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Pentrwyn Bronze Age Metalworking Site, Great Orme

The Pentrwyn site (immediate foreground) in the mid 1850's before the construction of the Marine Drive.

Summary

In 1997 David Chapman identified archaeological remains eroding out off a cliff on the Pentrwyn headland, Great Orme. These remains consisted of an apparent burnt layer and a 'v'-shaped feature, both exposed in section. Charcoal, shell and bone fragments were observed within these deposits, as were small fragments of copper slags. The potential of this site was raised by the near location of the prehistoric copper mines in the Pyllau valley on the Great Orme. The remains were brought to the attention of the Cadw: Welsh Historic Monuments who subsequently funded a partial excavation of the site. The excavation of the upper layers produced over one hundred fragments of copper slag, the highest proportion of which were associated with a small feature which has been dated to the fifteenth century BC, contemporary with the earlier periods of activity at the Pyllau valley site and making the Pentrwyn site the earliest known metal working site in Great Britain.

Re-deposited slags were also found in higher layers which appear to be the remains of medieval (cal AD 1220) activity, which consisting of a pit containing burnt stones and food debris and an associated hearth.

Please read on for the interim report of the excavation and the historical background of this fascinating sites. You can skip to each section via the headings below:

Archaeological Background

The earliest archaeological evidence for human activity on the Great Orme comes from the Upper Palaeolithic period (Sieveking 1960) when a number of natural caves were occupied. Some of these caves continued to be used into the Neolithic and Bronze Age periods (Lewis 1993, 12). Lloches yr Afr rock shelter is within 200m of the Pentrwyn site, and which when excavated in the 1970's produced evidence for archaeological remains from the Mesolithic period through to the Neolithic and possibly the early Iron Age (Davies 1989, 93).

The most notable, surviving monument on the Great Orme, is the chambered tomb of Llety'r Filiast, an Irish type Portal Dolmen (Lynch 1969, 140) , probably dating from the late Neolithic period. At least four cairns, one other possible megalithic tomb and one probable long barrow, now destroyed, are reported on the Great Orme (Lewis 1993, 13). At the foot of the Great Orme where the present town of Llandudno is located, there was reported an 'oval-shaped mound' (Roberts 1909) called 'Y Gorseddau' or 'high places/throne'. When the mound was levelled in the nineteenth century 'several earthern urns containing

what was believed to be cremated human remains' were uncovered. The land-ward side of the Orme is dominated by the promontory fort Pen y Dinas. Precipitous cliffs and earth and stone ramparts defended at least sixty five round huts. The only dating evidence for this site was a single sherd of Samian ware recovered in the nineteenth century, although its origins may be much earlier (Muckle 1993, 1). Both isolated and groups of round huts some with associated filed banks, indicate prehistoric or Romano-British occupation.

Evidence for Medieval activity is represented by a number of rectangular huts and extensive areas of associated ridge and furrow systems, some of which probably relate to the three Medieval townships of Gogarth, Cyngreawdr and Yr Wyddfid. A small group of rectangular structures, with associated enclosures and cultivation ridges, probably from the medieval period, are located on the plateau at the top of the cliffs above the Pentrwyn site. The church of St Tudno's on the headland, structurally dates to the twelfth century, but it is thought that its original foundation dates to the period contemporary with St Tudno himself, in the sixth century (Bibby 1979, xi). At the south-western foot of the Orme are the remains of the late thirteenth century, ecclesiastical grange of Gogarth.

A number of finds from the Bronze Age period have been found on the Great Orme, the most notable was discovered in 1898, when two boys uncovered a group of objects consisting of two gold, finely engraved, penannular ear-rings (not a pair), a damaged bronze palstave and a socketed bronze implement, probably an awl for leatherworking '*amongst the debris at the back of a large loose rock*' near Pigeon's Cave (Savory 1954, 51). All the objects are thought to be of the Late Bronze Age, while the ear-rings have been identified as Irish in style. No accompanying burial was found with the hoard. This cave is located to the west of Pentrwyn (300m from the site), below the Marine Drive.

