5: Iron and Ironstone

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5.1 Introduction

The archaeological investigation of iron working in England, as in the rest of Britain, is dominated by the smelting processes with little attention being paid to the extraction of the ores which were being smelted. For the post-medieval period onwards the increased availability of documentary evidence has meant that many mining historians have addressed the mining of iron ores but the coverage is patchy with a greater focus on the ironstone of the Coal Measures, haematite deposits in the north-west of England and other low phosphoric ores worked in the south-west of England in the late 19th century. The working of the Mesozoic iron ores along the Jurassic belt from the Midland counties northwards to Cleveland / north-east Yorkshire has, with exception of the latter area, largely been ignored. As a result, the history and archaeology of medieval and earlier periods abounds with questions as to the source of the iron smelted in the many hundreds of bloomery (direct smelting process) sites across England.

The use of iron, and the extraction and smelting of its ores in what is now England, has its origins in the 8th century BC, with the far south-west and the Great Perran Iron Lode identified through trace element analysis as a potential early source of iron ores (Ehrenreich 1985, 97-99). By the medieval period there was no part of the country which could not produce sufficient iron ore to supply a small bloomery hearth. Most of the extraction sites may have been small, sometimes no more than the ephemeral digging of bog iron deposits, and consequently unlikely to attract notice in the wider historical environment. There were, however, sources of ore which attracted increased attention from the late Iron Age and Roman periods onwards and those are highlighted in the discussion below.

There is no overall historical account of iron mining in England, nor have any of its regions been covered comprehensively except perhaps Cleveland and Furness. Mining is touched upon in histories of the iron industry from Schubert (1957) onwards but the focus is normally firmly on the processing of the ores, not their extraction. A few writers have, however, given some attention to the extraction of ores - see, for example, the work of Cleere & Crossley (1995) and Hodgkinson (2008) in relation to the iron industry of the Weald - and English Heritage's Monument Protection Plan (MPP) did include systematic coverage of iron mining (Instone 1995; Cranstone 2001 and 2002). Some individual mines have been covered by historical monographs; one of the earliest being Harris's work on Hodbarrow Mine in Cumberland, through to the recent work by Brooks on the Great Rock Mine in Devon (Harris 1970; Brooks 2004). Taken together these, along with articles published in mining history interest journals, come near to a comprehensive history for some regions. There are gazetteers of mine sites and some accounts of the surviving physical features on the mines which might aid the archaeologist but most accounts of iron mining, whilst providing the background to the history of individual sites, provide little to assist in their interpretation (*see*, for example, Brown 1975).

5.2 Geology and sources of iron ores

In Britain a wide range of iron ores were available, the majority of which had been worked by the medieval period and was known to the 19th-century iron masters (Table 1). Those ores were, of course, not a homogenous product; they vary considerably in their iron content and their chemical composition, with 'impurities', some of which might be beneficial and some which might not, depending on the way they were processed (Claughton 2005).

Table 1: Iron ores used commercially in Britain during the 19th /20th centuries (based on Atkinson and Baber 1987, Table 5).

Ore type	Chemical name	Location	% metal	As mined
Magnetite	Ferrous or iron (II) oxide Fe_3O_4	S. W. England	72.4	65
Red hematite	Ferric or iron (III) oxide Fe_2O_3	West Cumberland, Furness, Cornwall	70	55-60
Specular and micaceous hematite	Crystallised ferric oxide	Devon	70	55
Brown hematite or limonite	Hydrated ferric oxide $Fe_2O_3.xH_2O$	S. W. England, Wales, Forest of Dean. Jurassic Belt*.	60	30-45
Spathose ore	Crystallised ferrous carbonate $FeCO_3$	Weardale, Somerset	48	45
Clay ironstone	Argillaceous ferrous carbonate	Coal Measures, Cleveland	20-37	20-32
Blackband	Argillaceous ferrous carbonate	Coal Measures - mainly	17-30	17-30

	with coaly matter	Scotland

* Resulting from the alteration of carbonates through weathering – 30% or less metal content.

As already noted, Iron Age to Medieval mining used a wide range of ore sources, some of them tiny by later standards. Of the major iron-making areas, the Weald used clay ironstones, and the Forest of Dean limonite. Smaller deposits of Lower Cretaceous clay ironstones, as worked in the Weald, were also worked on other sites across the south of England. For example, in Norfolk, between Weybourne and West Runton, where there are extensive iron pits and smelting sites (Fullilove & Dennis 2006), and the cluster of bloomery smelting sites in the Chilterns, with no known iron ore deposits in the immediate vicinity, which may have sourced their ore from Cretaceous deposits in the Westbury area (discussion at the specialist workshop, Caphouse, 19 Feb 2011). The Coal Measures clay ironstones were also widely used, and with the development of coke smelting and steam-powered furnace-blowing in the 18th century, extraction centred strongly onto coalfields such as the Black Country, Derbyshire, and South and West Yorkshire.

