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The Copper Slag Blocks of Hayle, Cornwall: Remains of a late 18th Century Industry

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Abstract

The township of Hayle in west Cornwall developed around two important 19th century foundries: Harvey's Hayle foundry and Sandys, Carne and Vivian's Copperhouse foundry. The latter evolved directly from a company first founded in 1754 - to smelt Cornish copper ore in Cornwall. This was the Cornish Copper Company (CCC), although this name was not adopted until 1758. During their 60 years as copper smelters the CCC cast much of the slag from their furnaces into blocks, which were sold locally and used extensively for building. The surviving slag block buildings and other structures are characteristic of the Copperhouse area of Hayle. This paper considers the manufacture, use and distribution of these blocks. Also, recent chemical analysis of two samples of the material gives an insight into the efficiency of the smelting process and enables a comparison to be made with similar material from elsewhere.

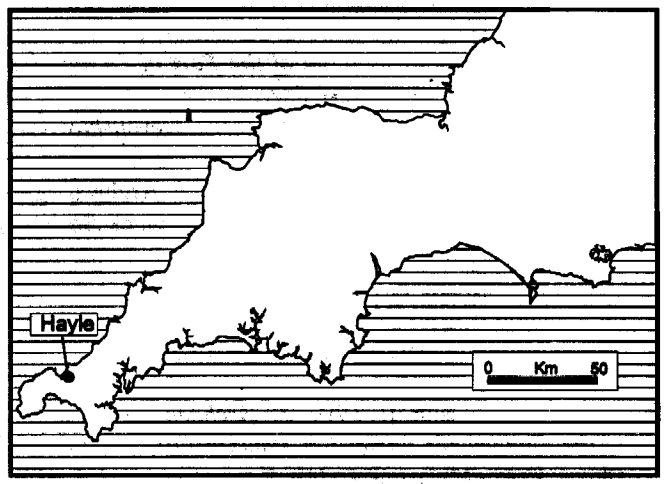

Fig. 1. Hayle. Location.

INTRODUCTION

Hayle is unique among Cornish towns insofar as its history covers a relatively short time period, beginning in the first quarter of the 18th century. This history starts with local entrepreneurs searching for a suitable site to build quays and cellars (warehouses) for the import of coal, timber and other sundries for the mining industry. It seems likely that this part of the Hayle Estuary was chosen as it would not involve any clash of interest with already established businesses. In many ways it was not ideal, there were difficulties in bringing ships in close for unloading and often goods had to be carried across the sand at low tide.

One of the consequences of the activities of these gentlemen was the attraction of other industries to this almost deserted part of the estuary. Copper smelting was one such industry, apparently attracted by the easy availability of coal. It was begun by John Cosier, probably in the year 1710, with a smelter sited by the Penpol stream close to the quays. After Cosier's death in 1729 the works were continued by Sir William Pendarves and Robert Coster (youngest son of John Coster of Bristol), until its closure in 1735. In 1752 Sampson Swaine and some mine owners formed a partnership to produce copper matte at Carn Entral, near Camborne. The idea behind the venture was to partially process the ore, getting rid of the waste prior to shipment to Swaine's works at Upper Redbrook (Bristol). They were unsuccessful largely because of the high cost of transportation of fuel, thus in 1756 they purchased land to build their smelter at Ventonleague. The site chosen was on the east bank of the Angarrack stream, about ½ mile (805m) from its confluence with the Penpol stream, with easy access to imported coal. After a meeting to raise more capital in 1758, the partnership agreed to trade as the Cornish Copper Company (CCC). Thus from 1756 until 1820 the CCC carried out copper smelting at this site, giving birth to the area of Hayle now known as Copperhouse (Fig. 2).