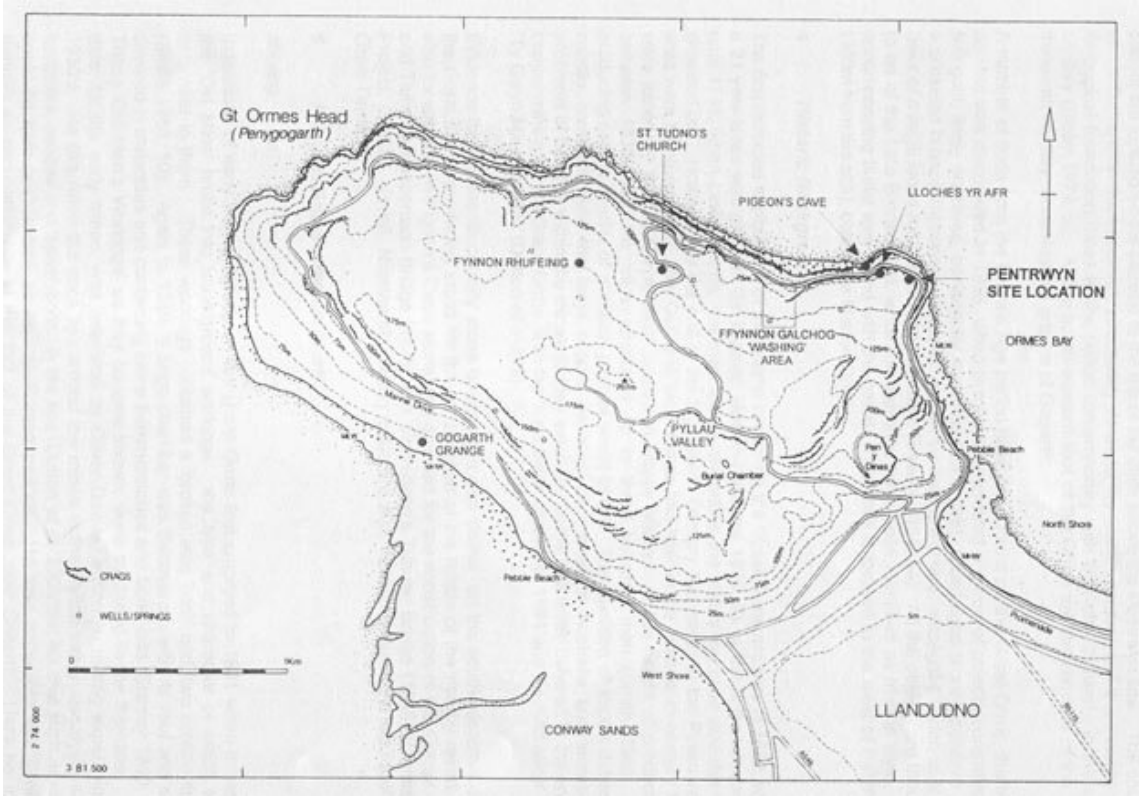

Figure 1: The Great Orme headland and the location of sites mentioned in the text.

Historic Background

The first recorded exploitation of the copper ores from the Great Orme appears in 1692, when a 21 year lease was given to Sir Thomas Mostyn (Williams 1979, 7). Little is then recorded until 1748, when Lewis Morris, the map maker, describes the mines as '*quite sizeable and drowned out*'. However, by the end of the Eighteenth Century two mines in the Pyllau valley area were being exploited: the 'Old' and 'New' mines and later in the nineteenth century they were joined by the 'Ty Gwyn Mine' located in Happy Valley. At the height of production, between 1830-1850, the mine employed up to three hundred men (Smith 1988, 11), producing over a quarter of a million pounds worth of ore. The abolition of import duties on copper combined with the large copper deposits discovered in Australia and increasing problems of flooding within the mines as they extended below sea level, ushered in the end of copper mining on the Great Orme, with the 'New Mine' closing in 1864 and the 'Old Mine' and 'Ty Gwyn Mine' in 1881 (Dutton *et al* 248).

Evidence for Nineteenth century stone quarrying is also visible on the south-eastern side of the Great Orme, producing stone for the construction of the hotels of the nearby resort and also for export. At Pigeon's Cave stone was quarried for the construction of the Conwy Cob and Telford's Suspension Bridge (1826) and Stevenson's Tubular Bridge (1848) (Ormesday Project, GOES). Small, Nineteenth century trials are also located around the whole of the Great Orme.

Previous Archaeological Work

Mining

Indications of early mining activity on the Great Orme first emerged in 1831 when miners in the 'Old Mine' broke into underground workings, the type and character of which were unfamiliar to them. These workings contained a 'broken stag horn' and 'two bronze items' (Smith 1988, 10). Again in 1849, a large chamber was discovered, with its roof and sides covered in stalactites and containing stone hammerstones and bone tolls (Stanley 1850, 68). These 'Old Men's Workings' as they became known, were attributed to the Romans. This date, for the early mines, was reiterated by Oliver Davies, a Roman mining expert, in the 1930's. He examined the spoil tips around the mines in the Pyllau valley identifying stone hammers, pestles and 'sawn' bone in the tips (Dutton *et al,* 250), but felt that such artefacts could be from post-Roman as well as Roman periods. He also excavated trial trenches through an occupation site at the foot of the Great Orme near Gogarth. Here he found occupation debris and some hammer stones, but no ore or slags. Sherds of Romano-British pottery date this site to the late 2nd century AD.

