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EARLY SURFACE FEATURES OF METAL MINING: TOWARDS A TYPOLOGY

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Abstract: The range of features to be found on pre-mechanisation metal mine sites is briefly surveyed, as a step to developing a national terminology for cross-regional studies. The paper also considers questions that should be asked of the field evidence, in order to maximise the interpretation of both date and function.

The study of 'early' metal mining landscapes is very much in its infancy; so much so that the vagueness of the term 'early' is deliberate and entirely appropriate. In the present context, I am using it for any features pre-dating the widespread use of mechanical power and railed transport, ie a period from the Bronze Age to the 18th century AD. Within this long period, it is not yet possible to define either the date range of many feature-types, or the range of features to be expected on, and perhaps in some cases diagnostic of, mines of any given period. This article is, therefore, an attempt to define the range of features that exist on the ground, with comments on their dating where possible, and to identify some of the questions that the fieldworker should be asking in order to best interpret a site. My experience centres on vein-dominated non-ferrous mining; some of the points made are also valid for the mining of stratified seam minerals (eg. coal and many iron ores), though important differences do exist.

The terminology of mining features can itself be a barrier to understanding, being dominated by a series of regional vernaculars as impenetrable to the outsider as the highest reaches of academic jargon. The precise meaning of many terms varies between regions, over time, and between authors. In this paper, therefore, I have avoided vernacular terms where possible, in favour of blander descriptive terms which may be more readily usable for cross-regional studies.

In term of their function, the surface features to be found on a mining site can be divided into four broad categories:- - prospecting to locate mineral deposits; extraction; processing to turn the mined mineral into a concentrated ore fit for smelting; and the infrastructure of transport links and (in some cases) water supply that is necessary for a mine to function. The mining site as thus defined will of course lie within a broader landscape of settlement, agriculture and other human activities, both contemporary to the mine and of different dates. This broader landscape is important to the full understanding of any mine site, but is outside the scope of the present paper. Smelting is also excluded, except to the extent that simple smelters can be considered as features of the mining landscape itself.

This functional classification to some extent cross-cuts other possible classifications, by form and/or the process by which the feature is produced, and the use of layout, upcast and process residues to separate the functions of visually-similar features is an important aspect of interpretation.

In particular, hydraulic mining can occur at several functional stages. It can be divided into two major types, hushing and streaming. Hushing is the use of intermittent torrents of water, normally on a relatively steep slope; the range of types and functions, and the dating and distribution, are discussed in more detail in Cranstone (1992a). Streaming is the use of continuous flows of water, normally on a gentle gradient, to extract ore (normally of tin) from alluvial and eluvial deposits. It has recently been discussed in detail by Gerrard (1987), and placed in a broader mining landscape context by Austin, Gerrard, and Greeves (1989, esp pp.42-53), and is therefore excluded from the present article.

PROSPECTING

Prospecting features have often been ignored in discussion of mining landscapes, except in Southwest England; they may be genuinely commoner here, due to the presence of deep weathering deposits in the only unglaciated orefields of Britain, and the persistence of tin ore in weathered deposits (whereas lead and especially copper ores are more vulnerable to weathering). The range of features visible in Cornwall is most clearly described in the Cornwall Archaeological Unit's survey of Kit Hill (Rose and Herring 1990).

Prospecting pits

Simple pits dug to prospect for minerals can presumably be of any date; they can in theory be distinguished from extractive pits by their failure to penetrate bedrock, and their upcast of overburden (normally tipped downhill), corresponding in volume to the size of the pit. Prospecting pits can be organised into lines, extending either across the expected line of a vein, or uphill 'chasing' weathered-out ore to locate a vein ('shode' in Cornish terminology). They grade into trial shafts, which do penetrate bedrock, and may be on a vein (prospecting, in this case, for a workable oreshoot).

Prospecting trenches

Trenches dug to prospect for minerals can similarly be distinguished by failure to penetrate bedrock, and layout across rather than on the line of any vein. Rose and Herring (1990, pp 15, 104-106) suggest that all the Kit Hill examples are Post-Medieval.

Prospecting hushes

The prospecting hush can be distinguished from the prospecting trench by the presence of a dam and/or leat at its head, and the absence of spoil heaps along its sides. It can be distinguished from other types of hush by its location across rather than along a vein, and its failure to penetrate bedrock. Prospecting hushes are typically straight and relatively slight, and in some cases several fan out from a single dam, to prospect a larger area of hillside.

