Further work on

lead/silver smelting at Combe Martin, North Devon

Introduction

Combe Martin, on the north coast of Devon, has a long history of mining for silver-bearing lead ores. Some aspects of the mines are well documented, from the first record in 1292 through to abandonment in the late 19th century. Although they were worked for short periods in the late medieval period, documentary evidence suggests that the mines were most productive in the 1580/90s, during the tenure of Bevis Bulmer (a mining entrepreneur who came to Devon from Mendip), with intermittent but undefined levels of production through to the end of the 17th century. Also deep working in the 19th century revealed extensive, earlier, shallow workings on all the major silver-bearing deposits. However, until recently relatively little was known about the smelting and refining of the ores prior to the 19th century other than that a water powered smelt mill was erected in the 1520s and new smelting technology appears to have been introduced in the 1580s. Despite reference to the associated water course and the survival of "divers monuments, their names yet to this time remaining, as the King's mine, the store house, blowing house and refining house" in the early 17th century, the location of the smelting site was unknown prior to a chance discovery of residues during excavations in the centre of the village during 2000. Residues from the excavations have been investigated to determine the date and type of smelting process and the source of the fuel used. With assistance of a geophysical survey, work has been carried out with a view to identifying the furnace site(s).

Figure 1: Combe Martin, looking up Church Street in 1880. Christmas Cottage is to the right with the garden, the site of the first three trial excavations, behind the character leaning on the wall. Middleton, the site of two further excavations, is out of the picture to the left.

The excavations

Three excavations were carried out in the garden of Christmas Cottage (6 Church Street, coloured red in Figure 2). A test pit (CC1), intended to period date the cottage, revealed undisturbed accumulations from the medieval period to the present day, including dense, heavy, black smelting slags. Whilst scatters of slag were found throughout the top 0.6m of the excavation, it was at the 0.5/0.6m contexts that it was discovered in quantity, and dated from associated 16/17th century clay pipe bowls and ceramic sherds. Burnt peat turves were found in 18/19th century contexts but mineral coal was

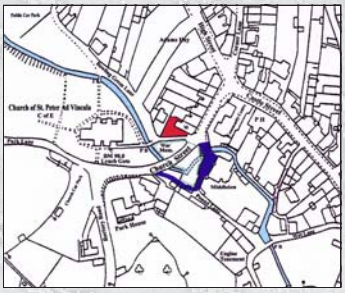


Figure 2: Location of the site, with the first trial excavations (CC1-3) in the garden coloured red, subsequent excavations (MN1 and 2) in the garden between the old road (coloured dark blue) and the river, and geophysical investigation in the garden immediately south of Middleton (see Figure 5).

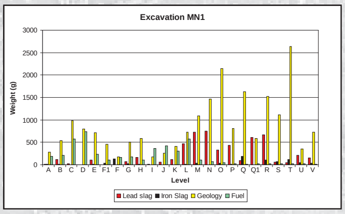


Figure 3: Quantities of lead slag, iron working slag, geological material and fuel recovered by level from trench MN1.

found in association with the 16/17th century slag. The discovery of calcite and carboniferous limestone suggested that some lead ore containing these gangue minerals was imported. Iron smithing slag and broken 17th century Flemish bricks with slag attached to the surfaces were also found. Two further 2x1m excavations (CC2 and 3) revealed almost identical stratigraphy as CC1. Trench CC3 suggested a north to south slope of subsoil profile with post-holes running east/west filled with slag of cruder composition containing geological inclusions. A Charles II farthing of 1663 and a pipe bowl of 1680, from secure locations at 0.4-0.5ms in the latter excavation, provided a terminal date for smelting activity of around 1670 to 1690.