The company having selected their site of operations soon started to improve the access to their works from the sea. By 1769 they had deepened and widened the Angarrack stream creating the Copperhouse Canal. The canal was approximately ½ mile (805m) long and in places up to 100 feet (30.5m) wide, stretching from Ventonleague westward to the Penpol stream where it entered the sea. They built quays and storage facilities next to the works on the south side of the canal and to the west, they incorporated Curnow's Quay and Penpol Higher Quay (part of the original developments mentioned earlier). The then Managing Director of the Company planned that they should also enter the mine supply business and they commenced a gradual take over of mine suppliers operating in the area.

As noted earlier the great disadvantages of choosing this part of the estuary was (and still is) the joint problem of shallow water at low tide and the silting-up of the deeper channels, which meant that boats could only have access to the canal and quays on the highest tides. By the last decade of the century the CCC had minimised this problem by creating Copperhouse Pool and by using tidal flood gates trapping water at high tide, were able to scour the sand out of the channels and the harbour.

Of the copper smelting itself nothing has survived except for the slag, although a local tradition refers to the uncovering and hurried burial of the foundations of 20 chimneys in the area where the works once stood, during a post-war redevelopment. No records were kept of the discovery.

Although much of the slag was used as aggregate to reclaim the low lying marshy ground along the banks of the canal and Copperhouse Pool, it was also cast into blocks. These were used in buildings of various sorts as well as in the construction of revetments and quays and are much in evidence today. The use of slag as foundations and for the surface of new roads which they constructed is still in evidence and can be seen on Black Road (1811), as well as in excavations for the installation of services in the low-lying areas of the town. Indeed the occurrences of both types of material are so obvious as to be largely ignored by residents and as a consequence little thought is given to their preservation. Sadly they are the only physical

record we have of the CCC's smelting activities and as such are an important part of the town's heritage.

The company smelted between 4,000 - 6,000 tons of ore annually until the beginning of the second decade of the 19th century, when surviving records show a considerable drop in ore purchased. They ceased smelting around 1820 for economic reasons combined with competition from the up-country producers. As had always been recognised, it was cheaper to take the ore to south Wales for smelting, than to bring the necessary coal and limestone to Cornwall. The 25 reverberatory furnaces used at Copperhouse were either demolished or converted for other uses. Some little while later, the rolling mill which had been erected in 1781 by the CCC at nearby St Erth, was also closed and sold. From 1820 until its final closure in 1867, the firm concentrated on its mining supplies activities as well as creating a foundry and engineering works in direct competition with the nearby Harvey Foundry, situated on the Penpol stream at Carnsew.

A detailed history of the Cornish Copper Company is to be found in Pascoe (1981), while Brian Sullivan (1974) gives much information relating to the use of slag. Buck and Smith (1993), list most of the buildings and features which incorporate slag block in their construction.

SLAG BLOCKS AND THEIR COMPOSITION

In general it can be said that the blocks themselves have a characteristic appearance, they are dark coloured, sometimes glassy and often have a ropy texture on one surface (Plate 1). This latter feature is likely to have been the outer surface of the block when cast and probably results from the viscous nature of the hot slag. The material is tough and breaks with a conchoidal fracture and as will be discussed later these factors controlled the way in which the material could be used during construction.

Individual blocks are heavy and Sullivan (1974, 73), estimates that a standard block as produced, weighs about 2 cwt (101.6 kg). The density measured on several samples is between 3.8 and 4.0, which implies that the standard block could be nearer 2 .75 cwt. (139.7 kg).

As far as can be ascertained no attempt had been made to analyse the Hayle slag until recently when analyses were reported by the author (Ferguson, 1994). These had been performed by Peter Watkins of the Geology Department, Royal School of Mines (Imperial College), London, on behalf of the author, being part of a general study of the industrial history of St Ives Bay. In the paper a summary of the major element analysis of two samples collected from Hayle were compared with similar data published by Eckell (1928, 632 Table 254), relating to slag blocks produced in Germany during the latter part of the 19th century. The samples analysed were collected at random, sample A coming from a block which is part of North Quay and sample B from a revetment on BIack Road. Both were taken from the outside of blocks and trimmed to remove the outer weathered surface before analysis. Although the material is glassy and does not appear to be particularly porous, it cannot be guaranteed that the 180-odd years of weathering will not have altered the composition significantly. The analysis was performed using inductively coupled plasma spectrometry, using methods developed to analyse geological materials. The complete analysis, published for the first time, is given in Table 1 .