The Roman date for the 'Old Men's Workings' remained unquestioned until the 1970's when underground explorations of the 'older' workings by Duncan James, beneath Bryniau Poethion provided the first date in Britain for Bronze Age mining 2940+/-80 BP (HAR-4845) 1410-920cal BC (Lewis 1998, 45). Since then further investigations in the Pyllau valley area to the south of Bryniau Poethion by the Great Orme Mines Ltd, Gwynedd Archaeological Trust and the Great More Exploration Society have identified an extensive area (5,000 sq m) of bedrock and surface workings (Dutton *et al,* 252) and over 6km of prehistoric underground passages, covering an area of almost 24,000m square and occurring to a depth of 65m below surface (Lewis 1998, 51).

A total of thirteen radiocarbon dates have been obtained from both above and below workings. These span a calibrated range of 1880-600 BC, covering the Early to Late Bronze Age (Lewis 1998, 49), with a notable grouping around 1300-1400 BC (Lewis 1998, 49).

Excavations at the Pyllau valley site have produced thousands of artefacts from prehistoric mining assemblages:

Bone tools

The neutral to alkaline conditions at the mine site and within the spoil tips help to preserve bone material, much of which is discoloured blue/green by impregnation of the copper carbonates solutions present in the ground water, or blackened by manganese solutions in the ground water (Dutton *et al* 1994, 269). A marked proportion of these bone fragments exhibit wear and fracturing consistent with use as primitive scrapers, chisels and gouges to remove the rotted dolomitized host rock around the ore bearing material. Tool marks consistent with this have been identified in the prehistoric workings, especially in areas of shale or mudstones. Animal long bone predominate, typically tibia, ulna and rib. Although, some may relate to food use, the butchery marks on some samples seem to indicate tool manufacture rather than marrow extraction (Lewis 1998, 49).

Stone tools

Over two thousand stone hammers/mauls have so far been identified. Typically ovoid in shape, and between 20kg to 29kg in weight, most are pebbles of igneous types common to local beaches. Wear patterns on the surfaces suggest a crushing or pound action taking place, and generally there is a low degree of modification for hafting (Lewis 1998, 49). Approximately 10% of stone tools found have 'hollowed crushing surfaces' (Dutton *et al* 1994, 272) with 'mortar' and 'pestle' types present in surface or near surface contexts, suggesting on site primary crushing.

Spoil

Due to the different techniques used to extract the ore in the prehistoric and modern periods, it has been possible to develop criteria for identifying waste types. In general perceived prehistoric waste comprise predominately uniformly sub-angular rotted dolomite with associated bone and stone tools. More recent waste generally comprises harder crystalline dolomite and limestones, of more angular and less sorted spoil.

Processing sites

In recent years work has been carried out to identify secondary processing sites on the Great Orme associated with the Bronze Age mining activity (Jones 1994 & Wager 1996). The crushing of the material removed from the mine, and the concentration of the ore to separate the ore from the gangue (host rock) would have been an important stage in the preparation of the ore for smelting. Mortar and pestle type stones found at the mine site suggest that some crushing was taking place there, but it has been hypothesised, that water separation or concentration may have taken place at the number of well sites on the Great Orme. As a result, these possible 'washing' sites have been the subject of a number of recent studies (Jones 1994 & Wager 1996). One of these at Ffynnon Galchog/Porth y Helig was identified as a 'Roman' washing site by a series of newspaper article written in 1909 (Roberts 1909). Such a statement follows a local, as yet unproven, tradition that the Romans mined copper on the Great Orme. However, as the site is attributed to such a tradition it infers that the site had not been used as a washing site in living or recent memory. The article goes on to describe how 'tons of copper slime' located around the well were transported to the smelters 'many years ago' (Roberts 1909), probably sometime before 1850. Excavation by the Great

Orme Exploration Society and Gwynedd Archaeological Trust in 1990 of two small trenches through the spoil tips which are still visible, confirmed that they consisted of well-sorted and graded deposits of dolomitic silts, sands and gravels similar to the dolomitic waste found at the mines (Lewis 1990, 10). Copper-stained bone artefacts, including three shaped tools and a number of hammerstone fragments were also recovered. Both the artefacts and the mineralogy resembled those from the prehistoric assemblages at the mining site and the crushed nature of the material suggests processing taking place (Jones 1994, 69). A single radiocarbon date was obtained from bone collagen within the tip, producing a date of 1200 +/- 60 BP (BM – 2753) or 720 – 740 AD and 680 – 960 AD Cal. (Lewis 1993, 56). This surprising date, remains unsatisfactorily explained, but may indicate that early Medieval mining activity, using techniques and tools almost identical to prehistoric ones, were taking place, or that this single sample may have been contaminated.