Prospecting adits and shafts

Adits can be driven, and shafts sunk, entirely for prospecting purposes. However it it rarely possible to separate these reliably from extractive shafts and adits from surface field evidence alone.

EXTRACTION

Extractive features on 'early' mine sites can be divided into the two very broad categories of point features and linear features, the latter reflecting the form of the underlying mineralisation. Point features are described first.

Adits and soughs

The classic Post-Medieval adit, large enough for horse transport and adjoined by a rail-laid finger tip, needs no description. However there are documentary references from 1297

onwards in both Devon (Claughton -this publication) and the Pennines (Raistrick and Jennings 1965, p70). Early adits and soughs may well have been smaller and less regular than later examples (for example the undated Sam O'on Level at Greenhow in North Yorkshire), but their character should not be assumed until a corpus of dated examples can be assembled. The terms should probably be restricted to genuinely-horizontal mine openings; the range of irregular openings present on many relatively-early sites are best referred to as 'entries'.

Shode pits

The 'shode pit', as defined in Cornwall, was used to work eluvial or alluvial deposits of tin ore, in situations where no adequate water supply for streaming could be obtained. They typically form dense clusters of pits up to 3.5 m across and 1.5 m deep, unrelated or vaguely related to vein lines (Rose and Herring 1990, pp 15, 106-107). The pits do not penetrate into bedrock. This type of exploitation is rare nationally, though Pennine examples exploiting alluvial deposits of galena have been suggested (Raistrick and Jennings 1965, pp 10-11).

Openpit mines

The open pit is one of the commonest forms of modern mine, but does have rare, early, antecedents. It can be defined as a working open to the sky, wider than it is deep, broadly sub-circular rather than linear, cut into bedrock, and over 5 m across (ie too large to be a test pit). Within the 'early' period, the best-known example is Dolaucothi, where two large open pits were partly worked by hushing. These have been widely accepted as Roman (Lewis and Jones 1969), though the most recent worker (Burnham 1990) rightly urges caution in relating the undoubted evidence for some Roman activity at Dolaucothi to the surface features in their surviving form (especially in view of new evidence for a Medieval phase of exploitation). Other examples of apparently pre-Industrial Revolution openpit mining are known (Cranstone 1992a, p 47), but appear to be rare. The openpit can be more-or-less distinguished from the opencast (normally a feature of seam rather than vein mining), which is very much wider than it is deep, and from the opencut, a linear working along a vein (see below).

Shafts

The shaft is, along with the adit, the most ubiquitous of mining features. Again, the distinctive features (if any) of genuinely-early examples are not yet clear (though see the discussion of gin circles and spoil heaps below). Many relatively-early shafts form part of rake-type workings (see below). One type of shaft that does merit further discussion is the so-called bellpit. Bellpits correctly defined are shafts that simply bell out downwards into a rudimentary working of a sub-horizontal seam or stratiform orebody (it is hard to see this form of extraction as suitable for fissure vein orebodies, though it could be used for shallow 'flat' deposits); once this limited area had been extracted, a new shaft was sunk nearby and its spoil used to infill the previous shaft. The resultant surface feature should be merely a collapse/subsidence hollow, with little or no remaining spoil heap. Unfortunately the term has also come to be used for the surface feature of a shaft (normally visible as a hollow) directly surrounded by a ring of spoil, which in fact should immediately suggest a more sophisticated form of underground working. For example at Bentley Grange, West Yorkshire (Egan 1987, pp 290-291) classic so-called 'bellpits' gave access to a network of horizontal galleries. In line with a previous article (Cranstone 1992b), I suggest that the term 'bellpit' should be restricted to the shaft proven to simply bell out at its base; shafts surrounded by a ring of spoil should be referred to as 'shaft-mounds', and shafts surviving as collapse or subsidence hollows with little or no surrounding spoil as 'shaft-hollows'.

