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Evaluation of industrial residues from
Tremadog, Gwynedd (G2108)

Dr Tim Young
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Dr T.P. Young

Abstract

The submitted assemblage comprised two main components: materials associated with the construction and operation of a limekiln and materials associated with some apparently small-scale iron working.

*Materials associated with the limekiln were apparently mainly structural, with both heat affected rock and artificial ceramics. The rocks were rarely identifiable because of their high degree of alteration, but most did not appear to be waste from the lime burning itself, but to be highly altered stones from the walls. The ceramics ('fired clay') included much that was not closely identifiable, but sufficient pieces with angles and corners survived to suggest that much of the assemblage had been in the form of brick or tile. A significant proportion of this ceramic had either been heated to the point of bloating and partial melting, or had been glazed with a clear-green wood ash glaze – indicating that this material too had probably been part of the kiln structure (although some of the heat damage might alternatively been attributed to some of this material being kiln wasters). Several of the fired clay pieces bore external moulds of tiny gastropods (comparable in form to *Hydrobia* sp., although not formally identified as such). One piece also bore a small fragment of external mould of a thin, finely concentrically ribbed bivalve similar to *Scrobicularia plana*. The presence of moulds of these shells indicates that the clay was probably derived from a deposit formed as an intertidal mudflat, or similar environment.*

Possible relict material from the lime-burning itself was limited to very small pieces of highly degraded rock with remnants of a rather coarse crystalline texture, but the high degree of alteration meant that these were not closely identifiable. Some lime deposits were present, but these did not contain recognisable relict material.

Iron-working was represented by one piece of smithing slag from deposits associated with the limekiln and by several samples of microresidues associated with a hearth. The amount of material was small, but it was perhaps noteworthy that the flake hammerscale present was particularly thick – although this might be a product of sampling bias.

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Methods

All materials were examined visually with a low-powered binocular microscope where required. As an evaluation, the materials were not subjected to any high-magnification optical inspection, not to any form of instrumental analysis. The identifications of materials in this report are therefore necessarily limited and must be regarded as provisional. The summary catalogue of examined material is given in Table 1.

This project was undertaken for Gwynedd Archaeological Trust.

Results

Materials associated with the limekiln

The kiln was associated with a variety of strongly altered rocks. The high degree of alteration suggests that at least some of these may have contained a minor component of lime (the local igneous rocks are commonly slightly secondarily calcified). Whatever the nature of the reactive component, it is clear that some rocks have undergone partial melting, with the development of a vesicular texture within the remnant rock and a somewhat mobile external slag phase. Most of the slag does not have the appearance of significant flow, although there are some examples of viscous slag 'flaps' (e.g. c3090 #357). The most strongly melted material is in the form of a black vesicular glass.

Even more pervasive than actual slagging, is the development of a clear to slightly green wood ash glaze, particularly on the more refractory (mainly quartz-rich) lithologies and on the fired clay (see below).

These very highly altered rocks are mainly in very large pieces – suggesting that they were originally from the fabric of the kiln.

In some contexts (e.g. c3090, find #342) there are finer grained materials that might include some residues from the burning process itself. These are generally very highly altered, but some retain a cellular structure, perhaps relict from a coarsely crystalline (dolomitic?) precursor.

The fine residues include a few pieces of white shell-like material (find #366), but none of this shows convincing morphological or microstructural evidence for actually being shell. Instead, it is more likely that these are remnants of secondary lime crusts formed on cracks within rocks and ceramics (cf. find #385, from the same context (3073) as find #366). Much of the material shows secondary lime deposits – including examples with very fine microstructure, coarse crystals or botryoidal texture.

Fired clay

The fired clay material forms an assemblage with several unifying characteristics. Firstly, sharp angles and corners are rather common amongst the assemblage, as are planar surfaces, suggesting the fired clay was largely or wholly originally in the form of bricks or tiles.

The fired clay typically shows slightly bleached surfaces, perhaps most commonly around large internal voids. These voids typically show rough, corrugated surfaces. Some are suggestive of external surfaces that have been smooth by wiping with a bunch of grass, but most are probably either irregular cracks formed during the kneading of the clay or possibly moulds of coarse organic temper (leaves?). Finer moulds of organic temper include tubes with longitudinal striations suggestive of grass stems.

