (hawthorn, rowan, crab apple, common whitebeam, wild service-tree)	–	–	–	–	–	–	–	–	1	–	–	1
<i>Ilex aquifolium</i> L.(holly)	–	–	1	–	–	–	–	–	–	–	–	1
<i>Fraxinus excelsior</i> L.(ash)	–	2	–	–	–	–	–	–	2	1	2	7
Total	28	6	27	1	33	8	6	35	85	8	8	245

Transverse, radial longitudinal and tangential longitudinal thin sections were cut from the wood and examined under a Leica DMR microscope with transmitted light source. The wood was identified by reference to wood identification texts (Schweingruber 1978; Schoch *et al.* 2004) and by comparison with modern type slides. The results are given in Table 9. Nomenclature follows Stace (1991).

Results

The small late Iron Age/Roman assemblages from Trenches 11 and 12 contained a limited range of species, including alder (*Alnus glutinosa*), hazel (*Corylus avellana*), ash (*Fraxinus excelsior*), oak and willow/poplar (*Salix/Populus*). The main assemblage was from the medieval trackway and most of it consisted of alder. Hazel and oak were also comparatively frequent but other species were rare. They included ash, beech (*Fagus sylvatica*), holly (*Ilex aquifolium*), cherry (*Prunus* sp.), willow/poplar and Maloideae type, which includes Rosaceae species such as hawthorn (*Crataegus* spp.), crab apple (*Malus sylvestris*), rowan (*Sorbus aucuparia*), common whitebeam (*S. aria*) and wild service-tree (*S. torminalis*).

Discussion of the wood identifications

Although the assemblages from Trenches 11 and 12 are very small they indicate the exploitation of local woodland comprised of alder, oak, hazel, ash and willow/poplar (probably willow although aspen or black poplar could have been present) and are consistent with the pollen evidence (see Caseldine, Griffiths and Crowther above). The wood from Trench 11 pre-dates the industrial deposits and a few pieces, including alder and hazel, showed evidence of charring, suggesting earlier activity in the local area. A peak in charcoal also occurs at this time in the pollen record from Trench 11. A piece of ash from Trench 12 also showed signs of charring and was probably associated with lead smelting activity. Further evidence of the fuel used in the furnace in Trench 12 is evident in the charcoal record where alder, oak and hazel charcoal were the main species identified (see below).

The assemblage from the medieval trackway suggests that alder woodland provided the main source of material for its construction and this is consistent with the pollen record which indicates alder in the

surrounding area (see Caseldine, Griffiths and Crowther above). In addition, oak made up a significant part of the structure and hazel was also quite widely used. Both taxa are present in the pollen record, although oak pollen occurs only in low amounts. The majority of the hazel was found in Trench 6 at the southern terminal end of the track, indicating the exploitation of dry land woodland communities. The greatest range of species, including a single piece of beech, also occurs in the trenches at the southern end of the track. This suggests a more diverse woodland on or at the edge of the dry land. Whilst willow is more likely to be found in wet woodland, most of the other taxa, apart from beech, can be found in either alder carr or oak woodland. Although alder, oak and hazel seem to have been preferred, the occasional occurrence of other species suggests that any wood that was readily available was exploited. However, birch is not recorded from the track, although the pollen evidence indicates it was present in the area, which could mean it was deliberately avoided.

Although availability was probably the main determining factor in the wood used for construction of the track, alder is durable in wet conditions and has been used to make tracks since prehistoric times, notably the Neolithic Abbot's Way in the Somerset Levels (Coles and Orme 1976). Oak and hazel have also been widely used in the construction of tracks and other wooden structures in wetland areas in England and Wales (Coles and Coles 1986; Bell *et al.* 2000). In addition, there is some limited evidence from other areas in Wales for the construction of wooden tracks dating to the medieval period. Further north along the Welsh coast, trackway timbers from a medieval trackway at Llanaber, near Barmouth, were identified as alder, ash and willow (Hibbert in Musson *et al.* 1989) and tree roots in the peat as alder. Wood, possibly part of a simple track, associated with the discovery of an Early Medieval brooch at Newton Moor, South Glamorgan included oak, hazel and alder (Redknap 1991; 1992).

CHARCOAL IDENTIFICATIONS

Charcoal from the industrial deposits at Llangynfelyn was identified to ascertain the species that were selected for use in the lead smelting process at the site. Most of the samples examined were from contexts that were also examined for their metallurgical content (Anguilano 2007; and report by Timberlake above), and for their plant macrofossils (see above).