Smelting evidence

During the past ten years further work by archaeologists have identified over twenty sites in Wales alone which have produced evidence for possible prehistoric phases of workings, seven of which have been radiocarbon dated to the Bronze Age (Pickin 1990, 69). As of writing no definite smelting residues or sites have been identified from known early British mining sites. This is the case on the Great Orme, where in the past prehistoric mining has generally been seen as a large-scale activity, which would have soon depleting the fuel sources on the Orme, resulting in the ore being transported to more accessible fuel resources.

In 1997, the University of Wales Bangor undertook a geochemical survey of the Great Orme, with the aim of locating mining, processing or smelting sites. Using a portable XRF field analyser (TN Spectrace 9000) soil samples from a 200m grid were taken, revealing major anomalies of copper (Cu). Some of theses anomalies were identified with the known mining areas, while others were located at the suspected secondary processing sites at Ffynnon Galchog and Ffynnon Rhufeinig. In addition, a area of possible smelting activity was identified around the summit of the Orme (Jenkins *et al* 1997, 29). During the fieldwork for this project and prior to the excavation, three samples were taken from the exposed section of the Pentrwyn site. At ground level, on the top of the terrace, a reading of 138 mg/g of Cu was recorded, a reading of 490 mg/g of Cu was recorded from a burnt layer just beneath the top soil (probably context 021) and a notably high reading of 1,260 mg/g of Cu was recorded from the 'v' - shaped feature originally identified in section (Jenkins *pers comm.*). All these reading are above natural levels, the final reading is particularly high.

Site Location

The site is located on the headland known as Pentrwyn, at the foot of overhanging limestone cliffs. It is all that remains of a once much larger natural terrace (*c.* 8 - 9m wider than present), that was truncated during the construction, between 1875 – 1878 (Wynne Jones 1975, 45), of the Marine Drive, which not only removed all the soil cover but also blasted away the underlying bedrock, as confirmed by the number of drill holes still visible in the exposed cliff between the road and the terrace. This road replaced a rough, and in places very dangerous, path known as Cust's Path (the path and original terrace can be seen in the immediate foreground of the front cover illustration).

There are no known areas of dolomitized limestone in the immediate vicinity and no notable deposits of copper mineralisation. There is a small trial (probably nineteenth century) below the site, to the west, at Pigeon's Cave, but it does not appear to have been productive. This cave forms part of a natural quay (it was indeed used as such in the nineteenth century to shipped quarried stone from adjacent cliffs (Jones 1994, 58). It is, also, one of very few coastal landing places on the eastern side of the Great Orme, accessible at high and low water and sheltered from the prevailing winds from the south-west and most other wind directions. Recent work on sea-level changes in the area, suggest that the present coastline on the eastern side of the Great Orme, has been much the same since the Neolithic period (Bannerman *pers. comm.)*. The location of the site, on the end of a headland, near to one of the few marine access points on the eastern side of the Orme, therefore, may indicate the importance of the sea as a transport route to the prehistoric metalworkers on the Orme.

The site itself is protected from the prevailing winds and close-up to the cliff also from easterly winds and rain due to the overhang directly above. This overhang would also prevent debris from the plateau above from falling directly onto the site.

The possible prehistoric copper ore 'washing' site at Ffynnon Galchog lies *c.* 500m to the west, on the plateau above the site. The extent of the spoil heaps associated with this site do not appear to extend to the area directly above the site, so contamination from the 'washing' area seems very unlikely. The absence of graded mining spoil on the Pentrwyn site (typical debris associated with 'washing' techniques) also seems to confirm this.

Excavation

Initially, a survey of the site and the immediate area around, was undertaken. The eroding section was then cleaned, photographed and drawn. The dark layer (005), at the top of the 'v' - shaped feature (see figure 2) that had originally lead to the discovery of the site, was identified as a possible buried ground surface, with evidence for leaching and deposition occurring below. The 'v'-shaped feature was sealed by a brownish pink silty clay (002), above which copper working debris was identified eroding out of a thin deposit (021) located immediately below the topsoil (001).