South of Christmas Cottage lies the village War Memorial, prior to 1909 the village pound. When the Combe Martin to Barnstaple turnpike road was cut in 1832 the pound's eastward side became part of the front garden of the property Middleton (Figure 2). Two 2x1m test pits were placed in this garden to determine the extent of smelting debris eastward across the turnpike road. The 2002 excavation (MN1) was abandoned at 2.4m, due to difficulty of excavating at this depth. The excavation followed similar stratigraphical patterns as CC1-3 except that the undisturbed accumulations were thicker (Figure 3) with volume analysis indicating greater accumulations of slag, and coloured industrial sands/fine grits not discovered in the CC excavations. MN1 cut through three major structural anomalies; a lime-ash floor at 0.8m, a cobbled floor at 0.8m and at 2.1m the base of a robbed out wall packed with crude slag as described in CC3. Beside this wall was a small sherd of BB1 pottery and at 2.3m a fine hammer-stone. Excavation MN2, south of MN1 in 2003, reached a depth of 2.1m before abandonment. The smelting debris, slag and artefacts recovered were again similar except for

Figure 4: Excavation MN2 showing large beach stones in the south-west corner.

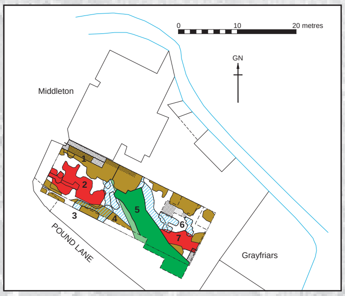


Figure 5: Interpretation of the gradiometer and resistance geophysical survey (Substrata Ltd); potential wall footings and robbed-out foundation trenches (1, 2, 3 and 6); service trench (5); possible ditch (4 and 7).

large oval stones in the south west corner - 0.25 to 0.30m in diameter - seemingly large beach stones of Hangman Grit (Figure 4). At 1.3m depth lay bands of solidified fine mud, the thickest at 2m, containing vegetable matter and wood, suggesting it had been water-borne and deposited quickly, possibly from an upstream mine.

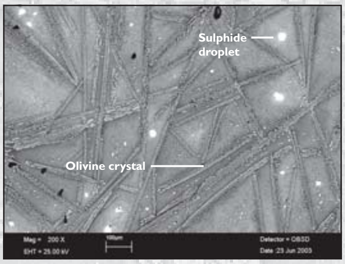
In 2004 a geophysical survey in the walled garden of Middleton indicated building foundations and robbed out trenches with possible wall footings and ditches which may represent demolished structures, and ditches on a different alignment to Middleton suggesting an earlier phase of activity on the site (Figure 5).

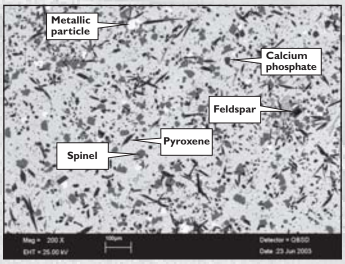
Analysis of slag

Thirteen samples of early post-medieval slag from a range of levels in trenches CC2 and MN1 were examined using scanning electron microscopy and energy dispersive spectroscopy. All but two samples had similar compositions and were mainly iron silicates (table 1). Any silver remaining in the slag was present at levels below the detectable limit (0.5wt%). Predominantly two types of slag microstructure were observed. The first type consisted of a glassy matrix surrounding olivine crystals and numerous, small, multi-phase sulphide droplets (Figure 6). The olivine crystals were iron- and magnesium-rich, also with ~6wt% MnO and small amounts of zinc and calcium. The droplets consisted of lead, copper, iron and zinc sulphide phases and small amounts of nickel. Antimony-rich inclusions were noted only rarely. The second common microstructure consisted of very finely dispersed two phase matrix and sulphide droplets (Figure 7). Two of the slag samples analysed were atypical; one was particularly lime- and phosphorus-rich and the other lead-rich (Figure 8).

Table 1: Average composition of 13 slag samples, 38 analyses, omitting two atypical fragments described below, normalised (English Heritage Centre for Archaeology, Report 79/2003)

Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	K_2O	CaO	TiO_2	MnO	FeO	CuO	ZnO	PbO
0.70	2.49	7.46	41.24	1.39	1.01	1.97	8.83	0.40	2.54	26.33	0.16	1.77	3.53





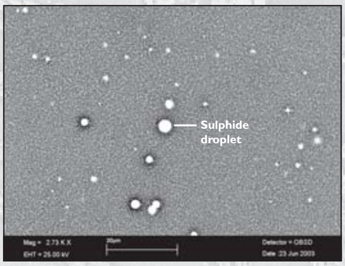


Figure 6 (top left): Back-scattered electron image of lead smelting slag, showing olivine crystals and multiphase sulphide droplets in a glassy matrix.

