

#### BEFORE THE COPPER KING

Mining history in Britain appears to be undergoing a powerful process of revision, perhaps even an 'industrial revolution'. While the origins of sophisticated deep coal extraction have been significantly redated and re-evaluated in Leicestershire (*Bulletin* 18.4), other recent discoveries have been at least as important for copper mining history.

The story of copper extraction in North Wales has hitherto focussed on its flowering in the late eighteenth century, and especially on the career of Thomas Williams, the 'Copper King'. The period's physical evidence is particularly apparent in the technicolour splendour of Parys Mountain, the port of Amlwch, and the manufacturing base of Greenfield Valley. Now, at Llandudno's Great Orme, a copper mine has been discovered which pre-dates William's enterprise by at least 3600 years. Of unprecedented size for its period, it has opened a radically new regional and international perspective on copper mining history. World-wide media attention marked the mine's first public opening last year; archaeological excavation and commercial enterprise have been successfully combined, and as the site's second tourist season draws to a close, continuing investigation has confirmed its international significance.

The Great Orme, a 200m high outcrop of Carboniferous limestone, dominates the coast above Llandudno. Its nineteenth-century copper mines are well documented. Output was small compared with Parys Mountain, but peaked several decades later, around 1830-50. Bronze, stone and staghorn items found in earlier workings were, at that time, attributed to the Romans. More recently, historians such as Chris Williams, David Bick and G D Jones began to consider that Bronze Age origins were more likely. In 1979, archaeologist Duncan James discovered bone tools subsequently carbon 14 dated to 900BC, in underground workings hitherto associated with the nineteenth century.

Nine years later, mining engineer Tony Hammond and geologist Andrew Lewis discovered the presently exposed Bronze Age workings during a land reclamation survey. The local authority's prospective car park scheme was abandoned, and a 40 year lease granted to the newly-formed Great Orme Mines Ltd. Archaeology and tourism were to meet in a commercial attraction, summertime public

access supporting a rolling programme of winter excavation.

The site presented many archaeological challenges, not least the initial wholesale machine excavation necessary to gain access to the historic mine entrances. 100,000 tonnes of mining spoil were removed, followed later by the top of the overlooking hill. Four roughly parallel main copper ore lodes were exposed near the surface, running north-south across the site, mainly in vertical fissures. From here has come the earliest evidence of mining so far—charcoal which has been carbon 14 dated to 1800BC. The early surface workings are disturbed by later industrial structures, presently undergoing excavation. Below them, a limestone cliff face has been exposed, pock-marked by Bronze Age and later tunnel entrances.

Over 3,600m of underground workings have been surveyed so far. Excavation is led by Resident Archaeologist Frank Jowett, assisted by Gwynedd Archaeological Trust and a small team. Most work is carried out during the winter season, with the mine closed to the public. Lighting and ventilation problems offset the inherent advantage of under-cover excavation, with all work also subject to the restrictions of the Mines and Quarries Acts. Compass, clinometer and tape produce the tradi-

tional record, combined with photography and infra-red survey techniques. Electronic data is downloaded to computer, eventually to produce a three dimensional image of the mine.

To date, exploration has shown the mine to extend 240m into the hill, and in the later industrial workings to a depth of 70m. The Bronze Age passages are significantly smaller than those of the nineteenth century, typically no larger than the size of the ore vein being followed. At the lower Bronze Age levels, around 25m below surface, they are only 0.2m wide and 0.3m high. It is surmised that young children were used as miners here. The nineteenth-century passages are by contrast more spacious and regular, distinctly horse-shoe or 'coffin' shaped, some following the near vertical veins upwards. The scale of Bronze Age working is epitomised by a chamber dated by carbon 14 to 1400BC and measuring 10m by 15m and 12m high. Half filled with mining spoil, it is very largely mined out, and appears to have been subject to only slight nineteenth-century reworking. It represents a major mining achievement given the acknowledged Bronze Age mining methods of stone maul, bone chisel and fire.

Trenching out and opencast working of the exposed blue-green veins exploited the near-surface carbonates-oxidised ores suitable for



The Crusher house at Frongoch lead mine, in 1984; see *Welsh Mills Group*, page 6

immediate smelting. The frequent discovery of early charcoal suggests that fire-setting was also employed as a mining technique in the Bronze Age—in harder areas of rock, the face would be cracked by heating, and shattered when quenched with water. Stone maul and bone chisel combined to work copper ore from the softer dolomitised limestone. Some 800 granite beach stones, weighing up to 29kg, have been recovered from the mine. Many show evidence of hammering at one end, although the larger stones would seem too heavy for normal use. About 8,000 animal bone chisels have been retrieved.