The samples were from a range of contexts including contexts from Trench 21 where a lead smelting furnace had been found; Trench 12 where there were industrial deposits; Trench 6 where industrial material had been dumped and over which the medieval trackway had later been constructed; Trench 17, the site furthest from the main area where waste deposits may have been associated with charcoal production, and Trench 23 where there was further industrial material (Table 10).

Results

Charcoal often fragments on archaeological sites so the number of fragments of a particular species does not necessarily reflect the actual quantity of the species at the site. However, taxa can be considered dominant or frequent at a site when they are present in most of the samples and occur in large quantities compared with taxa which only occur occasionally and/or in low concentrations. The most frequently recorded taxa at the site were oak (*Quercus* spp.), birch (*Betula* spp.), hazel (*Corylus avellana*) and alder (*Alnus glutinosa*), with oak present in the greatest quantities. Taxa that were present occasionally included ash (*Fraxinus excelsior*), cherry (*Prunus* spp.), willow/poplar (*Salix/Populus*.) and Maloideae type, which includes hawthorn (*Crataegus* spp.), rowan (*Sorbus aucuparia*), crab apple (*Malus sylvestris*), common whitebeam (*S. aria*) and wild service-tree (*S. torminalis*).

Table 10: Charcoal identifications from industrial deposits at Llangynfelyn

Trench	6	6	12	12	17	21	21	21	21	21	23	Total
Context	1128	1129	1119	1120	1115	1085	1091	1093	1109	1116	1095	
<i>Quercus</i> spp. (oak)	–	10	11	4	12	11	31	10	16	14	4	123
<i>Betula</i> spp. (birch)	1	3	2	1	2	7	4	5	1	1	–	27
<i>Alnus glutinosa</i> (L.) Gaertner (alder)	–	1	1	9	–	–	2	–	2	2	1	18
<i>Corylus avellana</i> L. (hazel)	–	1	–	5	4	2	–	4	1	3	–	20
<i>Salix/Populus</i> sp. (willow/poplar)	–	–	–	–	–	–	1	–	–	–	–	1
<i>Prunus</i> spp. (cherries)	–	4	–	–	1	–	–	–	–	–	–	5
cf. <i>Prunus</i> sp.	–	–	–	–	1	–	–	–	–	–	–	1
Maloideae type (hawthorn, rowan, crab apple, common whitebeam, wild service-tree)	–	–	–	1	–	–	–	–	–	–	–	1
<i>Fraxinus excelsior</i> L. (ash)	–	1	–	–	–	–	2	1	–	–	–	4
Total	1	20	14	20	20	20	40	20	20	20	5	200

Discussion of the charcoal identifications

Although the assemblages from individual contexts are relatively small, a few observations can be made. The charcoal assemblages, like the sediments from the deposits (see report by Timberlake above), are similar with little difference between those from contexts directly associated with the furnace and those from dumps of waste material. In general, oak dominates the assemblages, apart from one of the contexts in Trench 12 where alder and hazel are slightly more frequent than oak, although this could be related to sample size. However, the results suggest that, as well as oak, a wide range of species were used from the surrounding area as fuel.

Oak makes an excellent fuel, either as wood or as charcoal. Similarly, both birch wood and charcoal are good fuels, whilst alder wood, provided it is seasoned, burns well and the charcoal is excellent (Taylor 1981). Hazel, ash and willow are also good fuels. However, certain woods, for example oak and ash, which are denser than woods such as alder, willow and poplar, do provide a longer-lasting source of heat (Porter 1990). Hence larger volumes of light-weight wood would be required to produce comparable heat to that produced by dense heavy wood, especially oak heartwood (Cowgill 2003). In addition, fast-grown oak is denser than slow-grown oak (Gale 2003).

Timberlake suggests that the charcoal deposits in Trench 17 could indicate charcoal production, perhaps even charcoal clamps, in this area of the site. If possible, charcoal clamps were constructed near streams or pools in case the clamp caught fire, and the pollen evidence from Trench 17 (see above) suggests that there was water nearby. About six tons of wood are required to produce one ton of charcoal (Armstrong 1978; Horne 1982). Efficient carbonisation produces a smokeless fuel with about twice the calorific value of the uncarbonised wood. At Llangynfelyn it is probable that a fire of charcoal or wood and charcoal was used in the lead smelting process, although charcoal reduction was not a necessity for smelting ‘black ore’, galena, (Homer 1991; Craddock 1995) and wood alone could have been used. Charcoal reduction was necessary for smelting ‘white ore’ and to rework litharge (residual lead after silver extraction from argentiferous lead). Simple stone lead-smelting hearths where the ore was scattered on top of the fire are recorded from other parts of Roman Britain (Craddock 1995), whilst medieval records indicate that

layers of brushwood and crushed ore were piled onto a log base in a large hearth or bole (Homer 1991; Craddock 1995).