Figure 7 (left): Back-scattered electron image of lead smelting slag, showing multiphase sulphide droplets in a matrix made up of finely interspersed phases.

Figure 8 (above right): Back-scattered electron image of the unusually lead-rich sample of lead smelting slag, showing a glassy matrix containing crystals of lead silicate (very fine, needle-like, white crystals dispersed throughout the matrix), potassium feldspar, calcium pyroxene, calcium phosphate and magnetite spinel plus numerous metallic lead inclusions, within which small pieces of galena occasionally survived. Sulphide phases (predominantly of copper and lead) were forming around these inclusions.

The use of coal as fuel

The presence of coal at Combe Martin suggests that the move away from organic to mineral sources of fuel was taking place in non-ferrous metallurgy perhaps up to one hundred years before the perceived change, with the introduction of the reverberatory furnace. Two samples of coal recovered from excavation MN2 were analysed by Dr John M. Jones, late of the Fossil Fuels Institute at the University of Newcastle, using vitrinite reflectance determination. Sample 1 (1.4-1.5m depth) had a max. oil reflectance of 2.50% (indicating Carbon content - 92.0%, Volatile matter - 8%); Sample 2 (0.9-1m depth) had a max. oil reflectance of 2.24% (Carbon content - 91.9%, Volatile matter - 10%). Both samples are therefore semi-anthracite, 102 in the old NCB (National Coal Board) ranking. Such coals were mined in south-west Wales, close to the coast of the Burry Inlet west of Llanelli, where we have evidence, from the portbooks (PRO E190), of shipments overseas from the late 16th century and coastwise from the early 17th century.

It is not surprising that Combe Martin should be at the forefront of the transition to coal given its proximity to a coastal coalfield and the ease with which the fuel might be shipped. By the mid-17th century the port supported a small fleet, ships of 15 to 20 tons, engaged in a regular trade in coal from Pembrokeshire and Swansea for both lime-burning and domestic use (PRO E190/953/4 et seq.). Unfortunately, no shipments to Combe Martin from the Burry Inlet have yet been identified in the documentation.

Conclusions

Although in the middle of the village, between the church and the manorial centre, the site now occupied by the property Middleton was the site of lead smelting activity in the 16/17th century with a terminal date of perhaps 1690. Slag was dumped from the site in the direction of Christmas Cottage. A geophysical survey failed to reveal any clear evidence for the hearth(s); however permission has been received to investigate the anomalies in the walled garden.

Most of the slag analysed, from all levels of the excavations, was compositionally similar and so produced by similar technology. The low lead content indicates that it was a by-product from the final stage of the smelting process, i.e. a slag hearth. The slag was rich in iron, probably derived from the local ore, which contains iron gangue minerals. The single sample of lead-rich slag identified may be more representative of the slag produced in earlier stages of smelting, i.e. the ore hearth.

The slag was probably produced by Bulmer, and later lessees, using an ore hearth and slag hearth blown by water-powered bellows. Whilst the evidence for the introduction of the ore hearth into Combe Martin is largely circumstantial, Bulmer became involved because he was able to resolve the problems that had previously been encountered by others smelting the local ores. This would be consistent with the introduction of an ore hearth, as these were in use on Mendip prior to Bulmer's arrival at Combe Martin.

Although no waste from lead refining, to extract silver, was identified in the excavated assemblages, both mineralogical and documentary evidence indicates that silver would have been the primary product. Refining would have taken place in a hearth made from material rich in lime and phosphorus, such as bone ash. During the process the lead was oxidised to litharge and absorbed by the hearth leaving the silver to be recovered. The quantities of phosphorus and lime in the Combe Martin slag suggest that some litharge-impregnated refining hearth was smelted in the ore hearth together with local and imported ore; the lime-rich gangue in the latter would have further added to the lime content of the slag.

The presence of coal provides the earliest evidence for the transition to mineral fuel in the processing of lead ores. It is possible that the coal was only used in the slag hearth to affect a complete recovery of the lead and silver. However, with no organic debris being found amongst the residues, we should consider the possibility that coal may have been the only fuel used throughout the smelting process.

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