Gin circles

A gin circle is the circular track on which a horse (or horses) walked to operate a winding drum or (more rarely) a horse-powered pump; they are also referred to as 'whim circles', but this has a narrower connotation of winding which is perhaps best avoided unless pumping can be positively excluded. Two types can be identified, the cog-and-rung gin and the whim gin. In the cog-and-rung gin the horse turned a cog wheel geared to a windlass mounted over the shaft; the shaft is therefore within the horse-path. By contrast, in the whim gin the horse was directly coupled to a winding drum on a vertical axle, from which the winding rope passed to a pulley in a headgear over the shaft; the horse-path is therefore to the side of the shaft (Duckham 1970 pp 105-106, 231; Atkinson 1966 pp 30-34). The whim gin tended to replace the cog-and-rung gin during the 18th century; it is generally believed that the latter came into use in the early 17th century, but primary evidence for the pre-18th century history of either type appears to be weak. Gin circles of both types are relatively common, and are likely to indicate a Post-Medieval date. 'Horse runs', where the horse simply walked away from the shaft to haul the load, are also known to have existed.

Rakes

Turning to linear workings, a 'rake' can probably be defined as 'any continuous (or almost continuous) line of interconnecting surface features along the line of a vein'. The distinction from scattered non-linear features (shafts and shaft-mounds) along a vein seems to be reasonably clearcut in practice. From observation, rakes vary considerably in their physical form, but the following classification seems to fit the majority of those that I have seen:-

A) Opencut rakes. The dominant feature is a continuous rock-cut cleft, or a vegetated gully, along the line of the vein (the difference probably reflecting the nature of the country rock, the age of the working, and/or the degree of later backfilling). The distinction from an open stope (where the vein has been slit out from within the mine) is not always clearcut, resting on depth and on whether the vein was worked directly from the surface, or from underground.

B) Shaft-line rakes. The dominant feature here is a line or strip of shafts along the vein, the earthworks forming a more-or-less continuous band of surface disturbance. In practice this feature is normally fairly distinct from lines of widely-spaced single shafts along the line of a vein, the difference probably reflecting at least in part whether the vein was productive at surface, or was sterile at surface with an oreshoot at deeper level. A distinction can be made between:-

1) Rakes dominated by closely-spaced shaft-mounds. These are common, produce very pretty air photos (so are widely illustrated), and at simplest consist of a single continuous line of intertouching shaft mounds, often at uniform spacing. They are aligned along the vein, and penetrate into bedrock (as shown by the composition of their spoilheaps); lines of prospecting pits are distinct in these respects.

2) Rakes dominated by closely-spaced shaft-hollows, with much less evidence of spoil heaps; they can grade into an opencut or hush. This type is referred to as 'lode-back pits' in Cornwall (Rose and Herring 1990, pp 16, 107-108), though the distinction between pits and shafts is not obvious. In many cases, the shafts are cut from the base of a continuous trench, presumably to remove overburden from the outcrop of the vein. On a few sites, I have noticed 'swarms' of very closely spaced small shaft hollows, with no spoil heaps at all; this could result from later removal for reprocessing, or indicate mining confined to rich orebodies so that the relatively small proportion of deads could be totally backfilled into

the last-abandoned shaft (thus approximating to the 'bellpit' *sensu stricto*).

3) 'Reprocessed rakes', dominated by features produced by non-modern reprocessing of earlier deads and tailings tips ('buddling' in Derbyshire); the features, therefore, cannot be related directly to mining, and tend to be larger and smoother. In Derbyshire, D-shaped flat-topped tips are characteristic, and can be identified as the silt built up in rudimentary settling tanks. The form of the actual rake is often obscured; it can be either shaft-line or opencut.

4) Rakes dominated by (on present understanding) more amorphous humps and bumps. This sub-type is distressingly common!

Hushes

Extractive hushes can be divided into two types (see Cranstone 1992a). The 'exposure hush' was used merely to remove overburden down to the rockhead of an already-located vein, whereas the 'exploitation hush' was used for actual mineral production. Exposure hushes are located along rather than across a vein, but do not penetrate bedrock, whereas exploitation hushes do penetrate bedrock, sometimes dramatically. In practice, the distinction between hushes and opencuts is not always clear; some hushes are lined by spoil and tailing tips, indicating that they were worked by opencutting as well as by hushing *sensu stricto*, and many opencuts (or 'beamworks') on Dartmoor have dams and leats at their heads, and would be readily accepted as hushes in the Pennines.

Spoil tips

For site analysis, three important aspects of a spoil tip are the mineral composition, the form of its constituent material and tip morphology.