As species may have been deliberately selected for use as fuel, charcoal is not necessarily an accurate reflection of the frequency of the species or the range of species in the surrounding woodland communities. However, the taxa present suggest the exploitation of local oak, hazel and carr woodland and the pollen record (see above) confirms the existence of these communities in the local area. A distinct fall in *Quercus* pollen values as well as reductions in *Betula* and *Alnus* values at Trench 5a may well reflect the felling of woodland for use at the site. These species are also evident in other pollen profiles at the site. The distance to the woodland exploited may have been a consideration in the location of the site; the closer the woodland then the less time and labour would have been involved in transporting the wood.

Coppicing would have been the most efficient method of ensuring a supply of wood for fuel but there is no conclusive evidence from the charcoal record to confirm this. Coppicing tends to produce rapid growth but most of the charcoal examined displayed a growth ring pattern indicating slow rather than fast growth, suggesting exploitation of 'natural' rather than managed woodland. The presence of both fast and slow grown wood indicates the trees had grown under varying environmental conditions.

Low amounts of species such as ash and willow, which also make reasonable fuels, suggest these species were present less frequently or were largely avoided. Whilst ash may have been scarce, pollen evidence from Trench 17 indicates willow was clearly growing nearby, confirmed by the presence of *Salix* wood in the stratigraphy. A decline in *Salix* pollen associated with the deposition of industrial deposits suggests the clearance of willow woodland, but generally willow carr may have been more limited than other woodland and, perhaps because of wetter conditions where it was growing, less favoured for exploitation.

THE INSECT REMAINS

By D. Smith, C. Jolliffe, K. Nayyar, F. Sharrock, E. Tetlow and D. Vaughan

The insect remains examined in this report came from samples from two of the trenches excavated. Trench 5a was located on the medieval trackway c. 100m from the dry land edge. Six samples were analysed, the lowest one dating by interpolation to the fourth to second century BC and the upper one immediately pre-dating trackway construction in the early to mid eleventh century AD. Three samples were analysed from layers underlying industrial deposits in Trench 20, dating from sixth/fourth century BC to the first century BC/AD first century.

Samples were processed using the standard method of paraffin flotation as outlined by Kenward *et al.* (1980). Identification of Coleoptera fossils was carried out through reference to the Gurling and Gorham Coleoptera collections held at the Institute of Archaeology and Antiquity, University of Birmingham. Insect nomenclature follows Lucht (1987), while plant nomenclature follows Stace (1997).

Summary of results from Trench 5a

The six samples from Trench 5a (0–5cm, 5–10cm, 30–25cm, 50–45cm, 75–70cm and 95–100cm) produced moderately-sized coleopterous faunas (Tables 11 and 12). There appears to be little overall change in the local environment indicated by the insect remains.

The vast majority of these are species associated with shallow, slow flowing or stagnant waters often filled with rotting vegetation and detritus. Species typical of these conditions are hydreanids such as *Hydraena* spp., *Ochthebius* spp. and *Limnebius* spp. (Hansen 1986). Also typical of such situations are the various hydrophilids recovered such as *Enochrus* spp., *Chaetarthria seminulum*, *Coelostoma orbiculare* and *Cymbiodyta marginella* (Hansen 1986).