With regard to major elements, although there are differences between the two samples, there are no glaring inconsistencies and the figures for copper in particular are close. Variation between the trace element analysis is greater, but given the nature and history of the material this perhaps is not surprising.

TABLE 1

Percentage	**A**	**B**
SiO_2	63.37	52.12
Al_2O_3	5.65	7.41
Fe_2O_3	18.00	26.47
MgO	1.01	0.80
CaO	5.73	7.50
Na_2O	0.05	0.12
K_2O	0.31	0.25
P_2O_5	0.06	0.14
TiO_2	0.12	0.24
MnO	0.21	0.24
CuO	0.37	0.32
ZnO	2.15	1.67
LOI	-0.73	-1.80
ppm		
Ba	108	75
Be	11.8	7.6
Co	89	240
Cr	20	35
La	28	25
Ni	140	50
Sr	30	190
V	45	65
Zr	50	55

Table 1. Chemical analysis of two samples taken from slag blocks at Hayle.

TABLE 2

Locality	1	2	3	4	4	5	5
Year	**1888**	**1888**	**1888**	**1881**	**1888**	**1881**	**1881**
SiO_2	47.36	48.46	46.39	49.11	46.81	53.83	57.43
Al_2O_3	14.82	17.00	16.52	16.03	17.64	4.43	7.83
Fe_2O_3	4.72	4.64	2.77	9.64	7.213	4.37	7.47
MgO	6.73	2.22	0.85	3.90	3.68	1.67	0.87
CaO	18.35	23.19	21.51	19.77	19.15	33.10	23.40
CuO	0.29	0.28	0.30	0.71	0.33	0.25	0.30

Table 2: Major element analysis of German copper slags, from Eckell 1928. Localities: 1.Krug Hutte 2.Kock Hutte 3.Eckhardt Hutte 4.Kupferkammer Hutte 5.Sangerhausen Hutte.

The major element composition of the samples of German copper slags taken from Eckell (1928) are given in Table 2, so that a comparison can be made. Several important facts emerge. The residual copper of just over 0.3% is very close to that for the German material, and is a measure of the efficiency of the process used. The lower figures for the calcium and magnesium oxides by comparison may be important. I would contend that because limestone had to be imported and was an additional burden, only minimal quantities were used commensurate with the satisfactory separation of slag from metal. The high density of the Hayle slag can be attributed to the large amount of iron at around 20% which is much higher than the values for the German slags. These however are richer in aluminium. Table 1 also gives the trace element analysis for the two Hayle samples, there is no comparative data for the German slag.

The author has not had the opportunity to examine the slag in thin section.

SLAG BLOCKS: THEIR PRODUCTION AND USE

The production of copper from its ore is not a straightforward process and involves several stages, making it likely that only the slag from the first melting of the ore would be cast into blocks. Sullivan (1974, 71), assumes that these were produced by running the molten slag into cast iron moulds, although he also suggests the possibility that either granite or wood (lined with clay) moulds were used. Three types of block were made at Copperhouse denoted by Sullivan as Types A, B and C. Type A is a mitre-shaped block with the base of 18" (0.46m) and 6½" (0.165m) thick, used as a decorative capping for walls. Type B is a standard building block of size 12" x 10" x 18" (0.305m x 0.254m x 0.46m), while Type C is rarer and being 24" x 18" x 6" (0.6m x 0.46m x 0.15m) was probably too heavy for most practical purposes and only a few were manufactured. Obviously these measurements are an average and larger blocks of types A and B are known, produced either by overfilling the mould or by doubling up.