Such artefacts were believed before the current excavation to represent the extent of Bronze Age mining tools. However, small bronze fragments found in workings dated to 1400BC are now thought to be parts of Bronze Age miners' tools unique in Western Europe. It is finds such as this which have placed the Great Orme at the forefront of international mining history. Carbon 14 dates from charcoal of 600BC–1800BC have been obtained so far, suggesting a working span of 1200 years for the mine. It is thought that exploration of the earliest workings may push this sequence back by a further 200 to 500 years.

Unfortunately, no evidence of Bronze Age ore smelting has been found, with the area greatly disturbed by later industry. Nor is there local evidence for tin mining—the other necessary ingredient for bronze production. The uses of the extracted copper ore therefore remain, for the moment, a matter for speculation.

As would be expected, there is much evidence of later industrial age mining. Shot firing holes and iron pick marks show that more sophisticated techniques allowed ore extraction from harder rock than was permitted with stone mauls and bone picks. Drainage adits and tramming levels allowed the later workings to extend deeper and further, to reach the copper sulphides at 90–120m depth. These more chemically complex ores required pre-roasting before smelting, and were not used in the Bronze Age.

Down through one vein runs Vivian's Shaft, dropping to its 1830's depth of 140m. Into it ran pumping rods, activated by a water powered 'flop-jack engine'—nick-named Tom and Gerry, after two Regency bucks—1200m distant. Stone-lined pits for the rod supports still mark the route to the precipitous west face of the Orme. The 1835 base of the later steam pumping engine has recently been found. No

evidence of lifts or cages has been discovered, indicating the prolonged use of wooden and later chain ladders for mine entry.

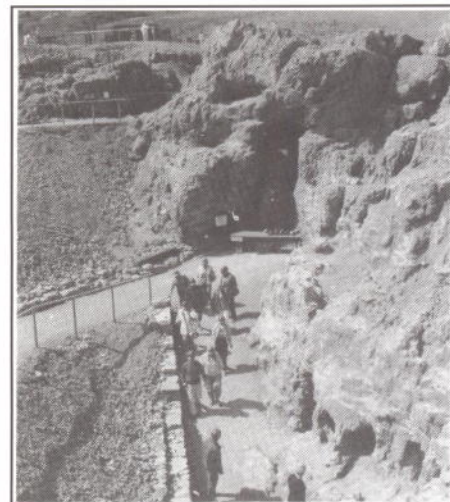
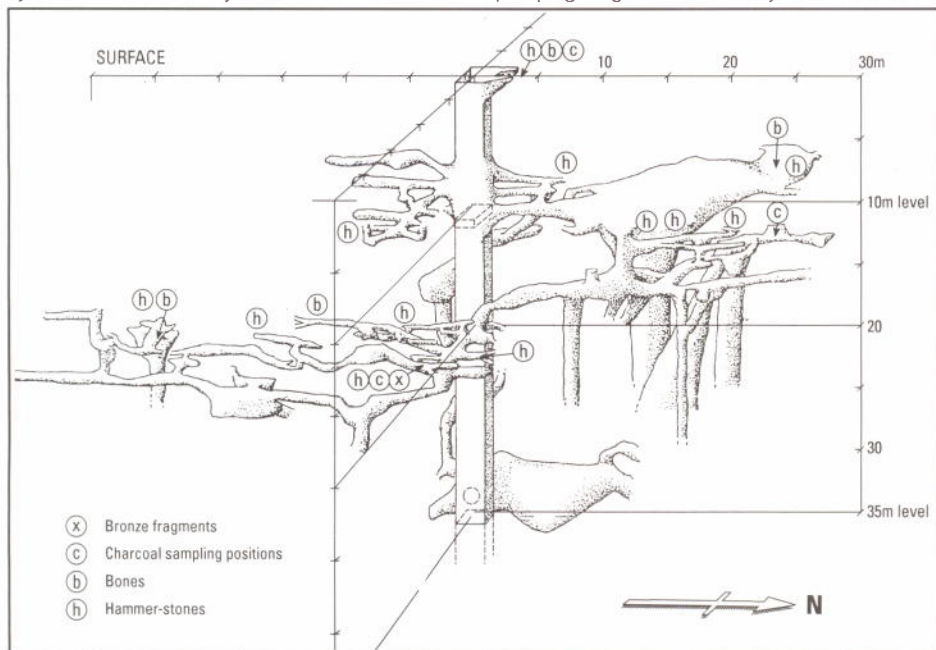
It is intended that as new mine areas are opened up, visitor access will be enhanced. Each season's discoveries will be exhibited, interpreted and published—providing a continually updated attraction for the visitor. At the moment, an audio-visual presentation sets the scene for a thirty minute underground guided tour to 18m depth. While many of the 42,000 first season visitors constituted 'passing trade', an international flow of mining enthusiasts and experts paid testimony to the site's global interest.