Clay ironstones, the principal source for the industry prior to 1850, were relatively low in iron content but were found in conjunction with coking coal and limestone. Although their phosphorus content was transferred to the slag in bloomery iron-making, in the blast furnace it passed into the pig iron, and thence into the wrought iron into which most pig was converted. Phosphoric pig was not a problem for most foundry purposes (and could be actively preferred). However, phosphoric ('cold-short') wrought iron was hard and brittle; it was suitable for nail-making but not for many high-quality purposes, or for steelmaking. The oxide ores, with the notable exception of the ores from the Jurassic belt, were generally low in phosphorus. Hematite from Furness and West Cumberland mines provided the main British source for 'tough' (non-phosphoric) iron and had been exploited since at least the Middle Ages. The iron masters recognised its value, shipping it to the coalfields as a rich supplement to the local ironstone; improving the quality of the iron product. Development of the Bessemer process stimulated the search for similar ores with renewed interest in the south-west of England, particularly when the manganese content of ores was recognised as a valuable de-oxidising agent, but interest was not matched by production. Between 1863 and 1889 a total of 30 companies were registered to work iron ores in the south-west, the bulk of them (26) in the mid-1870s (TNA: PRO, BT286). Of these only about half a dozen produced significant amounts of ore (Atkinson 1981; Burt *et al*. 1984 and 1987).

5.3 Historical and Archaeological Context

5.3.1 Medieval

Sources of information on iron mining prior to the 12th century are on the whole sparse but, although reference to specific mines is rare prior to the 13th century, iron mines are identified at Lyminge in Kent, in 689 (Sawyer 1968, 73), and at Rhuddlan in north-east Wales, then under English control, in 1086 (Domesday, Cheshire f. 269). There were some areas, the Forest of Dean, the Weald of Kent and Sussex,

Northamptonshire and southern Lincolnshire, and parts of west Somerset and east Devon, where there is evidence for substantial and continued production from the Roman period onwards (Claughton 2010, 59).

By the Late Medieval Period the demand from agriculture, building and the material of warfare gave iron production considerable impetus. A widespread industry, already well-established at the Conquest, was developed to supply local and regional demand. Areas specialising in the mining and smelting of iron ores can be identified. These drew on varied ore resources, each requiring different mining techniques.

Historians of the medieval iron industry have focussed attention on certain localities with substantial and sustained production, for example the Sussex Weald, south-west Yorkshire and the Forest of Dean. But iron was probably the most common mineral and sufficient could be mined to supply a small bloomery in most areas of England. For example, six settlements scattered across the western and southern parts of Somerset are recorded in Domesday as paying, or having paid, dues in iron blooms. The bloom was the product of one firing of the bloomery furnace, hammered to extrude the slag and resulting in a more or less homogenous mass of malleable iron (the direct process). Other payments in iron or reference to iron working can be found in at least four other counties (Domesday; Somerset 1,4. 3,1. 17,3. 19,4; 27; 65. 21,75-76; Index of Subjects, 98). It is also becoming evident from archaeological work that there were far more centres of specialisation than had previously been supposed. In south-west England recent work has strengthened the view that Exmoor and its borders hosted a thriving iron industry throughout the medieval period (Juleff 1997; Juleff *pers comm*). Similarly it has been demonstrated that mining and smelting of iron was carried out on the Blackdown Hills of east Devon from the Roman period until at least the mid-15th century (Griffith & Weddell 1996).

A significant proportion of demand for iron was local, agricultural and building sundries, which makes production difficult to quantify. Schubert has concluded that conflict during the reign of the early Norman kings reduced the agricultural demand for iron. Production recovered in the early 12th century as mines and forges were either acquired or established by monastic orders, principally by the Cistercians. There is reference in the Chartulary Book of Furness Abbey to a mine in the Orgrave area near Dalton, now in Cumbria, from 1235 onwards (Fell 1908; Beck 1844). Purchasing of iron by the Crown for military use, either in weapons or in castle building, is well documented, with the Forest of Dean as the largest supplier (Schubert 1957, 81-87 and 94-98). Production of iron in England is estimated to have been around 1,000 tons in 1300 (Miller & Hatcher 1995, 62, citing Pollard & Crossley 1968, 44). This was not enough to fully satisfy demand, and large amounts of iron were imported from Spain and the near continent. The availability of imported iron may have contributed to a decline in home production after 1300 although it is possible that a shortage of wood had a greater impact. Whatever the causes the evidence suggests a general fall in iron making capacity prior to the advent of the Black Death (*c.*1348-50). One exception appears to have been the Weald, where the proximity of London may have stimulated production. Here the introduction of water power for bloom processing (hammering) suggests a requirement for increased capacity. Renewed demand for iron in the 15th century was again accompanied by the application of water power to smelting and processing, allowing for increased production with the limited labour available. By the end of the century further increases in production were made possible by the introduction of the blast furnace (indirect process) into south-east England (Schubert 1957, 111-15 and 145; Miller & Hatcher 1995, 63; Crossley 1981). There is unfortunately

little evidence regarding capital required for iron mining and iron working. Before the 15th century it was probably low and came from the resources of the individual operator. With the introduction of water power to iron working processes, later evidence from the Weald would suggest that landowners were willing to invest in the fixed capital of the ironworks themselves (Zell 1994, 237-38).