The other record of slag block manufacture available to the author is in Eckell (1928, 628ff). Eckell defines slag blocks as a product cast from molten slag, not to be confused with slag bricks which are a mix of granulated slag and lime. He also notes that the product is not satisfactory for house construction as they are impervious to moisture and air, leading to damp dwellings, giving their chief uses as foundation and paving blocks. Their advantage when used as paving blocks lies in the fact that they are tough and highly resistant to abrasion, factors which are offset by their tendency to have a slippery surface. This defect can be overcome by casting double size blocks in a mould designed to give a notch around the block, enabling it to be split. The rough, fractured surface is then laid uppermost. An alternative solution to the same problem is to cast the blocks on a bed of coarse sand, which would give a granular surface.

Production of blocks in the United States, England and Germany during the latter part of the 19th century and the first decade of this century, are recorded. Some production details of blocks produced from copper slag at Mansfeldt, Saxony are given, quoting an earlier publication. In particular it is noted that rapid cooling produces a dark brittle glass, while slow cooling gives grey crystalline block which is both hard and tough. The Mansfeldt blocks were moulded on a bed of sand with iron partitions giving a cubic block with 6" (0. 1 5m) sides. The slag is covered with 12" (0.3m) of sand after it is run into the mould and left for 4-8 hours to cool. It is noted that elsewhere in this region (Saxony), larger blocks are produced in cast iron moulds which have covers to allow the slag to be compressed. He also notes that tiles 6" (0.15m) square and 1" (0.025m) thick have been produced at a copper smelter at Santiago de Chile. In this example the material is