The mine's singular significance is its size for the period—the largest Bronze Age mine yet discovered anywhere. Its importance for archaeology is almost impossible to overstate, and its evidence will radically alter Bronze Age industrial and commercial history.

The Great Orme Mines are open from April to October. Details are available from Great Orme Mines Ltd ☎ 0492 870447.

*Paul Sillitoe*

The assistance in preparing this article, of Tony Hammond, Andrew Lewis and Frank Jowett of Great Orme Mines Ltd is greatly appreciated.



above: Visitors about to enter the Bronze Age workings; the dark holes (bottom right) are some of the Bronze Age entrances. Photo: Great Orme Mines Ltd  
left: Three-dimensional (oblique) view of Bronze Age workings with sites of finds. The vertical shaft at the centre is Vivian's Shaft of the 19th century.

*Andrew Lewis & Great Orme Mines Ltd*

## EXPERIENCE THE MAKING OF BRITAIN

In 1993 the English Tourist Board will be launching a major campaign in which industrial archaeology societies and attractions affiliated to the AIA may wish to participate. The campaign will celebrate the growth of Britain as an industrial nation—from the early days of the Industrial Revolution up to the present time. Through a programme of leaflets, posters, competitions, package holidays, events, and other special promotions the campaign will encourage more visitors to those areas and attractions throughout the country which have strong connections with our industrial heritage.

The emphasis of the campaign will be put on convincing the public that 'industrial' does not have to mean dull, dirty or boring but that our industrial history can be fascinating and fun, and is often set amongst stunning scenery, both rural and urban.

The campaign will include power sources, extraction industries, manufacturing, public utili-

ties, commercial and domestic buildings and associated development. Canals, railways, docks and other transport; model towns and the communications industry will also be



encompassed. Visitors to participating attractions will be able to see how iron and steel, textiles, glass, china and pottery were manufactured, in many cases having the opportunity to watch the actual process or even sample the product (chocolate or cider, for example).

All participating attractions must be open to the public on a regular basis, be actively managed and wishing to promote themselves. They should all have signed the National Code of Conduct for Tourist Attractions.

The English Tourist Board wants to bring the campaign down to a very local level, encouraging people to notice buildings and objects with industrial associations that they have walked past many times without considering what they were—or still are—used for. It hopes that local groups of historians and industrial archaeologists will organise walks, talks and lectures about their areas; that local authorities will embrace the campaign's theme in annual festivals and council run museum exhibitions,

## TICCIH IN SPAIN

After Belgium and before Canada, the biennial International Congress for the Conservation of the Industrial Heritage (TICCIH) was held this year in Spain, with a visit to Barcelona and a conference in Madrid.

The pre-conference, superbly organised by the Catalan museum service, revealed many things of great interest: about Catalonia, the true potential for adaptive re-use of industrial buildings, and the effects of climate on industrial architecture.

Catalonia is the industrial powerhouse of Spain, its industrialisation making it the first such developed area on the Mediterranean by the mid-nineteenth century. By the 1970s it still accounted for 75% of Spain's textile capacity and 60% of its metallurgy. Yet the early Catalan textile revolution was fuelled by Welsh coal and equipped by Yorkshire entrepreneurs, and its remains provide striking lessons for industrial archaeologists from Britain.

The construction of vast industrial spaces in Barcelona had a very early origin. The Drassanes at the harbour end of the Ramblas are the world's greatest extant Medieval shipyard. Eight of the cathedral-like sheds were begun in 1378, but the last three were not completed until the seventeenth and eighteenth centuries. The vast area inside enabled simultaneous construction of thirty galleys. This maritime heyday of the Aragon-Catalan Kingdom was vital to all our histories in that it finally allowed the wresting of the Mediterranean from the Turkish fleets. Standing near the Maritime Museum enclosed in these huge halls one is bewildered by one's lack of knowledge of spectacular industrial remains abroad. Facing one is the huge eighteenth-century cannon-foundry of the Spanish Fleet, and towering above are cousins of the Eiffel and Blackpool towers, with a spectacular cable-car system strung between. This Aeri del Port of 1926-30 has a 3,876 feet long ride supported by 257 and 390 feet high rusting steel-lattice towers.

For the Catalonian minority culture it seems to be a matter of honour that its heritage should be cherished, and often adaptively re-used. This ethos even extends to factory chimneys. The three chimneys of Barcelona's original power station have been retained. So has a concrete stack in Barcelona's third-

and that the attractions themselves will take up an entry in the campaign's main promotional print. Grants are available to help attractions undertake new promotional initiatives, paid on a sliding scale based on their visitor numbers.