The techniques of mining varied from area to area depending on the nature of the iron deposits. In some areas bog iron ores, deposited by iron-rich water as a horizon in the soil, were worked at an early date by simple pitting (Tylecote 1986, 125). Stratified clay ironstone in the coal measures of south-west Yorkshire, comprising a multiplicity of thinly bedded nodular deposits, were well suited to working by means of bell pits once the outcrop deposits were exhausted. These shallow shafts, widened at their base to work as much ground as the roof stability would allow, are generally associated with coal working. However they appear to have been developed in the medieval period when iron was of greater value than coal. Abandoned workings are sometimes found back-filled with unwanted coal from the next shaft (Tylecote 1965; Moorhouse 1981) or a shaft sunk to work ironstone nodules would pass through a coal seam without any attempt to work that seam (Guy & Atkinson 2008, 90). Good examples of bell pit[1] workings for iron have been found during modern opencast extraction of coal (see Willies 1997). Iron deposits in the limestone occur in two forms: either as metasomatic alteration of the limestone to carbonate ironstone, as found in association with lead veins in Upper Weardale, County Durham, or replacement and karsitic deposits where iron oxides have replaced the limestone or filled existing cavities within the rock, as in the Forest of Dean and the Furness area of southern Cumbria. The former were worked at outcrop or in conjunction with lead/silver rake workings from the 12th century (Dunham 1990, 4). In the Forest of Dean the irregular masses of oxide ores (hematites and limonites) filling all or part natural cave systems were worked at outcrop by a combination of trenching and shallow tunnels, leaving a characteristic series of hollows and exposed caves locally referred to as 'scowles' (Hoyle *et al* 2007). Similar workings might be expected in Furness. On the Weald in south-east England ironstone nodules, found in Lower Cretaceous clays, were worked by pits at outcrop or by shallow shafts up to 12m deep (Cleere & Crossley 1995, 15-21 and 98-99). In east Devon the iron nodules, found in the Cretaceous Upper Greensand which caps the Blackdown Hills, have been worked by multiple shallow pits (Griffith & Weddell 1996). Lenticular deposits, as on Exmoor, and fissure deposits (veins) appear to have been exploited at surface as linear openworks, although a positive chronology has yet to be identified (Juleff 1997, 13).

There is archaeological evidence to suggest that some iron mining areas were exporting their ores for processing elsewhere. A cargo of iron ore was found in a boat, dating from 1240 to between *c.*1250 and 1280, wrecked at Magor Pill on the Severn estuary. The boat's structure was not suitable for work on the open sea and the probable origin of the ore was at or near Llanharry in Glamorgan (Nayling 1998, 105-15), although that source is disputed by Allen (2004). It does, however, imply a regional trade in iron ores. This is reinforced by archaeological evidence for the movement of Forest of Dean ores across the Severn to the Bristol area (Allen 1996). Even within an area of specialisation iron ore might be carried some distance before being smelted (Moorhouse 1981). Smelting locations were largely determined by the availability of fuel, wood charcoal, and, from the 15th century, by the availability of water as a power source.

[1] The term 'bell pit' should, however, only be used if proved underground. At surface, the evidence for shallow working (i.e. the spoil) might be referred to as a shallow shaft mound.

5.3.2 Post-medieval

With the introduction of the blast furnace (the indirect iron smelting process) into England in the late 15th century there was an acceleration of the movement to exploit sources of iron ore which could be sustained. The blast furnace was a bulk production process, eclipsing the bloomery and requiring much larger volumes of ore. Some areas such as the Weald continued to maintain a supply of ore but other areas rose to prominence as being well placed to sustain the supply, having the woodland resources required to provide the large amounts of charcoal and water-power for the bellows. Furness in what was north Lancashire (now part of Cumbria) is a good example. The area had maintained a small but significant iron industry throughout Late Medieval Period, largely sponsored by large monastic estates, but the first blast furnaces were not introduced until the early part of the 18th century (Bowden 2000). Exploitation of the rich haematite resources then responded to demand and progressed alongside the expansion of blast furnace production - at least ten charcoal fired furnaces were established in and around Furness with a further five on the West Cumberland ore-field to the north (Riden 1993). A similar expansion in production had also occurred in the West Midlands, particularly Shropshire, in this case exploiting the ironstone of the Coal Measures. In the Forest of Dean, a major source of 'tough' iron in the 16th and 17th centuries, the ores above the water-table (and therefore accessible before the development of mechanised pumping) were becoming exhausted, and the blast furnaces relied as much on the re-smelting of older slags as on fresh ore (For a comprehensive study of the development of bar iron production in the post-medieval period *see* King 2005).