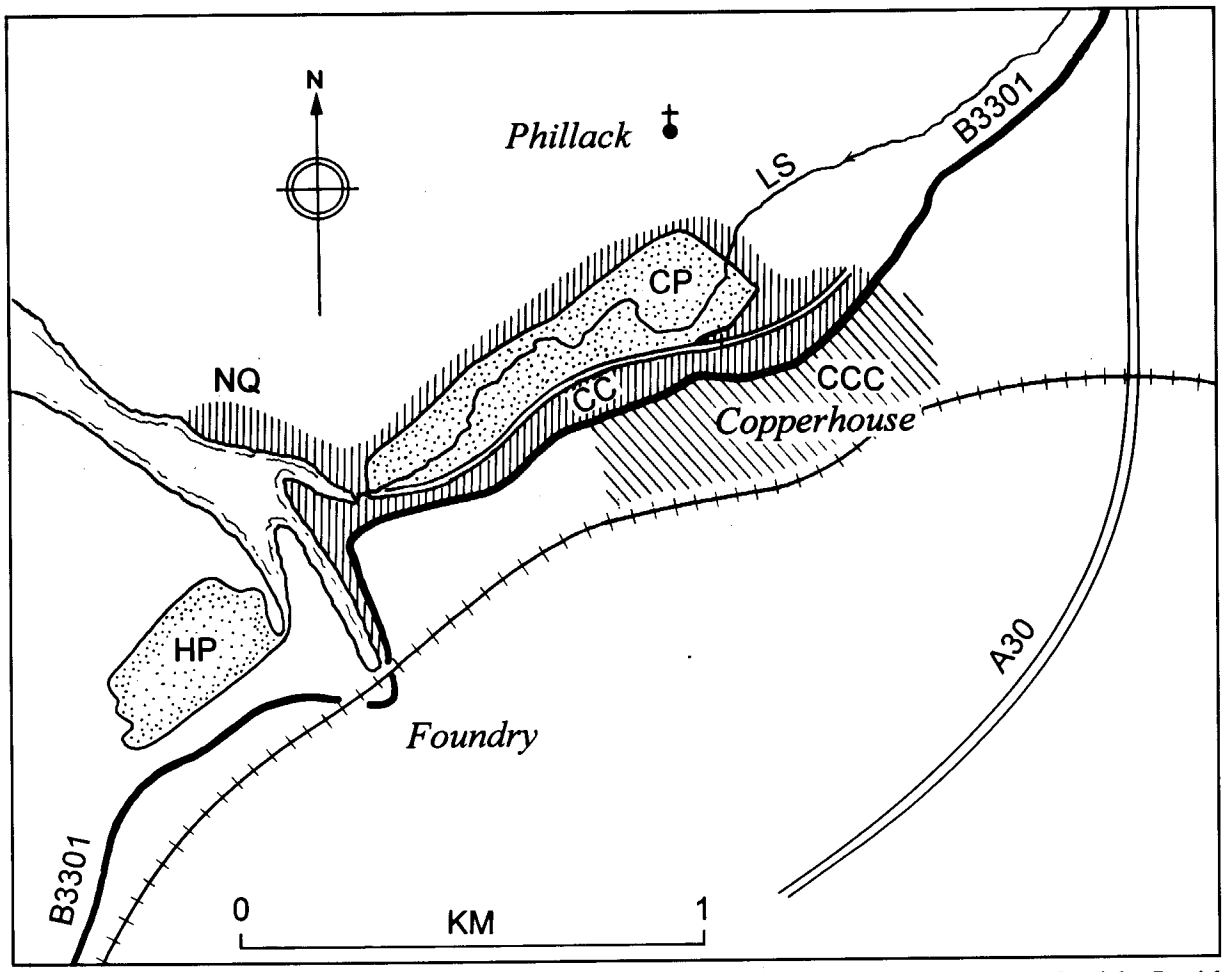

Fig. 2. Sketch map of Hayle showing the two main areas of the town: Copperhouse, built around the works of the Cornish Copper Company during the last quarter of the 18th century and Foundry, which was built around Harvey's Foundry in the first quarter of the 19th century.

KEY

Coarse shading : Approximate extent of copper slag block domestic building in Copperhouse, constructed prior to c.1820
Fine shading: The approximate extent of the use of copper slag aggregate to reclaim low-lying ground around Copperhouse Pool, up to c1812.
CCC - approximate site of Copperhouse smelter; CC - Copperhouse Canal; CP - Copperhouse Pool; HP - Harveys Pool; LS - Loggans Stream; NQ - North Quay.

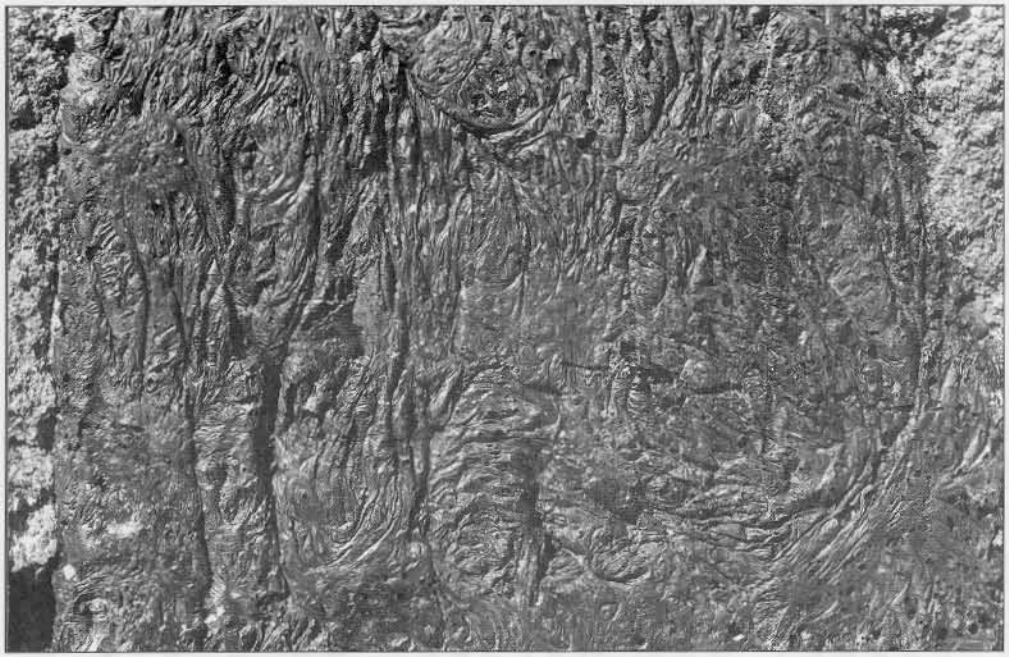

Plate 1. Detail of the upper surface of a copper slag block.