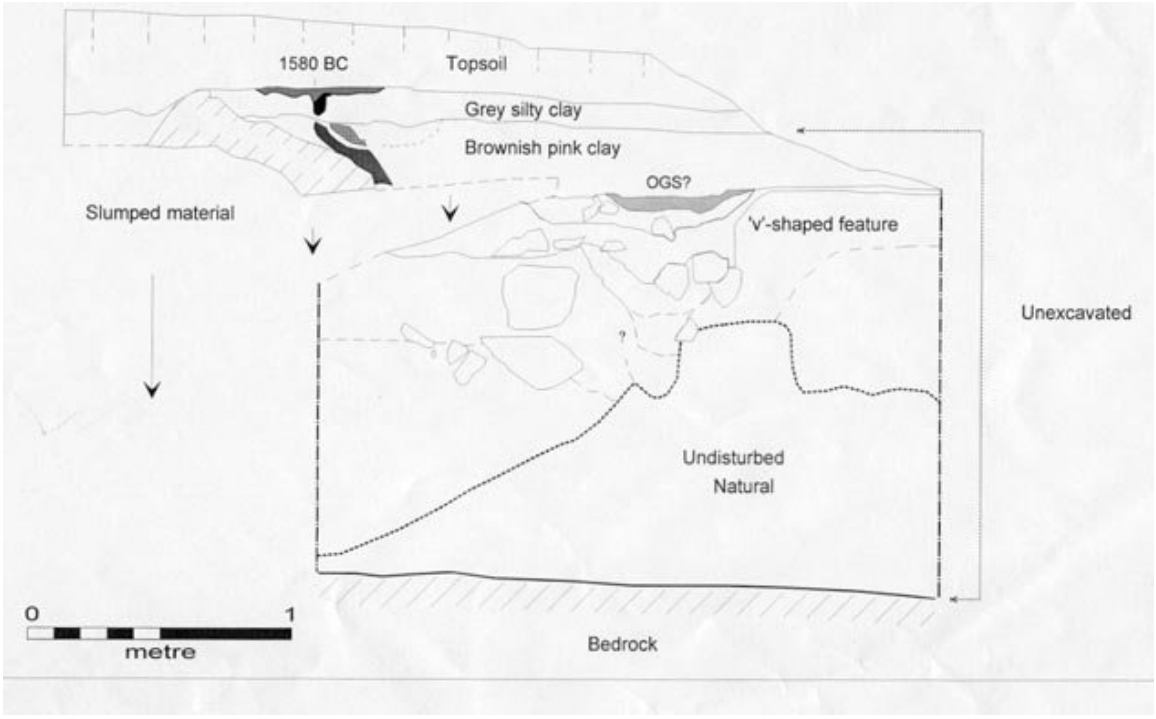

Figure 2: The main east facing section.

The topsoil was removed manually from an area measuring 2.2m by 1.8m, which constituted about 70% of the surviving terrace. Samples from all contexts were wet sieved on site in order to check for the presence of small fragments of metal working debris. Samples for post-excavation analysis were also collected.

This area was excavated down to a brownish pink silty clay (052), consistent with context 002 recorded in section. Bone and shell fragments were still present in the upper part of this silty clay, as were fragments of slag. This clay was interpreted as disturbed or possibly re-deposited natural, due to its mixed nature. It sealed the 'v'-shaped feature and the possible buried ground surface (005) (this feature remains unexcavated).

Directly overlying the clay, several pockets of a grey silty layer were found across the area excavated. They appeared to be at the same stratigraphic position, although, were separated by outcropping bedrock in places, and differential drainage over the site resulted in a number of different context numbers being allocated to it. This grey layer contained fragments of bone and ore (malachite in dolomitised limestone), as well as slags.

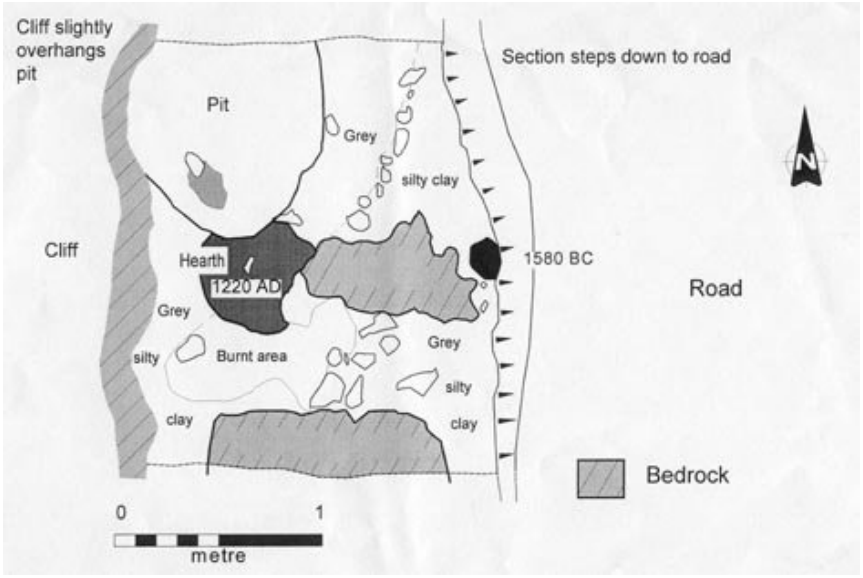

Figure 3: Plan of the site (after the removal of the topsoil)