5.3.3 After 1750

After the development of coke-fired blast furnaces during the 18th century it was the Coal Measure ironstones which rose to prominence as the principal source of ore. By 1850 the iron industry in Britain had already extended the range of ores it used to satisfy demand for a quality product. As outlined in the Geological Background (above) local ore resources were supplemented by other ores, primarily haematite from mining fields such as Furness on the West Coast, shipped into iron works based in those coal fields with suitable coking coal. Yet the iron industry remained largely located in those areas which were defined as having favourable ore/fuel resources after the introduction of coke smelting some one hundred years earlier. The development of railways did allow some extension, for example into upland Northumberland and, more importantly, Teesside. With the development of bulk-production techniques in steel making (the Bessemer process), and the response to early failures in technique, came a demand for ores with particular qualities not readily satisfied from local resources.

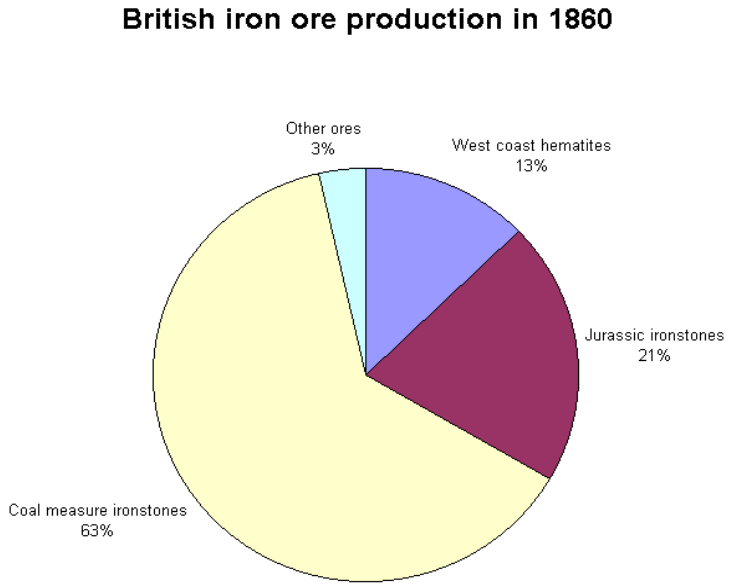

Figure 1

The Bessemer and Siemens open-hearth processes for making mild steel, developed in the 1850s and 1860s respectively, could only work with low-phosphorus iron. This led to an enormous expansion in demand for non-phosphoric ores, notably from Cumberland, Furness, and the Brendon Hills (Somerset), together with increasing imports of Spanish and other haematites, and to the decline or even collapse of some coalfield iron industries. The development of the Gilchrist-Thomas or 'basic Bessemer' resolved this problem by using a lining of dolomite to react with the phosphorus content of the iron and remove it as 'basic slag'. While this stimulated a major expansion of Cleveland iron mining (supplying the Teesside iron industry), and later of the East Midlands Jurassic belt, it did not cause a major revival of coalfield iron mining; mining technology and economics increasingly favoured the low-grade but massive and easily-worked Mesozoic ores of the Jurassic belt over the smaller, less capable of being mechanised, and increasingly worked-out Coal Measures ore deposits. These trends continued in the 20th century, with mechanised open-casting promoting a *floruit* of the East Midlands ore-fields (*see* Figure 3 below), while other ore-fields declined and the remaining blast furnaces relied increasingly on imported ores.