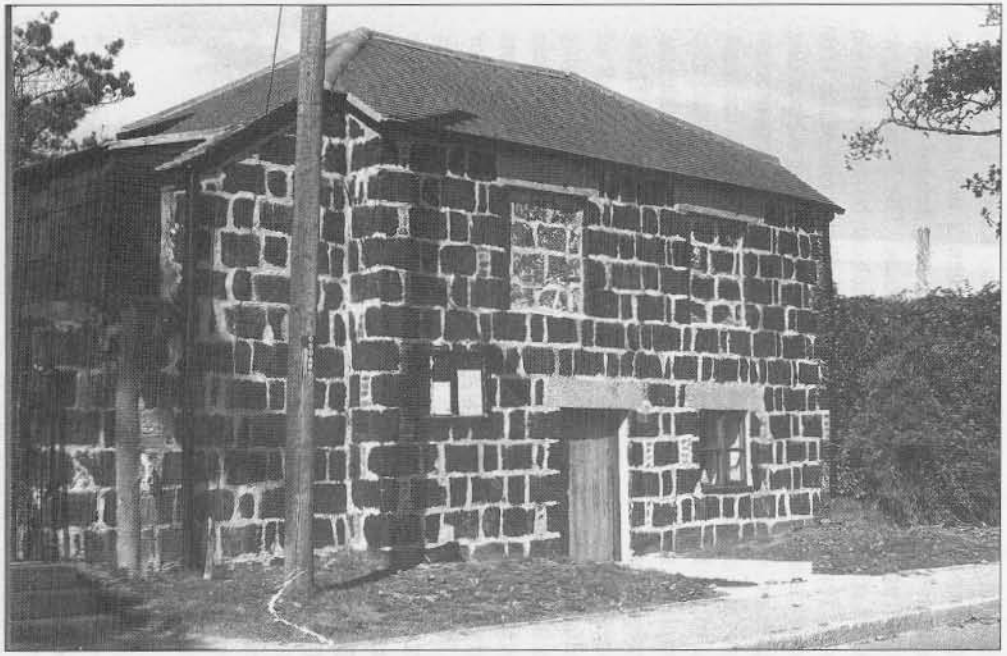

Plate 2. Phillack Church vestry (NGR SW 565384). Note bricks used as closers.

Plate 3. Bridge over Loggans Stream, between Copperhouse and Phillack. Note the height of the arches and batter on right hand revetment.

Plate 4. Cottage at Churchtown Rd, Phillack, illustrating the use of slag blocks in the quoins of a building.

cooled slowly on a heated hearth.

Based on the comments from Eckell, we must assume that the CCC must have also made provision for the slow cooling of their blocks, to prevent them becoming brittle. Exactly how this was done is not now known. It may be that if moulds other than cast iron were used, the mould itself would have had sufficient insulating properties to get around the problem of fast cooling.

The Hayle material appears to be unique insofar as it was used extensively in domestic and religious building, as well as for the construction of walls and revetments. The only example where it is used in a form of paving is where it is used as steps, as for example those leading to Clifton Terrace. However these are of a much later date, being built circa 1840. Because of the limited time period of production of the blocks, they provide some basis for dating some of the earlier properties in Copperhouse, which were largely built of this material. This must be approached with caution however, as buildings dated as late 1901 have utilised the material.