Probably the most interesting aspect of the fired clay is that several pieces contain moulds of former shelled organisms. These include tiny gastropods (c3075 #375, c3075 #376, c3090 #384) which have not been studied in detail, but closely resemble the brackish water gastropod *Hydrobia* sp., and one example of a

finely concentrically-ribbed bivalve, which closely resembles *Scrobicularia plana*, another creature of brackish and intertidal environments. These two together are the most common shelly organisms on modern intertidal mudflats. Such material is not likely to have been added to the clay deliberately and is almost certainly an indicator of the origin of the original clay.

The heat alteration of the fired clay is instructive; it includes examples where the ceramic grades into highly bloated textures, showing intense heating of the ceramic (almost certainly during use – although some over-firing during manufacture cannot be excluded), but also includes examples where the low-fired ceramic is overlain by a clear-green wood ash (or otherwise lime-rich) glaze, indicating a lower temperature reaction. This suggests use of the fired clay ceramic at different locations within the kiln structure.

Lead

The assemblage included two fragments of lead sheet. These are not immediately interpretable, but may be scrap/offcuts from lead working for building purposes – but might also be scrap from lead 'baggage tags'.

Ironworking residues

The only significant piece of macro-residue attributable to ironworking is a small fragment of dense iron slag from c3037 (find #371), which appears to contain charcoal clasts. Other ceramic-derived slags and fuel ash slags from the kiln area might be from ironworking – but are just as likely to be derived from the limekiln.

Site 03 produced ironworking microresidues from several contexts (c3011, c3015, c3051, c3052, c3053). These microresidues included flake hammerscale (FHS; the product of the superficial oxidation of hot iron in air), spheroidal hammerscale (SHS; droplets of superficial oxide expelled during forge welding), slag droplets (mainly formed by dripping of the slag within the fuel bed of the hearth), slag flats (thin slag accumulations from the surface of the workpiece or smith's tools), blebs of fuel ash or lining slag (mainly formed from melted hearth material) together with small angular fragments from broken slag pieces and assorted pieces of fired clay. In addition to these materials several contexts yielded examples of materials cemented by the redistribution of iron following corrosion of iron debris, forming various ferricrete materials, including smithing pan – a deposit of microresidues cemented by secondary iron minerals. These microresidues are typical of materials found around early smithing operations. The only slightly unusual facet of this material is that much of the flake hammerscale is rather thick. The scale grows through oxygen and iron diffusion, so thickens with time at high temperature – so thick scale suggests prolonged high temperatures. This is usually an indication of the extra time required to heat up large pieces of iron. It is possible however, that sampling bias has exaggerated the occurrence of the thick scale if fine scale fragments were less well recovered during sieving.

A small quantity of the material from c3020 provides a slight suggestion that coal might have been employed as well as charcoal in the smithing – with two tiny possible coal fragments and a bleb of slag resembling clinker (partially melted coal residue). Coal was

frequently used as a fuel for smithing in the Roman period (Smith 1997; Tylecote 1986, p. 226), but thereafter disappears as fuel (particularly in areas far from the coalfields) until the late- or post-medieval periods.

Interpretation

The collection of residues from the limekiln area adds disappointingly little to the understanding of the resource exploited, although there are hints that it was a limestone rock, rather than shell material.

The biological evidence of extraction of clay from intertidal deposits is interesting. It parallels the early 19th century extraction of clays for brick-making from reclaimed salt-marsh in the area, during construction of Porthmadog (<http://www.tremadog.org.uk/content/29.php>) - a time when the Tremadog area was again used for lime-burning. This later use of the clays of the estuary area would indicate their suitability for brick manufacture and the evidence from this site would suggest that suitability was also exploited at an earlier period.

The small scale evidence for ironworking provides little indication of the purpose of the activity, although, if genuine, the apparent abundance of thick flake hammerscale might suggest that larger objects were being fashioned or repaired.

Evaluation of potential

Although interesting, the assemblage contains little that might provide additional useful information through further detailed analysis.

The limekiln residues are dominated by altered materials from the kiln construction, rather than containing surviving materials that would assist with the sourcing of the raw limestone.

The ironworking residues are very few and the potential of such an assemblage of microresidues to generate useful data is currently very limited.

