Iron Production in Leicestershire, Rutland and Northamptonshire in Antiquity

by Frances Condron

Iron production in Leicestershire, Rutland and Northamptonshire during the Roman period is well attested, though to date the region has not been considered one of importance. This paper outlines the range of settlements involved in smelting and smithing, and suggests models for the organisation of production and development through time. It is suggested that surplus iron was being made and transported outside the region, possibly to the northern garrisons, following the archaeologically documented movement of lower Nene Valley wares. A gazetteer of smelting and smithing sites is provided.

Iron production in Leicestershire, Rutland and Northamptonshire during the Roman period is well attested, though to date the region has not been considered one of importance. Two iron-working regions of note have been revealed, on the Weald of Kent (Cleere 1974; Cleere & Crossley 1985), and in the Forest of Dean (Fulford & Allen 1992). In the East Midlands, the range of settlements involved and duration of production indicate a long and complex history of iron working, in some cases showing continuity from late Iron Age practices. However, there were clearly developments both in the nature and scale of production, at the top end of the scale indicative of planned operations. This paper explores the organisation of this production within sites and across the region, and outlines possible trade networks.

The transition from Iron Age to Roman saw the introduction of new iron working technology (the shaft furnace in particular), and of equal significance, a shift in the organisation of production. Iron was an essential material, used to create hard, durable edges on agricultural equipment, to build and fit out houses, and for a wide range of tools and armour. The conquest and reorganisation of Britain created an upsurge in the use of iron, with the construction of forts and new towns, and greater food production, which is reflected in an increase in the number and size of iron working sites. Such trends are seen in Leicestershire, Rutland and Northamptonshire, though of particular interest is the development of specialist smelting centres from the late first century AD. Their concentration over rich sources of ore and longevity point to production for more than local needs, and it is possible that the East Midlands served as a source of iron for a wider area.

Distribution of Iron Working Sites in the East Midlands

A wide variety of sites has been found in the East Midlands, represented in illus.1 (showing sites for the whole of the Roman period; details have been obtained from county SMRs, local and national journals and published excavation reports). The location of outcrops of iron ores at or within 3m of the surface is also shown, following

the Jurassic and Liassic ridge that runs from Oxfordshire to Lincolnshire (details obtained from geological maps of the area). Deposits deeper than 3m from the surface may not have been utilised, as Romano-British quarry pits found in Leicestershire, Rutland and Northamptonshire were sunk to this depth at most.