Table 11: Coleoptera from samples associated with the Llangynfelyn trackway

Ecological grouping & Phytophage host plants	Trench 20			Trench 5a					
	53-63	33-43	5-22	100-95	75-70	50-45	30-25	10-5	5-0
CARABIDAE									
<i>Nebria brevicollis</i> (F.)	-	1	-	-	-	-	-	-	-
<i>Nebria</i> spp.	-	-	1	-	-	-	-	-	-
<i>Notiophilus</i> spp. Dum.	-	1	-	-	-	-	-	-	-
<i>Elaphrus uliginosus</i> F.	ws	1	-	-	-	-	-	-	-
<i>Elaphrus cupreus</i> Duft.	ws	1	-	-	-	-	-	-	-
<i>Elaphrus</i> spp.	-	1	-	-	-	-	-	1	-
<i>Loricera pilicornis</i> (F.)	-	-	-	-	-	1	-	-	-
<i>Clivina fossor</i> (L.)	-	-	1	-	-	-	-	-	-
<i>Dyschirius globosus</i> (Herb.)	-	-	1	-	-	-	-	1	1
<i>Trechus quadristriatus</i> (Schrk.)	-	-	2	-	-	-	-	-	-
<i>Trechoblemus micros</i> (Hbst.)	ws	-	-	-	-	-	-	-	1
<i>Bembidion doris</i> (Panz.)	-	-	1	-	-	-	-	-	-
<i>Bembidion</i> spp.	-	1	2	-	-	-	-	-	-
<i>Harpalus</i> spp.	-	-	1	-	-	-	-	-	-
<i>Stenolophus</i> spp.	-	-	1	-	-	-	-	-	-
<i>Pterostichus strenuus</i> (Panz.)	ws	-	-	-	-	-	-	1	2
<i>Pterostichus diligens</i> (Sturm.)	ws	-	-	-	-	2	-	-	-
<i>Pterostichus anthracinus</i> (Ill.)	-	5	-	-	-	-	-	-	-
<i>Pterostichus minor</i> (Gyll.)	-	4	-	-	-	-	-	-	-
<i>Pterostichus angustatus</i> (Duft.)	-	-	-	-	-	-	-	1	-
<i>Abax parallelepipedus</i> (Pill.Mitt.)	-	1	-	-	-	-	-	-	-
DYTISCIDAE									
<i>Hydroporus erythrocephalus</i> (L.)	a	-	1	-	-	-	-	-	-
<i>Hydroporus melanarius</i> (Sturm.)	a-m ¹	-	-	-	-	-	-	-	4
<i>Hydroporus</i> spp.	a	6	2	-	-	1	-	-	-
<i>Agabus</i> spp.	a	3	-	-	-	-	-	-	-
HYDRAENIDAE									
<i>Hydraena</i> spp.	a	10	10	-	-	7	-	-	-
<i>Ochthebius</i> spp.	a	-	6	-	-	-	-	-	1
<i>Limnebius</i> spp.	a	15	1	-	1	-	-	-	-
<i>Hydrochus elongatus</i> (Schall.)	a	-	1	-	-	-	-	-	-
<i>Helophorus</i> spp.	a	-	5	-	-	-	-	-	4
HYDROPHILIDAE									
<i>Coelostoma orbiculare</i> (F.)	a	-	2	-	1	4	-	-	-
<i>Cercyon impressus</i> (Sturm.)	d	-	-	-	-	-	1	-	-
<i>Cercyon convexiusculus</i> Steph.	a	8	-	-	-	-	-	-	-
<i>Cercyon</i> spp.	d	1	3	-	-	3	-	-	-
<i>Megasternum boletophagum</i> (Marsh.)	d	1	-	-	-	-	1	-	2
<i>Hydrobius fuscipes</i> (L.)	-	4	-	-	-	-	-	-	-
<i>Enochrus affinis</i> (Thun.)	a	-	-	-	-	-	-	-	1
<i>Enochrus</i> spp.	a	-	-	-	1	-	-	-	-
<i>Cymbiodyta marginella</i> (Fabr.)	ws	-	2	-	-	-	-	-	2
<i>Chaetarthria seminulum</i> (Herb.)	a	-	1	5	5	-	2	4	5
HISTERIDAE									
<i>Acritus</i> spp.	-	1	-	-	-	-	-	-	-
SILPHIDAE									
<i>Silpha</i> spp.	-	1	-	-	-	-	-	-	-
SCYDMAENIDAE									
Genus and species indeterminate	-	-	1	-	1	2	6	-	-
<i>Cephennium gallicum</i> Ganglb.	-	-	2	-	-	-	-	-	-

continued

Table 11: Coleoptera from samples associated with the Llangynfelyn trackway *continued*