References

- Smith, A. H. V., 1997. Provenance of Coals from Roman Sites in England and Wales. *Britannia*, **28**, 297–324.
- Tylecote, R.F. 1986. *The prehistory of metallurgy in the British Isles*. The Institute of Metals. 257pp.

Table 1: Summary Catalogue

context	item	sample	label	number	weight	notes
Site 01						
3003	307			1 (4)	1205	vitrified stone: broken glazed rock with mullion- or voussoir-like half-hexagon cross-section, but most likely a natural fracture. Mostly glazed. The rock itself is of uncertain nature - it had large rounded vesicles and a dominantly fine grain size - probably feldspathic, with some larger natural: crystals, some interstitial Fe oxides and some euhedral quartz on some external breaks
3003	361		poss natural metallic piece (copper?)	1	0.19	natural: grain of quartzo-feldspathic rock with biotite on one end
3003	350	8		1	<	natural: single coarse grain of rounded black grains set in pale, almost lilac, matrix - not a slag
Site 02						
3001	303		burnt clay (with possible finger mark)	1	78	fired clay: with fingertip-like hole extending in from highly bloated pale surface
3001	305		glazed stone	1	936	vitrified stone: glazed end of stone slab. Internal granular texture, appears to be quartzose sandstone with quartz veins
3001	306		burnt clay	8 + bits	786	fired clay: large blocks of oxidised fired clay. Some show planar surfaces, but most irregular. Several show abrupt coverage by apparent glaze on an unvitrified surface. All very soft, low fired. Some show small angular grit particles, but seems generally to have rather little temper
3001	324		slag?	-3	470	vitrified stone: appears to be slagged porous rock and a second slag fragment from a similar system. Texture difficult to recognise - possibly calcite replaced basalt?
3001	324		lead	1	26	lead: small piece of oxidised lead sheet 2-4mm thick but irregular
3001	329		glazed stone	1	50	glazed (clear to dark green) deep pinkish material, highly vesicular - could be highly altered andesite? - or could be vitrified bloated ceramic
3001	363	16	burnt clay?	3	0.63	fired clay: 1 scrap of oxidised clay with bleached rough surface at one end, scrap of bloated FAS, 1 scrap of reduced fired clay with abundant organic temper
3001	378	16	burnt clay	17	26.92	fired clay: variably but mainly oxidised clay now in rounded abraded pieces. Largest piece shows two perpendicular faces with surficial bleaching and internal ?grass temper
3037	371	19	slag?	6	37	largest piece is a dense slag with pendent lobes on base and charcoal clasts - possibly an iron slag; 4 pieces of vesicular fuel ash slag grading to black vesicular glass; 1 curious blebby piece - possibly the altered rind off a slagged stone?
3037	380	19	burnt clay	3	10	fired clay: 2 small fragments of oxidised clay and one large piece. Faces at right angles have pale surface with local light vitrification and hint of flowage - suggests a crude brick corner
3059	351	12	slag	assm	10.95	full range of material from heat decomposed stone: FAS, dark glassy slags, dull slags and lime-rich particles
3059	360		fe waste?	1	0.31	natural: possibly an iron pisoid from the Tremadoc ironstone
3059	377	12	burnt clay	assm	666	fired clay: well oxidised, turns white near surfaces. Organic temper. Some of the white surfaces look as if they were smoothed with bunches of grass of some similar artefact. Some of the material is so fired that it has greyed and bloated - but the glassy surface is overlain by white-yellow deposits - is this decomposed glass or lime?