The greatest concentration of slag was found in a small, charcoal-rich feature (021) first seen in the section. It was a sub-circular patch of dark material, cutting the grey silty clay layer. It was about 200mm in diameter and 30mm deep and was removed in its entirety. Directly beneath this was a small, conical-shaped hole (030) (40mm in diameter and 1200mm in depth) which cut the grey silty clay and was filled by a charcoal rich, dark silt (029). Two small fragments of slag were recovered from this context, along with nine small (*ca.* 5mm) fragments of a fine grained, weakly cemented, sediment matrix with one surface coated with a thin grey/dark grey curved vitreous skin, with small blebs penetrating the matrix below. These fragments are

thought to relate to a smelting process, perhaps representing the remains of a crucible fragment or slag spill (Jenkins *pers comm.*). Further analysis of these fragments is being undertaken by Dr Chris Salter, Oxford University. Charcoal fragments from this context have produced a radiocarbon date of 3310+/- 80 BP or cal BC 1580 (Beta-127076).

Two further charcoal concentrations were found on the terrace (though not visible in the main section). The earliest (023) was a thin layer of burnt debris, which overlaid the grey silty layer. It contained charcoal fragments, slag, burnt stone and some unburnt animal bones (032), and became more mixed at the edges. This was cut by a shallow bowl-shaped feature (031), 150mm deep and 550mm in diameter, which also cut the grey silty layer. The lower fill of this feature (036) consisted of almost 100% charcoal, dropping to 70% charcoal in places. This was covered by a layer of ash suggesting *in situ* burning. A charcoal sample from 036 produced a date of 840+/-60BP or cal AD 1220 (Beta-127077).

The hearth was cut by a pit (025). This pit also cut the grey silty and on its north-eastern side, it also cut a small, roughly triangular depression (042), which overlaid the grey silty clay and was filled by a firm yellowish brown silty clay (044). It was not fully excavated, with the northern side continuing into the section at the northern limit of the excavation; while on the western side it slightly undercut the base of the cliff. The excavated portion was sub-circular in shape and approximately 1m in diameter. It contained two fills: the lowest of which (035) was a dark grey clayey silt, containing fragments of burnt stone and animal bone (including one tooth) and marine shells, mostly limpets (*Patella vulgata).* This fill sloped from north to south within the pit and was seen to underlay a mid brownish grey silty clay (026 & 038). Again this fill contained fragments of burnt stones (pebbles), sea and land snails and bone fragments, both burnt and unburnt. A whetstone was recovered from the top fill (026) of the pit. It shows signs of polishing, and also, there is evidence that it has been used to hammer or crush material. The pit was approximately 0.4m deep, sloping (east to west) at the bottom with the fills of the pit probably consisting of the mixed disturbed grey silty clay and debris.

Few examples of slag material were recovered during excavation, due to the small nature of the artefacts (<5mm). However, on site wet sieving did produce nearly one hundred fragments of slag. Most slags were found around the small feature of Bronze Age date (029) and the lower contexts, with few slags recovered from the southern and western sides of the area.

Fragments of burnt stones, shells (both land and sea) and bones were found in the topsoil, as was a fragment of a dark shale bracelet. No slag fragments were recovered from the topsoil.

Finds

Slags

Close to a hundred small pieces of copper-rich debris were recovered from the site. These consisted of crushed malachite and dolomite and small fragments of copper metal within a slag matrix. These finds suggest that several different processes were being carried out in the vicinity. Copper ores do not occur naturally on this part of the Orme and must therefore have been brought to the site; and copper metal can only be produced in a furnace at high temperatures (Chapman *pers. comm.)*. The slags are currently being analysed by Oxford University, where initial analysis has identified them as slags derived from the smelting of sulphide ores and not the expected carbonate ores (Salter *pers. comm.*).

The small, crushed nature of the slag material recovered may be the direct result of a crushing process used to retrieve prills of copper from the slag matrix after the initial smelting. Once separated from the slag the prills could then be melted into larger quantities of copper metal. Identical crushed slags have recently been produced during experimental smelting of Great Orme ore using a bowl furnace by Chapman and Roberts (Chapman *pers comm.*).

Lithics

Only three stone artefacts were recovered from known contexts: a piece of shale bracelet from the surface of a brownish grey silty clay (020) overlying the pit; a flint flake from the topsoil (001) and a whetstone from the pit (025).

Whetstone

The whetstone was retrieved from the upper fill (026) of the pit 025. The stone surface is uniform “light olive grey” (Munsell: 5Y6/1) in colour, and its well defined orthogonal shape is determined by a major and two minor planar joint surfaces. It has a uniform fine grained texture (grain size 0.1-0.2mm) with quartz, felspar and biotite visible, together with occasional blebs of pyrite: it would appear to be fine grained silicic/intermediate igneous rock such as a microgranite.