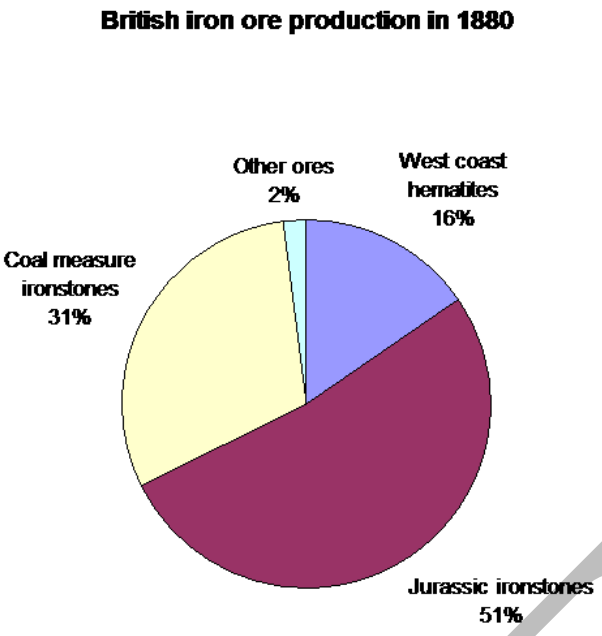

Figure 2

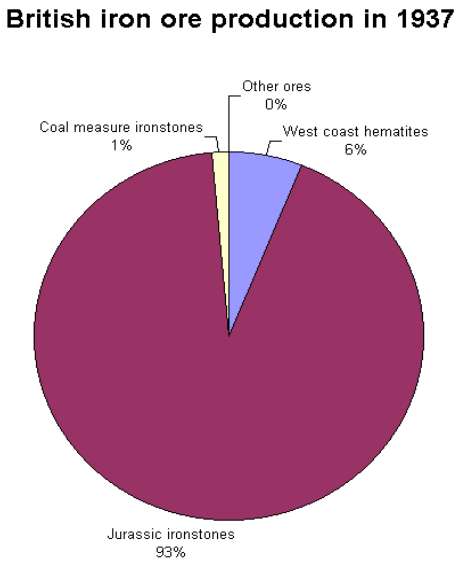

Figure 3

5.4 The Technology and Techniques

Certain techniques were unique to the working of some iron ores deposits. In the large irregular haematite deposits of Furness a technique known as 'top slicing' was used to remove ore from the upper parts first. The

ground above the deposit was then allowed to collapse as the supporting pillars of ore were removed and extraction of ore at the next level started. Ore continued to be removed in 'slices' to the full horizontal extent of the deposit, working downwards in stages until all the ore in the deposit had been removed. Subterranean evidence for 'top slicing' is unlikely to be encountered as the ground above was allowed to collapse leaving the abandoned workings inaccessible but its use is evident at surface as it collapsed leaving immense depressions which subsequently flooded after the abandonment of the mine. In the Cleveland iron mines there were some working techniques which were not adopted elsewhere in metalliferous mining, for example, the use of hand operated rotary or ratchet drills from the late 19th century onwards. In some mines, such as Eston, they were the only form of drill used after about 1903 (Pepper 1996, 14-15).

Whilst not unique to the exploitation of iron ores, the techniques of quarrying the Mesozoic ironstones will leave characteristic surface features where large amounts of overburden have been stripped away using, with time, increasingly large mechanised excavators, including the large walking draglines also used in the opencast working of coal. The widespread use of narrow and standard gauge railways to facilitate the removal of the Mesozoic ironstone in the Midland counties is also a characteristic not met with on a similar scale in other metal mining industries.

Some techniques in ore preparation will have left evidence at surface which is unique to iron mining. Unlike non-ferrous mining, iron ores were rarely subjected to large-scale mechanical concentration procedures at the mine. Although the crushing of iron ores was not a common practice, it was carried out at some mines working Mesozoic ores, for example, at the Oxfordshire Ironstone workings from around 1920 onwards (Tonks 1988-92, II, 138 et seq) However, most carbonate (and some oxide) ores were roasted, either at the mine or at the furnace; this converted the carbonates to oxides, expelled any sulphur content, and also broke up the as-mined lump ore into smaller more porous pieces suitable for blast-furnace smelting. Roasting might be in open heaps (with or without permanent bases or chimneys) or in calcining kilns of various forms; the former should be detectable by geophysical survey, and the latter survive as prominent features at some mine sites, for example in the Cleveland field (*see* for example Owen 1998, 65-71). Some hand picking of Coal Measure ironstone was carried out at surface (Ivor Brown, *pers comm*) and in some cases, as in West Somerset, magnetic concentration and briquetting using a continuous firing kiln were attempted (Jones & Hamilton 2010, 474-75).

5.5 The Infrastructure of Iron Mining

5.5.1 Settlement

In some areas, once iron mining developed on a large scale remote from other centres of industry, it attracted its own associated settlements. This is evident in the Cleveland area which has villages with characteristics more akin to coal mining settlement, erected by speculative builders to satisfy a rapid expansion in the mid-1800s. Early settlement in this and other expanding ore-fields would have used temporary and barrack accommodation and evidence for these might survive in some areas (Hempstead 1979, 240-42; *see* also Owen 1998, 49-56). In the north-west of England it was the shipping points for iron ores which had a major influence on the settlement pattern. The town of Barrow in Furness owes its very existence to the decision by

the local iron companies to export from the port from the 1780s onwards and in the 19th century the town of Millom, the port of Borwick Rails and settlements such as Haverigg and Steel Green expanded in line with production from the Hodbarrow deposits (Brian Cubborn pers comm).

In East Leicestershire the 19th /20th century industry has had little effect on the appearance of local villages. Some workers at more remote locations were housed in wooden cabins which have long since vanished, as was the case in Oxfordshire where Italian and Polish workers were housed in this manner during and immediately after the Second World War. An exception is Asfordby Hill in Leicestershire, a new village with brick terraces, developed from the late 1880s to house workers at the Holwell Company's adjacent blast furnaces, (plus foundry and machinery repair shops from the early 1900s). It remained a very self-contained community, with its own school and social club etc. This pattern would be repeated along the Jurassic belt where settlement focused on the iron smelting sites.