	Ecological grouping & Phytophage host plants	Trench 20			Trench 5a					
		53-63	33-43	5-22	100-95	75-70	50-45	30-25	10-5	5-0
ORTHOPERIDAE										
<i>Corylophus cassidoides</i> (Marsh.)	-	1	-	-	-	-	-	-	-	-
<i>Orthoperus</i> spp.	df	-	-	-	-	-	1	-	-	-
PTILIDAE										
<i>Acrotrichis</i> spp.	-	-	1	-	-	-	-	-	-	-
STAPHYLINIDAE										
<i>Micropeplus tessera</i> Curt.	-	1	-	-	-	-	-	-	-	-
<i>Micropeplus fulvus</i> Er.	-	1	-	-	-	-	-	-	-	-
<i>Proteinus</i> spp.	-	-	-	-	1	-	2	-	-	-
<i>Omalius</i> spp.	-	1	-	-	-	-	-	-	-	-
<i>Olophrum piceum</i> (Gyll.)	ws	6	1	-	-	-	15	1	-	-
<i>Acidota crenata</i> (F.)	df	-	-	-	-	-	-	-	-	2
<i>Lesteva heeri</i> Fauv.	ws	4	-	-	-	-	5	-	-	-
<i>Lesteva</i> spp.	ws	-	3	-	-	-	2	1	1	-
<i>Trogophloeus</i> cf. <i>rivularis</i> Motsch.	-	-	6	-	-	-	-	-	-	-
<i>Oxytelus rugosus</i> (F.)	df	-	2	-	-	-	1	-	-	-
<i>Platystethus</i> spp.	-	-	-	1	-	-	-	-	-	-
<i>Stenus</i> spp.	-	10	5	1	-	1	2	1	2	9
<i>Medon</i> spp.	-	-	1	-	-	-	-	-	-	-
<i>Lathrobium brunnipes</i> (F.)	-	-	-	2	-	-	-	-	-	-
<i>Lathrobium</i> spp.	-	6	3	-	1	-	4	1	2	3
<i>Cryptobium fracticorne</i> (Payk.)	m ²	-	-	-	-	1	-	1	3	-
<i>Xantholinus linearis</i> (Ol.)	-	-	-	-	-	4	-	-	-	3
<i>Xantholinus</i> spp.	-	1	1	3	-	-	-	-	6	-
<i>Philonthus</i> spp.	-	-	2	-	-	-	2	-	6	1
<i>Quedius</i> spp.	-	9	-	-	-	-	1	-	-	-
<i>Tachyporus</i> spp.	-	-	2	1	-	-	-	-	-	2
<i>Tachinus</i> spp.	-	1	-	-	-	1	-	-	-	-
<i>Aleocharinae</i> gen. & spp. Indet.	-	6	10	1	1	1	6	-	-	-
PSELAPHIDAE										
<i>Bryaxis</i> spp.	-	1	3	-	-	-	-	-	-	-
<i>Brachygluta</i> spp.	-	-	4	-	-	-	-	-	-	-
MALACHIIDAE										
<i>Malachius</i> spp.	-	-	-	1	-	-	-	-	-	-
ELATERIDAE										
<i>Adelocera murina</i> (L.)	-	1	-	-	-	-	-	-	-	-
<i>Ctenicera pectinicornis</i> (L.)	g	-	-	-	-	-	-	-	-	1
EUCNEMIDAE										
<i>Dirhagus pygmaeus</i> (F.)	t ³	-	-	-	-	-	1	-	-	-
HELODIDAE										
Helodidae gen. & spp. Indet.	-	3	1	-	-	-	-	-	-	-
<i>Cyphon</i> spp.	ws	1	-	-	1	3	-	-	-	-
DRYOPIDAE										
<i>Dryops</i> spp.	ws	2?	1	-	-	-	-	-	-	-
<i>Elmis aenea</i> (Müll.)	aff	2	-	-	-	-	-	-	-	-
<i>Esolus parallelepipedus</i> (Müll.)	aff	1	-	-	-	-	-	-	-	-
<i>Riolus</i> spp.	aff	-	-	2	-	-	-	-	-	-
CRYPTOPHAGIDAE										
<i>Atomaria</i> spp.	-	-	1	-	-	-	-	-	-	-

continued

Table 11: Coleoptera from samples associated with the Llangynfelyn trackway *continued*