The whetstone showed several distinct wear patterns, suggesting different uses. Whilst the larger flat surfaces and the side edges show evidence of polish, suggesting use as a whetstone, short edges and corners show evidence of abrasion by percussion, suggesting use as a hammerstone. The corners show damage consistent with having been used to crush some material, while larger missing flakes from the corners suggest a far more vigorous battering or hammering action. In places these crushing and battering marks had been partly worn flat by it’s re-use as a whetstone. Therefore, the stone appears to

have been a multi-purpose tool, used as a sharpening implement tool and also a crushing implement.

It is possible that the whetstone was used to crush up the ores found on site. However, microscopic inspection of the abraded surfaces of the whetstone revealed no evidence of its use in ore or slag crushing – for example in embedded fragments of chalcopyrite or of malachite (Jenkins *pers. comm.*). Any fragments of ore or slags, though, may have already corroded. It is, therefore, unclear if this stone was involved in any prehistoric metalworking on the site and was re-deposited in the Medieval/post-medieval pit or is indeed a Medieval/post-medieval artefact.

Shale bracelet fragment

A fragment of a shale bangle/bracelet was recovered from the surface of the grey silty clay 020 at the southern end of the site. It appears to have delaminated along natural bedding plains, so that it now appears as half sectioned. It is made from a very dark grey carboniferous shale, examples of which are found locally at Bangor and on Anglesey. The identification of micro-fossils in the shale could locate its origin more precisely. It has a number of cut marks on the outer surface. By extrapolating the curvature of the bracelet it is possible to reconstruct its original dimensions. It's external diameter would have been approximately 850mm and it's internal diameter approximately 660mm. Jet ornaments are known from the Beaker period in Gwynedd, but shale ornaments from any period are rare. A shale ring from the Romano-British period has been found in Caernarfon (White, 1985), and a number of Late Bronze Age examples are known from Flag Fen (Pryor, 1991, 117 & 96).

Flint Flakes

A weathered flint flake was recovered from the topsoil (001) at the southern end of the site. It still retained part of the original nodule surface, suggesting that was not, originally a beach pebble and may well be imported.

A weathered flint flake, with possible micro chipping, was also recovered from slump material that had eroded out of the main site section, prior to excavation.

XRF Trace element data

During the excavation, Dr David Jenkins of the University of Wales, Bangor, took twenty seven samples from the main contexts on the site for XRF trace element analysis. These samples showed a range of values for copper (Cu) from around the crustal average (55mg/g) to 1%. Two samples, from 021 and 029 had levels that indicated 'major' contamination (10,400mg/g & 9,750mg/g), which could only realistically arise if metal working was taken place on site, as the solid geology is devoid of any indications of local mineralisation. Other values (200-100mg/u) could indicate either minor direct contamination through metal working or, post-depositional distribution of Cu through leaching from other contexts. Such readings were identified in most contexts apart from the topsoil and the *in situ* burnt area. Contamination levels were also recorded in the re-deposited, brownish pink clay layer which overlay the unexcavated 'v'-shaped feature. The original geochemical survey of 1997, also recorded a notably high level of copper contamination in the top (old ground surface?) of this 'v'-shaped feature. Both may be the result of the minerals leaching down through the contexts.

Of the other elements for which the XRF produced data, none of the chalcophilic elements which might be associated directly with copper (Cu) show any significant correlation with high readings of copper. This might suggest that either the purer hydroxy-carbonate (malachite) ore was being processed or that a pure metal was being worked (Jenkins *pers. comm.*).

Conclusions

The excavation has revealed two principal phases of use: the earliest is interpreted as a Bronze Age smelting site, and the later phase as Medieval domestic activity.

The only remaining *in situ* feature from the early phase is the small feature (021&030) located on the very edge of the eroding section, which contained the highest concentration of slag material. It has been suggested (Chapman *pers. comm.*) that the contents of this feature may be the contents of a cleaned crucible, the fragments of possible crucible or furnace surface also found within this context may confirm this interpretation. The grey silty clay layer, that contained slag fragments, may have be a contemporary layer, however, it has been disturbed by Medieval (possibly post-medieval) activity, notably by the cutting of the pit (025) and hearth (031), resulting in residual slags (and perhaps the fragment of shale bracelet) being re-deposited.

The food debris found associated with the Medieval features suggests that the terrace was used as a domestic site utilising edible shell fish from the beach below, and perhaps taking advantage of the slightly overhanging cliff for shelter. The remains of the hearth are more consistent with cooking than with the high temperature furnaces needed for smelting. The whetstone found within the pit may be a re-deposited find, but unfortunately, examination of the crushed surfaces on the stone have failed to identify any slag or ore remains, so its connection with the prehistoric smelting site remains unproven. It would appear unlikely that copper smelting was taking place at the site during the Medieval phase.