5.5.2 Transport

The work of Eric Tonks on the *Ironstone Quarries of the Midlands* and their railways highlights the role that transport played in the effective working of the iron mines. Aerial ropeways were used in a local context, as at the Loftus Mine in Cleveland (Chapman 1998, 92). Significant amounts of Cleveland ironstone were shipped by sea from Skinningrove and other harbours on the coast of north-east Yorkshire, and the majority of the hematite mined in England would have been shipped from Barrow-in-Furness and other ports in north-west England, but railways were to provide the essential transport link for the industry.

An essential shift in the location of the iron and steel industry took place within a comparatively short space of time between 1850 and 1900 with the shift in the logic of location taking place really between 1850 and 1880, caused in the main by a dramatic decrease in fuel used per ton of pig and expansion in the use of British and then foreign haematite ores. The logic had to be very strong to shift an industry which suffered from intense geographic inertia. Transport was a crucial factor to iron and steel masters who bought their supplies from whoever could supply their required materials at the works at the cheapest rate, including transportation cost.

Because the shift was essentially from coalfield to orefield to coast over this short period and because the raw material sources had separated it is essential to emphasise transportation systems associated with the works or regions in considering archaeological remains. It is either a case of local railways, or even canals in the 18th and early 19th centuries, making the exploitation of a particular deposit a viable proposition or the extension of a regional transportation system in facilitating the development of an entire ironworking area.

Examples of the former would be the Brendon Hills railway (Jones & Hamilton 2010); the Florence tramway on the southern slopes of Exmoor (Messenger 2002); the Rosedale railway (Hayes & Rutter 1974); the Ravenglass and Eskdale railway; and the opencast Jurassic quarry railways (Tonks 1988-1992) and examples of the latter would be the extension of the Stockton and Darlington (and later the North Eastern Railway) into Cleveland and Weardale and eventually across the Pennines; the Glamorgan, Monmouthshire and Brecon & Abergavenny canals and associated tramways in south east Wales; and the Furness Railway in Cumbria. The development of the railway system in the latter region was intimately linked to iron mining as

demonstrated by Melville and Hobbs (1951). Transport systems deserve a major place in preserving the archaeology of iron ore production.

5.6 The Archaeology of Iron Mining and Quarrying

Recorded archaeological investigation of iron mining sites in England ranges from overall survey, as with the largely desk based Scowles Project (Hoyle *et al*. 2007) in the Forest of Dean (Gloucestershire), to the detailed examination of particular mining features with, for example, a gradiometer and earthwork survey at Roman Lode on Exmoor in West Somerset (Dean 2003; Fletcher *et al* 1997) or an integrated study of mining and its infrastructure, as on the Brendon Hills also in West Somerset (Jones & Hamilton 2010). Some investigation has recorded particular features and presented their interpretation in archaeological and historical context as, for example, with the recording of Coal Measure ironstone working including exposures during opencast coal working (Guy & Atkinson 2008, 90; Willies 1997; Moorhouse 1981). The recording of the latter is however not a new phenomenon associated with post-war opencast working. In the 1880s shallow shaft workings for Coal Measure ironstone described, probably accurately, as 'bell pits' quite close to the centre of Leeds were investigated and reported on by an antiquarian (Holmes 1885-86, cited by Sitch 2007, 43).

The bibliography of iron mining (Appendix ##), drawn largely from county Historic Environment Records (HERs), might at first seem quite comprehensive but few of the works cited in the HERs are records of archaeological investigation. However, several recent projects have brought iron mining into focus. An example of an integrated approach to iron mining investigations, building on historical research to investigate the extraction processes as part of landscape study, is found in is the Royal Commission on the Historical Monuments of England (RCHME - now part of English Heritage) project *Furness Iron*. Commenced in 1994 and published in 2000 this project included survey work and interpretation on a small number of iron mining sites, some of possible medieval date and other well documented late 19th century mines, in the south-west of what is now Cumbria (Bowden 2000, 12-21). Complementing the work of the RCHME in Cumbria is that of archaeological and mining history groups some of which has been published, for example the work on the Carter Ground Iron Ore Mine carried out by the Duddon Valley Local History Group (2009, 90-91).