context	item	sample	label	number	weight	notes
3067	382	17	burnt clay	4	54	fired clay: 3 small rounded abraded nubs of oxidised fired clay, 1 larger piece with planar base (i.e. brick like?) and highly vitrified end burnt off irregularly,
3069	326		lead strip, bent	1	18	lead: tightly folded small piece of thin lead strip, probably c.80mm x 12-15mm x 1-2mm
3073	344	9	burnt residue - slag	assm	156	burnt stone and FAS: dark vesicular fuel ash slags in thin sheets attached to granular lime rich material. All rather difficult to interpret. One small piece has angular brecciated brown ?mudstone chips bound by lime (at least one piece of the granular white material is large enough to section)
3073	356	9	poss burnt lumps of lime	2	12.3	burnt stone: one piece is contorted and fissured grey low density bloated rock fragment or ceramic fragment, surface lime-coated in places - with possible fuel impression. Second piece is somewhat rounded low density lump that is undergoing explosion, presumably some expandable heat product inside
3073	366	9	lime slag?	c26	2.8	burnt stone: includes 5 fragments of thin lime sheet - superficially like shell, but no hint of morphology or microstructure to support this, so probably a coating; 1 piece appears to be a decomposing burnt limestone, the rest are a wide variety of decomposed stones and fuel ash slags, all very lime encrusted
3073	385	9	burnt clay	assm	366	fired clay: similar to other examples. Larger lumps indicate clearly that the material had planar surfaces, often the surfaces, cracks and vesicles are coated in white material - presumably lime. The cracks sometimes show multiple plates of lime - suggesting that they opened (and filled) over several discrete events; some pieces show organic temper - but very difficult to identify
3073	395		stone/slag	1	256	vitrified stone: block with vesicular black glassy clinkery material with maroon-brown surface binding various highly altered stone fragments. One appears to be a siltstone (just possibly a ceramic) and one is a dark rock with dark, almost purple, superficial vesicular melted layer - possibly a manganiferous slate?
3073	396		glazed stone	1	1100	vitrified stone: pale large rock fragment glazed on all sides with clear glaze with green patches. Rock pale with elongate parallel holes weathering in surface - possibly welded tuff?
3073	397		slag	1	1955	vitrified stone: appears to be large wedge-shaped stone block, heavily altered and slagged. Slag is dark vesicular and has a very shiny mineral in it (?hematite). Remnant stone is porous brown and has a somewhat clotted texture
3073	398		slag		1625	vitrified stone: highly slagged material with dished surface and slightly slagged surfaces on at least two perpendicular sides - probably the end of a structural component? Stone remnant is brownish and granular with lots of secondary lime. Lime also fills cracks and forms botryoidal masses in some voids, towards outside the clotted texture locally becomes almost columnar or dendritic; slag is vesicular and rich in secondary lime
3075	349	10	Fe object?	1	0.2	natural: granular material - possibly oxidised pyrite rod - fossil burrow
3075	353	10	Fe/slag	c60	7.05	slagged/vitrified stone: mainly dark vesicular glassy slags - but some are paler and greener and some are more crystalline materials - possibly rock remnants rather than slags
3075	354	10	non-magnetic slag?	c20	3.07	FAS and burnt stone: mainly vesicular greenish fuel ash slag, but also fragments of bleached sandstone, some highly fired clay and a piece of burnt bone
3075	365	10	Fe frags	3+	0.44	fragments of strange red pelletal material with iridescent sheen to interstitial material - could this be oxidised Tremadoc ironstone - perhaps a sulphidic variety?
3075	370	10	burnt 'glazed' stone	4	26	vitrified stone: 3 pieces of slaggy grey vesicular material with glazed surface and hints of quartz-rich substrate; 1 small glazed probably sandstone pebble