	Ecological grouping & Phytophage host plants	Trench 20			Trench 5a					
		53-63	33-43	5-22	100-95	75-70	50-45	30-25	10-5	5-0
PHALACRIDAE										
<i>Phalacrus</i> spp.	ws	-	-	-	-	-	-	1	-	-
LATHRIDIIDAE										
<i>Lathridius</i> spp.	df	1	2	-	-	-	2	-	-	-
COLYDIIDAE										
<i>Cerylon</i> spp.	t ⁴	1	-	-	-	-	-	-	-	-
LYCTIDAE										
<i>Lyctus linearis</i> (Goaze)	-	-	-	2	-	-	-	-	-	-
ANOBIIDAE										
<i>Anobium punctatum</i> (Geer.)	t ⁵	1	-	-	-	-	-	-	-	-
SCARABEIDAE										
<i>Geotrupes</i> spp.	df	1?	-	-	-	-	-	-	-	1
<i>Aphodius sphaelatus</i> (Panz.) / <i>prodromus</i> (Brahm)	df	3	-	-	-	-	-	-	-	-
<i>Aphodius foetidus</i> (Hbst.)	df	-	-	6	-	-	-	-	-	-
<i>Aphodius fimetarius</i> (L.)	df	-	-	1	-	-	-	-	-	3
<i>Aphodius contaminatus</i> (Herb.)	df	-	-	-	-	-	-	1	-	2
<i>Aphodius</i> spp.	df	-	1	-	-	1	-	-	-	-
<i>Phyllopertha horticola</i> (L.)	g	1?	-	-	-	-	-	-	-	-
CHRYSMELIDAE										
<i>Donacia impressa</i> Payk.	ws ⁶	-	-	1	-	-	-	-	-	-
<i>Donacia / Plateumaris</i>	ws	1?	-	-	-	-	-	-	-	-
<i>Plateumaris discolor</i> (Panz.)	ws ⁷	2	-	-	-	-	-	-	-	-
<i>Plateumaris sericea</i> (L.)	ws ⁸	-	-	-	-	-	-	-	1	-
<i>Plateumaris braccata</i> (Scop.)	ws ⁹	-	-	1	-	-	-	-	-	-
<i>Plateumaris</i> spp.	ws	-	1	-	-	-	-	-	-	-
<i>Phaedon</i> spp.	g	-	-	1	-	-	-	-	-	-
<i>Phyllotreta</i> spp.	g	-	-	3	-	-	-	-	1	1
<i>Chaetocnema concinna</i> (Marsh.)	g	-	-	1	-	-	-	-	5	4
<i>Chaetocnema</i> spp.	g	1	-	-	-	-	-	1	-	-
CURCULIONIDAE										
<i>Apion cruentatum</i> Walt.	g ¹⁰	1	-	-	-	-	-	-	-	-
<i>Tanyssphyrus lemnae</i> (Payk.)	ws ¹¹	-	2	-	-	-	-	-	-	-
<i>Leiosoma deflexum</i> (Panz.)	- ¹²	-	1	-	-	-	-	-	-	-
<i>Micrelus ericae</i> (Gyll.)	m ¹³	-	-	-	-	2	-	-	1	1
<i>Ceutorhynchus</i> spp.	g	-	-	-	-	-	3	-	1	-
<i>Gymnetron</i> sp.	d	-	-	1	-	-	-	-	-	-
<i>Limnobaris ?pilistriata</i> (Steph.)	ws ¹⁴	-	-	-	-	-	-	-	3	1
<i>Rhynchaenus</i> spp.	t	-	-	-	-	-	4	-	-	-

Key for ecological groupings

a = aquatic species; aff = aquatic species associated with fast flowing water; ws = waterside species either from muddy banksides or from waterside vegetation; df = species associated with dung and foul matter; d = species associated with dung; g = species associated with grassland and pasture; t = species either associated with trees or with woodland in general; m = species associated with moorland.

Notes for Phytophage host plants (based on Koch 1992)

1. Acid water specialist; 2. *Sphagnum* moss; 3. Range of hard wood trees; 4. Dead hardwoods; 5. Dead hardwoods; 6. *Schoenoplectus lactustris* (L.) Palla (Common Club Rush); 7. Usually on *Eriophorum* spp. (Cotton grass); 8. Usually on *Carex* spp. (sedges); 9. *Phragmites australis* (Cav.) Trin. ex Steud. (water reed); 10. Usually on *Rumex* spp. (Dock); 11. *Lemna* spp. (Duckweed); 12. *Caltha palustris* L. (Marsh marigold); 13. On *Calluna* spp. and *Erica* spp. (Heathers); 14. Juncaceae (rush family) and Cyperaceae (sedge family).