On Exmoor and its borders, West Somerset and parts of North Devon, the investigation of iron mining from the Roman period through to the 19th century has been taken up by academic interests and the local mining history community. The Exmoor Iron Project, looking primarily at the processing of iron ores, has encouraged the study of the extractive processes - see, for example, the work of Bray on iron production in the Roman period (Bray 2006). Geomorphological work on the southern slopes of Exmoor has identified the evidence for both Roman and 16th /17th century iron mining and, to the east, on the Brendon Hills, the work of the Exmoor Mines Research Group has assisted in the interpretation of the 19th-century activity which supplied the iron and steel industry in South Wales (Jones 2006). The results of the latter have recently been published as an integrated study of the history and archaeology of mining and its infrastructure which might be held up as an example of good practice for community led investigation (Jones & Hamilton 2010). Also on Exmoor, at Colton Pits, earthwork survey has revealed the extent of an iron mine, now under plantation, with both 'early' and 18th-19th-century surface evidence (Riley 2000; Riley & Wilson North 2001, 112-14). In East Devon, on the

Blackdown Hills, excavation of one of the many extraction pits for iron nodules in the Cretaceous sandstones provided a Roman period date although documentary evidence and examination of smelting sites indicate that working extended well into the Late Medieval period (Griffith & Weddell 1996). On south-east Dartmoor, survey and investigation has taken place at Ausewell Wood, an early 17th century smelting site (Newman 1998). Elsewhere in Devon and Cornwall the focus has been on the history of mining with little investigation of the archaeological features related to ore extraction. Some recent monographs however provide useful historic context, including Brooks (2004) *Devon's Last Metal Mine* and (2011) *A History of Iron Mining in Cornwall;* Jones (2011) *The Brendon Hills Iron Mines and West Somerset Railway*. In the Forest of Dean, Gloucestershire, the study of features known as 'scowles' has dominated the archaeological investigation of iron mining although, as in other iron mining areas, there are historical accounts and the smelting processes have received significant attention (Hoyle *et al* 2007).

For those counties where there was working of Coal Measure ironstone the investigation of mining features is relatively limited. In some cases the close relationship between the mining of coal and ironstone has masked the evidence for the latter. The work by Willies (1997), taking the opportunity to record and interpret the evidence for early ironstone mining in Derbyshire during opencast coal working, has assisted in understanding the techniques used in working iron in the Coal Measures. It also opens up the potential for further work if adequate archaeological monitoring is in place during opencast coal operations. In the Telford area of Shropshire the investigation of ironstone working in advance of development work has expanded our knowledge of its working but has not been translated into firm archaeological evidence (Brown 1998). The medieval iron industry in West Yorkshire has been examined by Moorhouse (1981) and he has identified evidence for ironstone extraction. Possible evidence has also been highlighted in the course of survey work carried out by the University of Bradford in support of the Judy Woods Project to the south-west of Bradford but no investigation was carried out to differentiate it for coal working (Charlton *et al* 2006). In respect of some projects looking at iron working in West Yorkshire, Moorhouse has been critical of the lack of appreciation for the overall landscape context for iron working; where investigation has a tendency to focus on smelting activity without taking in to consideration its infrastructure (Moorhouse 2007, 23). Post-medieval features have also been identified in what is now South Yorkshire but investigation appears to have been limited to landscape survey with little examination of archaeological features (Fitzgerald 2002; Jones 1995). In some of the coalfields where iron worked alongside coal, there are distinctive features which can mark out iron mining. One example, in the Telford area of Shropshire is the characteristic flat topped spoil dumps clearly identifiable in historic photographs and, in some cases, surviving undisturbed under regenerated vegetation (Ivor Brown *pers comm*).

In the south-east of England the main iron working area was in the Weald of Kent and Sussex where nodular iron deposits were worked in the Lower Cretaceous mudstones (clay). The area has received considerable attention from archaeologists but, again, the main focus has been on the iron smelting processes. Some ore extraction pits, dated to the second half of the 12th century, were examined when exposed during quarrying for material at the Sharpethorne Brickworks and others have been mapped (Swift 1986, 54-55; Cleere & Crossley 1995). In addition, there are frequent references to both the documentary and field evidence for iron ore extraction in the pages of *Wealden Iron*, the Bulletin of the Wealden Iron Research Group.

The working of Mesozoic ironstone from the Midland counties northwards to Cleveland and north-east Yorkshire was by far the greatest contributor to iron ore production in England from the 1850s to the late 20th century, it is well documented, yet it has largely been ignored by both archaeologists and mining historians. Much of what has been published on ironstone extraction in the Midland counties has come from industrial railway interests, particularly the work of Eric Tonks (1988-1992). Although much of the ironstone workings on the Jurassic belt in the Midland counties have been reclaimed there are areas of working surviving under woodland, as at Irchester in Northamptonshire. Many of those sites were identified in the English Heritage MPP assessments (Instone 1985, 36-38; Cranstone 2002, 13-14) and some have been subject to archaeological Investigation (*see*, for example, Cadman 1997).

Archaeological investigation in advance of late 20th century ironstone quarrying at Harringworth and Wakerley, in Northamptonshire, identified ironstone extraction pits from the Roman period and earlier but was not concerned with the quarrying process then underway (Jackson 1981). The 19th /20th century ironstone workings in Lincolnshire have received rather more attention from industrial archaeologists. For example, the history and surviving features of the Claxby Mine were reported by Squires and Russell (1999) and later reassessed (Squires 2003). These and the nearby mines at Nettleton were within the area covered by a RCHME study (Everson *et al* 1991) but, whilst making reference to slag finds and other evidence for medieval smelting, no investigation of ironstone extraction was carried out (Everson *et al* 1991). Archaeologists can be assisted to some extent in interpreting the field evidence for the late 20th century mines by the recollections of those involved in the industry (*see* for example Brown n.d.; Wells 2005). Some mines are still maintained and might be accessed, with permission, to record the underground features - as at the Dragonby Mine, near Scunthorpe (Brown 2006).