As regards mineral composition, the tip may consist of:
overburden (soil, peat or glacial drift), indicating that the tip derived from prospecting or site clearance;
non-mineralised rock, indicating 'dead work' driving or sinking off the vein (and therefore perhaps prospecting rather than extraction, if only non-mineralised material is present);
mineralised material ('veinstuff'), indicating driving or sinking on a vein.
It should be noted, however, that the only waste from actual extraction that will end up on the spoil heap (as opposed to the tailings tips from ore processing) is 'deads' separated underground; remaining mineralised material will derive from work on the vein, but not within an economic orebody.

The form of the constituent particles may give some indication of the underground extractive technology. Most obviously, blasting produces large chunks with occasional visible shotholes. Firesetting can also produce visibly reddened or friable stone (firesetting is discussed in various papers in Crew and Crew 1990, and Willies - this publication), and the debris from pickwork should also be distinguishable. However the form may also be affected by the type of rock, and by weathering on the tip - shale in particular tends to break down into fragments regardless of its method of extraction.

Tip morphology is perhaps the most obvious analytic feature, and again the later forms are the most distinctive. The classic 'finger tip', with a flat top wide enough for a railway, is the immediate indicator of an 18th century or later mine, though a railway of 'leitnagel hund' type was probably used by the Mines Royal at Newlands, Caldbeck, and Grasmere in the 16th century, and perhaps at Talybont in mid-Wales in the 1660s (Hammersley 1988 pp 65, 367, 370; Lewis 1970 p 17).
Finger tips can also be barrow-laid; the tops can be much narrower and less flat, though there need be no obvious difference. Barrow tipping from a linear working can produce 'cuesta' tips, though these have so far only been identified on streamworks (Gerrard 1987, pp 17-19).

Tipping from hand-held baskets or buckets may tend to produce rather rounded and irregular 'finger' or 'cuesta' tips. Tipping by direct shovelling (potentially by far the commonest technology on early sites) should produce small tips very close to the origin of the spoil, either of 'cuesta' form or steep-sided with knife-edge or conical tops.

Pre-Industrial Revolution tools rarely survive as surface evidence, with one exception. This is the hammerstone (Crew and Crew 1990, various articles, and Lewis - this publication). Hammerstones are now associated with Bronze Age C14 dates on a number of sites; while it would be premature to assume that they are diagnostic of a Bronze Age date, they certainly produce a case worthy of more detailed examination.

ORE PROCESSING

While the earliest mining may have concentrated on orebodies rich enough to be extracted and smelted without further processing, it was normally necessary to effect a separation of ore from waste ('gangue') minerals in order to produce a smeltable concentrate. Sophisticated washing floors are outside the scope of this paper, which is confined to a brief treatment of the processing features to be found physically intermingled with mining features. It should be noted that that while actual processing features are fairly common on tin sites in Devon and Cornwall, they are rare on the Pennine lead mines, where the waste ('tailings') tips are the normal indicators.

The processes of ore separation can be briefly summarised as:-

1) Hand picking of large pieces of ore and waste. It is unlikely that built storage bays for unprocessed ore (the later 'bouse teams') were used in our period, so the only field evidence is likely to be the waste tips, of large mineralised waste.

2) Breaking down of veinstuff pieces to a smaller size for wet separation. This might be done manually on a knockstone (the norm for lead), or mechanically in the crushing circle or the stamping mill (see below).

3) Various processes of washing the broken-down ore in currents of water ('buddling') and sieving either dry or in a vat of water ('jigging'). In Industrial Revolution technology, jigging was the first process, to produce gravel-sized concentrates, and the finer material was then buddled. Earlier processes were less simple in process flow, and seem to have varied considerably from metal to metal and from area to area (for example Kiernan (1989, pp 15-16) suggests that in 16th century Derbyshire the ore was first concentrated by washing, then sized by riddling). The visible field evidence for sieving or jigging in our period seems to consist entirely of tailings tips, but visible buddles do exist. It should be noted that the ability to use the finer sizes of ore depends on the smelting technology; Kiernan (1989, pp 139-140) argues that for lead the bole could only smelt large ore efficiently, whereas the ore hearth could use wash ore (gravel size) mixed with smitham (under ½ inch). 'Slime' ores could not readily be smelted until the reverberatory furnace was introduced.