Table 12: The percentage proportions of the ecological grouping of Coleoptera from Trench 5

Trench depth of bulk sample (cm)	100–95	75–70	50–45	30–25	10–5.01	5–0
Total number of individuals	12	22	64	11	40	55
Number of species	8	11	22	10	17	23
<i>Ecological grouping</i>						
aquatic	58.3%	27.3%	18.8%	18.2%	10.0%	27.3%
aquatic fast flowing	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
waterside	8.3%	18.2%	37.5%	36.4%	22.5%	10.9%
dung	0.0%	0.0%	10.7%	40.0%	0.0%	5.8%
dung/foul	0.0%	8.3%	14.3%	0.0%	3.7%	23.5%
tree	0.0%	0.0%	17.9%	0.0%	0.0%	0.0%
grass	0.0%	0.0%	10.7%	20.0%	25.9%	17.6%
moorland	0.0%	16.7%	0.0%	0.0%	3.7%	2.9%

There are also indications that stands of sedges (*Carex* spp.) and reeds (*Phragmites australis* (Cav.) Trin. ex Steud.) occurred in the area, especially towards the top of the sequence. This is most clearly suggested by the presence of the ‘reed beetle’ *Plateumaris sericea* and the weevil *Limnobaris pilistriata* both of which are associated with sedges (*Carex* spp.) and rushes (*Juncus* spp.), as are the *Phalacrus* species (Koch 1992).

There are also clear suggestions that moorland and heathland existed in the area. This is suggested by the small diving water beetle (*Hydroporus melanarius*), which is associated with small pools of acidic water in swamps, bogs and marshes (Nilsson and Holmen 1995). Similarly the rove beetle (*Cryptobium fracticorne*) is often associated with pillows of *Sphagnum* moss. Heather (*Erica* spp. and *Calluna* spp.) is indicated by the small weevil (*Micreles ericae*) which is found in some numbers (Koch 1992). The latter species does seem to occur more often at the top of the sequence, perhaps suggesting that the bog surface had progressively dried (or periodically dried-out) before the establishment of the track. This is confirmed by the pollen and plant macrofossil evidence which also indicates raised bog vegetation in the area at this time (see Caseldine and Griffiths above).

There is also a suggestion that fen or wet woodland might have occurred later in the sequence represented by these samples. This is suggested by the presence of the Eucnemid *Dirhagus pygmaeus*, a species which is associated with the dead wood of oak and other hard wood trees, and the leaf miner (*Rhynchaenus* spp.). The information from the pollen and plant macrofossils is much clearer and suggests that alder (*Alnus*) and birch (*Betula*) expanded during this time.

The presence of a number of individuals of *Aphodius* and *Geotrupes* dung beetles, particularly from just below the trackway in samples 0–5cm and 5–10cm may indicate that large grazing animals were present in the boglands or are associated with the use of the trackway itself, since these species are associated with ‘dung pats’ lying in the open (Jessop 1986). However, as with the indicators for woodland, this actually represents a very limited number of individuals and should not be overstressed in the interpretation of these faunas and the use of the trackway itself. Equally, dung beetles fly very long distances as they search for new pats to colonize (Kenward 1975; 1978), which means it is just as likely that these individuals could have come from the nearby dry land as the bog itself.

Summary of results from Trench 20

The three samples from below the trackway in Trench 20 (5–22cm, 33–43cm and 63–53cm) produced a series of moderately sized insect faunas that are essentially similar to those from Trench 5a, and to each other

Table 13. The percentage proportions of the ecological grouping of Coleoptera from Trench 20

Trench depth of bulk sample (cm)	63–53	43–33	22–05
Total number of individuals	137	84	48
Number of species	48	32	31
<i>Ecological grouping</i>			
aquatic	30.6%	23.8%	18.8%
aquatic fast flowing	2.2%	0.0%	4.2%
waterside	13.1%	9.5%	8.3%
dung	2.7%	0.5%	3.0%
dung/foul	5.8%	8.9%	21.2%
tree	2.7%	0.0%	0.0%
grass	4.1%	0.0%	15.2%
moorland	0.0%	0.0%	0.0%

Note: not all taxa have been assigned to an ecological group and as a result percentages do not total 100%

(Tables 11 and 13). A range of water beetles, for example *Ochthebius* spp., *Hydraena* spp., *Chaetarthria seminulum*, *Coelostoma orbiculare* and *Cymbiodyta marginella* and *Cercyon convexiusculus*, all indicate the presence of slow flowing or stagnant water (Hansen 1986). Similarly, there is some indication that stands of water reeds and other emergent vegetation occurred in the area. The clearest indication for this is the presence of individuals of the reed beetles (*Plateumaris braccata*), which is associated with *Phragmites* water reed (*Phragmites australis* (Cav.) Trin. ex Steud.), and *Donacia impressa*, associated with common club rush (*Schoenoplectus lactustris* (L.) Palla.). Similarly the small weevil *Tanysphyrus lemnae* is associated with duckweeds (*Lemna* spp.).