Cleveland and the iron mines in north-east Yorkshire have, by contrast, been studied in some detail by mining historians and industrial archaeologists - see Tuffs (1997) for a selected bibliography. There are numerous reports by the Cleveland Industrial Archaeology Society (CIAS) on the mines and the associated infrastructure such as calcining kilns (Cooke & Owens 1994).[2]

[2] A list of CIAS publications can be downloaded as a PDF document at http://www.teesarchaeology.com/new/documents/CIAS_Publications_2008.pdf

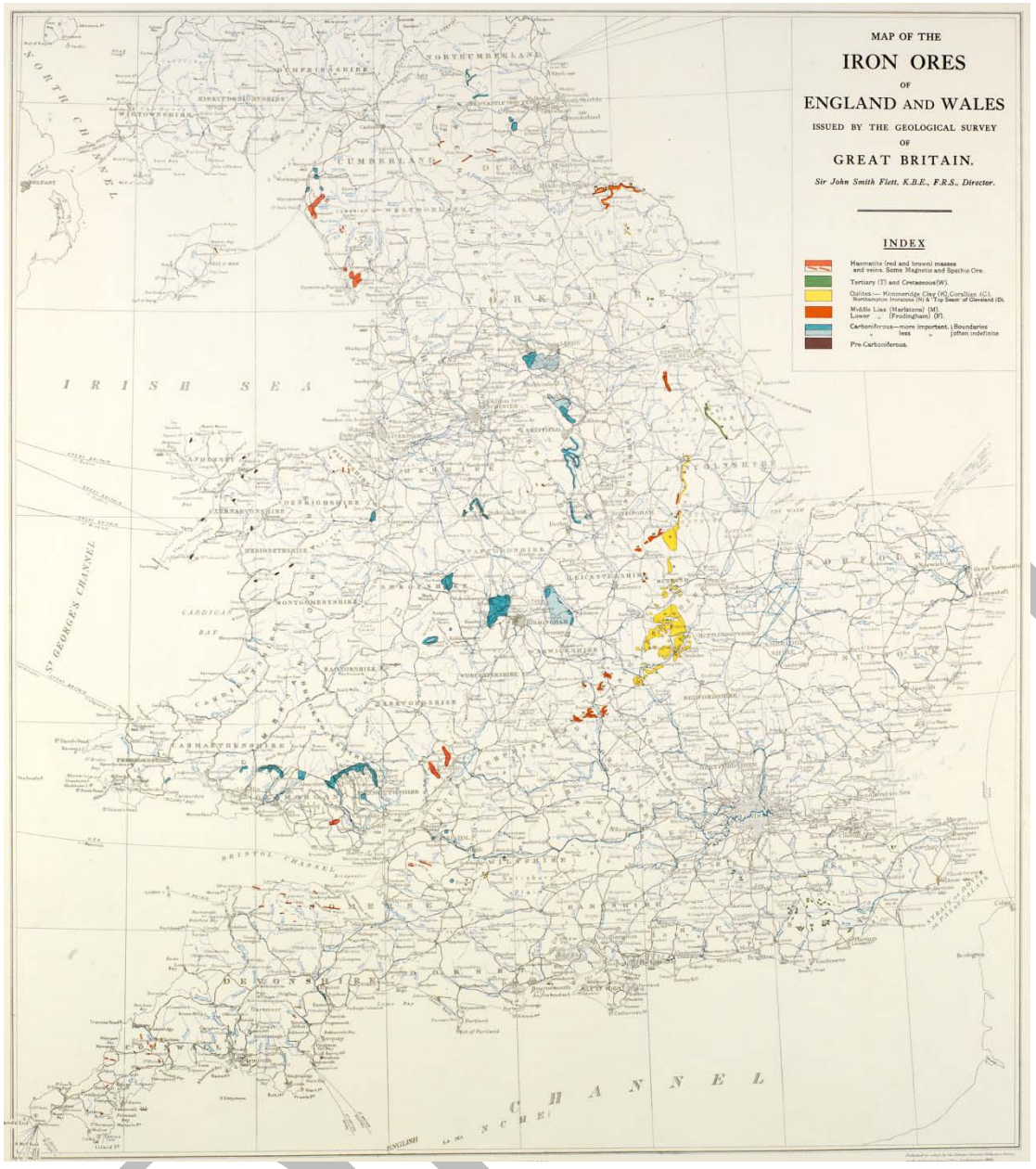

Figure 4

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