The campaign will provide an overall promotional umbrella to help publicise these activities, principally through its print and public relations programme. In addition, some of England's regional tourist boards and local authorities will be producing literature for the campaign.

The English Tourist Board is keen to learn of any local events and activities in 1993 which can be incorporated into the 'Experience the Making of Britain' campaign. If you, or your society, are organising something please notify your regional tourist board or the campaign office direct by contacting Helen Beioley, Project Manager, Industrial Heritage '93, English Tourist Board, Thames Tower, Black's Road, London W6 9EL. *Helen Beioley*

worldish outskirts where delegates arrived in time to see an aluminium saucer being raised to crown it and contain a surreal nightclub. The very symbol of the town of Terrassa (20 km north of Barcelona) is the redundant chimney of a brickworks.

A realisation grows that Catalans have a long tradition of cherishing and re-using their surroundings. The most spectacular example of Art Nouveau in Terrassa, La Masia Freixa, with its parabolic roof and sweeping columns, started as a spinning mill. In 1907 it was converted into an entrepreneur's residence. From 1936 to 1939 it was The People's Library, and now it is the Municipal Conservatoire of Music. In Barcelona itself the initial welcome for delegates took place in the University School of Industry, formerly a textile factory operated from 1867 to 1895. In 1908 the buildings were taken over by the university. The tall factory chimney has, of course, been kept.

Re-use can extend to great lengths to achieve original effects. Four groups of concrete silos for a cement works outside Barcelona are gradually being converted to offices by Ricardo Bofill's internationally known architectural practice, itself based in one of the silo groups. Windows have been punched in the walls and a staircase spiralling inside one silo gives access to those adjoining. A roof garden has shrubs trailing over walls scarred by the former processes with no attempt made to produce a gentrified exterior. A second converted silo is Bofill's house above and an architectural model store below, with cement chutes adorning the ceiling.

The former power station, the Central Catalana d'Electricitat, is also now offices. This has a striking construction of buttresses of brick and tile-work clasped between green-painted lattice girders. This frame resisted the vibration of the steam engines and supported the overhead crane which still soars gloriously over the secretaries and computer operators inside. Elegant stairs lead onto a gallery with the original control panels. This coal-fired power station, built in 1897, was converted into the Catalan Hydro-electric Company's offices in 1980. It is much smaller than Battersea, but the story of re-use is infinitely more successful.

However, it may be that re-use has overreached itself. After the Born Market, built in 1873-6 and Catalonia's finest example of iron

and glass construction, became disused in 1977, there was a fierce campaign of public protest to ensure its survival. But infrastructure improvements to accompany the Olympic games found only short-term roles for this and the Northern Railway Station (closed in 1972 and seen on television hosting Olympic table tennis). The French Railway Station (Estacio de Franca) built for the World Exhibition of 1929 and reputedly the largest in Europe when completed, was refurbished for the Olympics but its vast curved train-sheds are now mostly quiet. Another prodigy of the 1929 Exhibition was the harbour cable-way, but its groaning machinery and rusting towers escaped Olympic refurbishment and one wonders how long this unsung wonder of southern Europe can be maintained. The region is full of competing problems of under-investment. Nevertheless, the Catalan people and their government see their industrial heritage as an integral contributor, through re-use, to their campaign to enhance their surroundings.

A more sinister conversion, that of the Casaramona Spinning Mill in central Barcelona to a barracks for Franco's police in 1939, illustrates lessons of interest concerning the adaptations of British industrial structures to a different climate. To British eyes the idea that these blocks with no lighting in the barrel-vaulted roofs could have been spinning-sheds seems bizarre; but then one remembers the intense heat and light which have to be ameliorated. Such roofs would not survive a sever frost. Some of the tall blocks of textile mills that survive, as in the rural model settlements or 'Colonia' at Colonia Guell or Colonia Sedo, have no windows but brick-built louvres to let in any breeze and exclude sun.

The 60 industrial Colonia in Catalonia were built following English models, in remote locations with water-power potential. However, such has been the decline in the textile trade that all the factories have closed and the Colonia are threatened. Those at Sedo and Guell have conservation schemes and the buildings are full of small workshop and factory units. The workers' tenements at Sedo mar-

*below left: A study in creative re-use of difficult structures: Ricardo Bofill's offices constructed in a disused concrete works silo* *Photo: Peter Wakelin*  
*below right: Tower at the Casaramona spinning mill, Barcelona* *Photo: Peter Wakelin*