There are suggestions that acid water and moor conditions occurred throughout the sequence. In the lower samples this is indicated by the presence of *Plateumaris discolour* which is associated with cotton grass (*Eriophorum* spp.) (Koch 1992) and in the upper sample by the small water beetle (*Hydroporus erythrocephalus*) which is often associated with fen and bog waters (Nilsson and Holmen 1995). In the lower sample from Trench 20 there are a few individuals of elm mid riffle beetles, including *Elmis aenea*, *Esolus parallelepipedus* and *Riolus* spp. These taxa are often associated with sandy substrates and flowing water (Holland 1972), but in these circumstances probably occur in gravelly areas on the edges of open pools where small waves lap against the shore.

Similar to the insect faunas recovered in Trench 5a, there are again a number of dung beetles present throughout the sequence. This may indicate that animals grazed the moorland, though they also may have flown in from the adjacent dry land.

There also appears to be limited evidence for the presence of deadwood or woodland. This is suggested by the presence of the woodworm (*Anobium punctatum*), the powder post beetle (*Lyctus linearis*) and the *Cerylon* spp. These taxa could be associated with woodland communities on the dry land or any fen woodland in the nearby vicinity. The pollen and plant macrofossil remains indicate that in fact alder carr was a dominant feature of the landscape at the dry land edge. Alder is a species of tree which is persistently under represented in the palaeoentomological record probably as a result of the fact that there are very few species of beetle that are specifically associated with it (Girling 1985; Robinson 1993; Smith *et al.* 2000; Smith and Whitehouse 2005).

Discussion of the insect remains

The insect faunas from Llangynfelyn clearly suggest that throughout the period of peat development the area consisted of acidic fen and bog supporting sedge, reeds and cotton grass vegetation. Locally, there appears to have been patches of heather and fen woodland. There are also slight indicators that animals grazed either the open bog or the nearby dry land. The bog surface may also have dried before the establishment of the trackway and there may have been periods when fen woodland occurred in the area. These results are broadly in agreement with the pollen and plant macrofossil evidence. The insect remains recovered appear to indicate that the deposits sampled were from the later part of the sequence of development identified by Godwin and Newton (1938) and by Hughes and Schulz (2001) from further out in the bog and reflect conditions at the margin.

In terms of archaeoentomology, there are very few studies of similar deposits in the area. One notable exception is the series of faunas from late Mesolithic/Early Neolithic deposits from the river Clettwr, Ceredigion (Jolliffe 2006). The insects from the trackway at Cors Fochno are certainly the only insect faunas from the area of this relatively late date. Although a similar medieval track, is known at Llanaber near Barmouth (Musson *et al.* 1989) no insect faunas were associated with it. Other insect faunas associated with tracks in Britain are of a much earlier date, for example the Bronze and Iron Age tracks at Goldcliff, Gwent (Smith *et al.* 2000) and the Neolithic and Bronze Age examples from the Somerset Levels (i.e. Girling 1977; 1979; 1980).

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NOTES

1. All of or formerly of the Dyfed Archaeological Trust, The Shire Hall, Carmarthen Street, Llandeilo, Carmarthenshire, SA19 6AF.
2. All of or formerly of the School of Archaeology, History and Anthropology, University of Wales, Trinity St David, Lampeter, Ceredigion, SA48 7ED.
3. Early Mines Research Group, Ashtree Cottage, 19, The High Street, Fen Ditton, Cambridgeshire, CB5 8ST.
4. All of or formerly of the Institute of Archaeology & Antiquity, University of Birmingham, Edgbaston, Birmingham, B15 2TT.
5. Ordnance Survey, 1972, 72 426 271. Copy in the National Monuments Record, housed with the RCAHMW, Aberystwyth.

6. E. C. Grimm, TILIA and TILIAGRAPH (Springfield: Illinois State Museum), 1991; TGView Version 2.0.2. (Springfield: Illinois State Museum), 2004.

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