The main field features of ore processing on an early site may be summarised as follows.

Knockstones

Stone platforms on which ore was broken by manual 'knocking'. These, or their sites, are often surrounded by dumps of veinstuff chippings.

Crushing circles

The crushing circle consisted of an

edge-runner stone operated by horse-power; the field remains can be confused with those of the horse gin, though they can normally be distinguished by the presence of runner stones and/or of crushed waste, and the absence of an immediately-adjacent shaft. Crushing circles are not documented before the late 18th century (Lynn Willies pers. comm), but the simple technology suggests that a much earlier origin is possible.

Stamp mills

The stamp mill consisted of a battery of vertical iron-shod beams, raised by cams on the axle of a waterwheel and dropped by gravity to crush ore in a trough below. Stamping mills are commonest on tin mines, where they are documented from the 15th century, though they were also used on copper and lead mines from at least the 16th century. They may survive as an earthwork ruin, approached by a leat, but this is not in itself readily distinct from a smeltmill, and the mortarstone (see below) is the most distinctive field feature. Buddles are often associated. The archaeology of Cornish stamp mills is detailed by Gerrard (1989).

Mortarstones

Large roughly-rectangular blocks of stone were used as the bases for stamp mills, producing distinctive rows of rounded hollows (often in more than one face, since the blocks could be turned over for re-use); these are diagnostic of the mechanised stamping mill. The term is also used for smaller blocks or hollowed bedrock surfaces, with a single hollowed face, produced by manual hammering or crushing - relatively common on Pennine sites.

Buddles

Simple buddles and washing troughs are not common (or have not yet been widely recognised) as field monuments within our period. Stone-lined structures such as the magnificent examples on Bonsall Moor (Palmer and Neaverson 1989a p22; 1989b p 322) are rare. Small triangular earthwork hollows, often next to stamping mills, are now recognised as buddles on Dartmoor (Gerrard 1989, Greeves - this publication), and may well await recognition elsewhere.

Tailings tips

The tips of waste from the various processes are far commoner visible survivals than the structures themselves. They are by definition of 'gangue' minerals, and their tip morphology is similar to that of mine spoil tips. Their particle-size composition is the most important diagnostic feature. Picking produces tips of large poorly-sorted material. Knocking and stamping produce little directly-dumped waste, except for chippings round knockstones. Jigging and sieving however produce very distinct tips of gravel-sized veinstuff, common on Pennine lead mines. The finer wastes (slimes) from buddling survive less often on early sites, as they have often been reprocessed.

Slag

Smelting is outside the scope of this paper. However it should be noted that tips or scatters of slag do occur occasionally on the mine. Where these are *in situ* tips (as opposed to material brought in as road metalling), they indicate a smelting site, and if this is in the open air without water power it is a strong indicator of a Medieval or earlier site. Bloomery tips directly associated with mining are becoming quite commonly-recognised features in County Durham, and bole lead smelters are sometimes on or near the mines (Willies and Cranstone 1992).

INFRASTRUCTURE

Space does not permit a full discussion of the other features that may be less directly associated with an early mining site, or may occur in the same landscape without direct associations with mining. However three common types of feature may be briefly noted.

Miners' huts ('coes' in Derbyshire)

Small buildings are common on mine sites, and may have been used for shelter and/or storage (of both equipment and ore). In Derbyshire they are often directly over a shaft.

Leats and dams

Water control systems are very common on mine sites, and may have been used for water power (for stamping or smelting, or for pumping on the more sophisticated Post-Medieval mines), for water supply for ore processing or hushing, or to channel water pumped or wound from the mine, either for use or for disposal. As well as their intrinsic importance, they can be crucial for providing the horizontal stratigraphy by which the sequence of a complex site can be worked out.

Trackways

Transport links are an important part of any mine. Footpaths, packhorse tracks, and cartways all occur, though they can be very hard to date.

CONCLUSION

This paper has attempted to survey the range of features visible at surface on an 'early' mine site, and identify the questions that can be asked in order to attempt an interpretation, both of date and of function. It is far from complete, but will have served its purpose if it provokes others into filling its deficiencies. Our uplands are littered with mining sites, of all periods, and there remains a pressing need for high-quality survey by those armed both with the skills to record accurately and the understanding of mining that is necessary for any correct interpretation.

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