In the early days of production it seems that the principles of the CCC were prepared to supply free of charge, blocks to those who built their own homes on land belonging to the Company and leased on 3 lives. It is likely that many of the earlier cottages around Ventonleague such as Caroline Row for example, as well as some cottages at the back of the Market House were built under this scheme, during the period 1760 - 1790. The site of such housing was governed by the direction of the prevailing winds, blowing the obnoxious and poisonous fumes from the smelters. Many of these cottages have the upper part of their walls built from cob, which is thought to be a consequence of the weight of the blocks. It has been recorded that slag block houses are cold and damp, but at least one example where this is not so has been reported to the author.

Blocks were also sold, originally at 6d (2½ p) a score and as a consequence have quite a wide distribution around the Hayle area although the shear weight of any quantity probably acted as curb on distribution. The farthest travelled observed by the author are at Marazion some 4 miles (6.44 km) distance. Across Copperhouse Pool at Phillack is possibly the largest concentration of slag blocks outside Copperhouse. The Rector of Phillack, Reverend William Hockin bought several hundreds of these blocks in 1805, when they were then being sold at 9d (about 4p) a score. He used them to construct the Vestry (Plate 2) and Churchyard walls, as well as various outhouses and garden walls of the Rectory. He also built a Church School in the Glebe Field from slag blocks, this is now residential after use for some time as a barn. Indeed Phillack Vestry is one of the finest and least altered (externally) of all the slag block buildings in the area. Some of the Rectory out-buildings have now been demolished.

Perhaps the most famous copper slag building was the Methodist Chapel at Copperhouse, which was built in 1785 close to the CCC works, near the canal basin. Known as the Round Chapel it was much admired by Charles Wesley. Nearby a Methodist Sunday School was established in 1798 in a building also of slag block. The Round Chapel was demolished sometime after 1816 when a new chapel was completed at Ventonleague, but the Sunday School still stands by the canal, opposite the Market House. The Ventonleague Chapel contains some slag blocks which can be seen in the side walls. The front elevation is rendered. By the end of the 18th century many of the roads had been laid out using copper slag aggregate, in particular the roads on either side of Copperhouse Pool (that on the northern side was later to become the track bed of the Hayle Railway - built 1837). The CCC had also completed many of the quays, which were faced with slag blocks, as was much of the canal embankments. In 1811 the company built Black Road across the Pool to the foot of Phillack Churchtown Hill, again using slag aggregate and slag block revetments. A bridge, (Plate 3) was built across Loggans stream using slag blocks, it has two arches, one higher in than the other. This arrangement allowed the Rector of Phillack to get his punt into Copperhouse Pool, from its mooring on the banks of the stream. This bridge is also a fine example of slag block construction.

Figure 2 shows the limits of building construction where copper slag blocks were employed in large numbers. It also shows areas where slag aggregate was extensively used. As mentioned above, the historical audit carried out by the Cornwall Archaeological Unit (Buck and Smith, 1993, 23ff), details the important surviving slag block structures.

BUILDING TECHNIQUES

Revetments and quay linings are constructed in header bond, often with little overlap or offset. They are sloped back at 5°-10° to give a battered front face (Plate 3) and as can be observed at a number of sites this is an extremely strong form of construction and has proved ideal along the banks of the Copperhouse Canal. Phillack Vestry is constructed using Flemmish Bond, that is alternate headers and stretchers. Because the blocks were difficult to cut, bricks are used as closers, as can be seen in Plate 2. Rectors Bridge is in the more common stretcher bond (Plate 3) and also uses bricks as closers. Note that 'ornamental' mitre shaped blocks are used as a coping on the side walls.

One of the more commonly occurring use of the blocks is in the construction of quoins, either on the gable ends or lining doorways or windows, as illustrated in Plate 4. This particular use continued at least until the first decade of this century.

ACKNOWLEDGEMENTS

I am grateful to Stuart Smith for his suggestion to investigate further the slag block buildings of Copperhouse and to Mr Peter Watkins for carrying out the chemical analysis of the slag samples. Also I acknowledge the help given by residents of Hayle who have freely given of their time and helped clarify some points of debate.

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