If Medieval activity was indeed taking advantage of the cliff overhang directly above the site, disturbance it may have been restricted to the area immediately up against the cliff. Other level areas survive to the east and north of the excavated site which hold great potential for our understanding of the present site and its context.

This site represents the earliest evidence for copper smelting yet discovered in Great Britain and adds yet another dimension to the developing picture of one of the most complete Bronze Age copper production centres in the country.

Discussion of results

As stated earlier the preliminary analysis of the slags indicates that primary sulphide ores were being processed on the site. This along with the radiocarbon date (cal 1580BC) has interesting implications for the development of metallurgy on the Great Orme. In the past it has generally been accepted that the colourful carbonate (secondary) ores were the first to be exploited, before exhaustion of these ores led to the exploitation of the sulphide (primary) ores. Also, on the Great Orme the process of dolomitisation which occurred during the transformation of primary ores to secondary carbonate ores, softened the host rock, allowing for the relatively easy extraction of the carbonate ores. Present evidence suggests that fire-setting was used only occasionally throughout the prehistoric period, and notably where harder rock was located. Therefore, this technique, along with the introduction of metal tools, would have allowed for the exploitation of the primary sulphide ores generally found within harder host rock. Evidence, from the Pyllau valley mines, suggests that certain abandoned areas of workings were subsequently reworked to extract the residual primary ores. In one area, evidence of fire-setting produced a date of 1428-975 BC (CAR-1280), while adjacent (worked) areas were dated between 1885-1465 BC (CAR-1184) (Dutton *et al*, 284). Dutton states that this does not necessarily imply that available carbonate ores had been exhausted (certain carbonate bearing workings have been dated to 1410-920 (HAR-4845)), rather that the exploitation of sulphide ores was developed in parallel to the carbonate ores (Dutton *et al,* 384).

The dated smelting activity at Pentrwyn indicates that the exploitation of sulphide ores was taking place earlier than previously thought on the Great Orme, during the earlier period of mining activity in the Pyllau valley. It is known that in eastern Europe sulphide ores were being smelted as early as 3200-3000 cal BC (Budd *et al* 1994, 100), so the technology to do this may have existed from the beginnings of the mining on the Great Orme, but it was easier to extract and process the carbonate ores first.

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Environmental Report

The environmental analysis of the material from the site was carried out by Dr Astrid Caseldine & Ms Kate Barrow at the University of Wales, Lampeter. The section below is a summary of that report.

Samples from six context were processed using a simple wash-over technique to recover the charred remains and then the residues were washed through a stack of sieves. The samples were then sorted and identified using a Wild M5 microscope.

The charred plant remains were sparse and mostly came from the pit fill (026). 'Although radiocarbon evidence suggests a medieval date for most of the contexts examined, the remains themselves indicate that some, if not all of the remains, are possibly residual and prehistoric in date.'

Most of the grain and chaff comprised *Triticum* (wheat) and *Triticum dicoccum* (emmer), which would be in keeping with the Bronze Age date from the site. *Hordeum sativum* (barley) was also identified, as were weeds of cultivation *Chenopodium album* (fat-hen) and *Persicaria lapathifolia* (pale perscaria). Fragments of *Corylus avellana* (hazelnuts) could indicate the collection of wild plants for consumption or be the result of collecting wood for fuel.

In conclusion 'The charred plant remains indicate some cereal cultivation and crop processing in the area. Although the results are relatively scarce and dating is uncertain, the plant remains possibly add some further evidence to the relatively meagre record for Bronze Age cereal cultivation in Wales.'

A small amount of charcoal was identified and examined using a Leitz binocular microscope with transmitted light source. Oak (*Quercus spp.*), ash (Fraxinus excelsior), alder (Alnus glutinosa), birch (Betula spp.), hazel (Corylus avellana), holly (Ilex aquifolium) and yew (Taxus baccata) were recorded. All could have grown locally, with holly and hazel possibly representing the understorey of an oak woodland in the area. 'Alder and birch could be from nearby carr woodland. Apart from birch and yew, the other taxa have all been recorded from the mine workings on the Great Orme (Caseldine 1994) and it is possible that some of the charcoal is residual, although it is equally possible that the remains represent contemporary medieval woodland.'

Caseldine, AE. 1994 Charcoal and wood identifications. In A Dutton and PJ Fasham 'Prehistoric Copper Mining on the Great Orme, Llandudno, Gwynedd'. *Proceedings of the Prehistoric Society 60, 280.*

Land and marine molluscs, including limpets and winkles were also present. Small bones and bone fragment from rodents, fish and birds were also identified. Bones from larger mammals were also identified, including cow, fox, sheep and possible a small cat!

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