context	item	sample	label	number	weight	notes
3075	375	10	burnt clay	ass	818	fired clay: large collection of good orange burnt clay. Several pieces show good right angles, one has tiny gastropods, several show the swirled/corrugated surfaces- in one case this is definitely internal, most are not vitrified, but some go as far as slightly flowed glaze; right angled corners are common
3075	376	10	burnt clay partly glazed	assm	27.94	fired clay: one piece shows vitrified surface but below is fracture with external mould of cf. <i>Scrobicularia plana</i> and also gastropods, all pieces oxidised fired; where seen the glaze is milky green
3090	342	13	slag? Waste product	assm	130	burnt stone and slag: large number of small fragments ranging from rare dark vesicular glass, through sandy fuel ash slags to more common possibly degraded limestone fragments - these show a hard cellular structure with voids filled with a brown shrinking material. Also bits of Tremadoc ironstone and other rocks. A wide variety of burnt bits!
3090	357	13	lime slag?	6	2.3	slag: remains of probably 4 slag blebs - one is oddly folded over - all probably fairly viscous
3090	384	13	burnt clay	assm	50	fired clay: similar to other examples - has pale bleached rough surfaces, some with organic marks. One piece has two probable small gastropods, one piece shows gradation into blebby drips of fuel ash slag. A minority of the material is reduced fired - this is harder denser and often shows odd complex shapes.
3090	386	13	burnt clay with linear pattern on one side and fingerprints on the other	1	16	fired clay: with white ?external surface with wiped texture. Internally rich in organic temper (grass?). Larger voids have botryoidal? white material (these are these so-called finger prints)
3097	394		lime pieces	3	628	lime: large blocks of fairly homogeneous cream coloured lime - with cavities and cracks with both crystalline and tufa-like secondary materials. Some broken surfaces reveal clasts (grey and red) and ghosts of lime clasts - but there is no evidence for surviving primary texture. One face of two of the pieces grades into a tufa-like gritty layer with clasts of small rounded pebbles
3100	379	20	burnt clay	assm	13	fired clay: many tiny fragments of mainly buff coloured silty clay, a couple of grey pieces, a couple of well fired vesicular bits and one fired stone
3103	381			1	4	vitrified stone: small chip from surface of glazed rock - pale fine ?feldspathic body with clumps of dark mineral - microgranite?
3103	387	21	burnt clay/slag?	assm	62	fired clay: burnt clay fragments with organic temper and sometimes charcoal internally, has pale planar surfaces or possible wicker impressions, one piece shows a sharp 60 degree angle to surface, This piece has smooth surfaces intersected by round holes, internally it is a brown clay with voids filled/lined by white (presumed lime).
u/s	374		stone with slag	1	9.42	vitrified stone/clinker: clinkery blebs adhering to white foliated burnt stone - could potentially, but not necessarily, be modern
Site 03						
3011	329	1	slag	1	0.6	slag: black glassy lining slag bleb
3011	352	1	hammerscale/metal waste	assm	9	smithing microresidues: rich assemblage of coarse FHS, some SHS, slag flats, slag droplets and angular slag debris
3015	346	2	Fe shards (magnetic)	assm	138	smithing microresidues: rich assemblage of rather thick flake hammerscale and slag flats, occasional slag droplets and other broken slag material

<i>context</i>	<i>item</i>	<i>sample</i>	<i>label</i>	<i>number</i>	<i>weight</i>	<i>notes</i>
3015	358	2	burnt residue slag	5	2	FAS: highly bloated fuel ash slag blebs with dark opaque iron slag veneer
3015	359	2		15	4.36	smithing pan: small particles of concretion with scale, fuel ash (some iron stained), slag fragments, slag flats
3020	343	3	slag	14	<	2 tiny fragments of possible coal 1 large clinkery maroon surfaced complex bleb 3 tiny fragments of dense slag? 6 pieces of highly vesicular fuel ash slag 2 pieces of probable ferricrete
3020	369	3	3 pieces glazed on one side	2	16	glazed stone: 2 pieces of laminated quartz-rich rock. The larger piece shows some highly porous material on one end (decalcified), both show a dominantly clear glaze with some bright green patches
				1	20	glazed stone: deep green glazed end of red stone/brick. Glazed face concavely curved. Face meets planar lower face at c 60 degrees.
3020	389		burnt clay		392	fired clay: many pieces of oxidised fired clay with organic temper. Some rough pale surfaces might be due to larger temper pieces but might be contact with wicker or stone? One piece shows a slightly vitrified front face with a pale, transparent glaze.
3051	392	6	hammerscale?	17	0.28	smithing microresidues: small particles including smithing pan, FHS, slag flat, glassy lining slag, stone ?charcoal
3052	341	14	hammerscale		<	3 small pieces of flake hammerscale plus several dark rock fragments
3052	383	14	burnt clay?	8	4	small concretions in dark brown deposit with coarse sand and charcoal
3053	340	15		assm	0.39	small collection of slag debris, FHS and slag flats with charcoal
3094	388	22	burnt clay	1	0.56	fired clay: small rounded piece of buff/orange fired clay with small elongate moulds

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Unit 6,
Block C,
Western Industrial Estate,
Caerphilly,
CF83 1BQ.

Mobile:
E-Mail:
Web:

07802 413704
Tim.Young@GeoArch.co.uk
www.GeoArch.co.uk