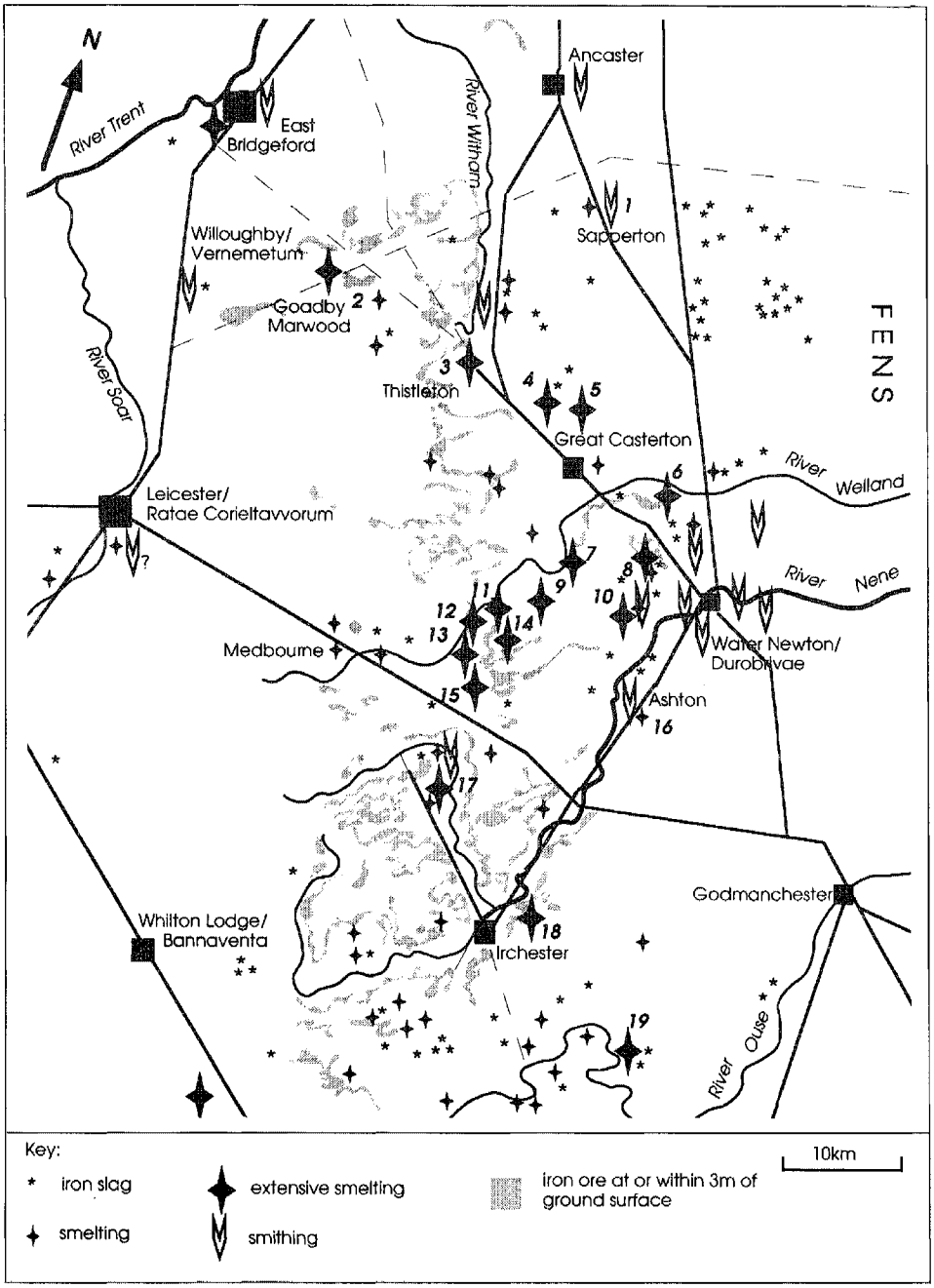
The distribution of production sites gives some indication of the extent of iron smelting and smithing in the region, though archaeological cover is by no means comprehensive. Evidence ranges from occasional finds of slag (from almost all sites from the Iron Age onwards), to more substantial features such as furnace bases, channel hearths, slag heaps and even workshops. Although there is a cluster of smelting centres overlying stratified ironstone, this was not the only source of ore available. Recent fieldwalking in the Fenlands illustrates this well: find-spots of slag in the north-eastern portion of illus. 1 were identified during the Fenlands Project (the Fens have only recently come under the plough, and finds are relatively unabraded). These sites do not overlie known outcrops of ironstone, and presumably 'bog ore' was being utilised. This cluster of iron working may provide a more accurate picture of widespread, low-level smelting and smithing in Roman times, compared with the rest of the study area where hundreds of years of ploughing has destroyed many sites. Nodules of ore could also be dug from glacial drift, and were suitable for smelting. Thus for most of the Midlands iron ore was available in small amounts for very local production.

However, other settlements were clearly using thicker deposits in the Jurassic ridge, and in some cases on a large scale. These are revealed by thick spreads or dumps of slag over large areas, and where excavation has been carried out, by series of furnaces, hearths and associated buildings for smelting activities, and hearths and scraps of iron for smithies. Large-scale production was limited by the quality of ironstone, which declines as the ridge progresses northwards, to the extent that smelting in Romano-British furnaces was not possible using ores much beyond Goadby Marwood (no. 2 on illus. 1). The numbered sites show where smelting or smithing was taking place on a large scale, more than sufficient to meet the needs of the immediate population. Those associated with smithing are: (16) Ashton; Water Newton/Durobrivae, and (1) Sapperton. Smelting on a large scale has been attested at (1) Sapperton; (2) Goadby Marwood; (3) Thistleton; (4) Clipsham; (5) Pickworth; (6) Sacrewell; (7) Collyweston; (8) Bedford Purlieus; (9) Laxton; (10) King's Cliffe; (11) Harringworth; (12) Wakerley; (13) Gretton; (14) Bulwick; (15) Corby; (17) Kettering; (18) Higham Ferrers; (19) Milton Ernest. (Details on each site are provided in the gazetteer at the end of this paper).

Settlements involved in iron working ranged from subsistence farmsteads with occasional and small scale production, to villa-complexes and several 'small towns' specialising in smelting or smithing. With such evidence, it is possible to explore the development of this industry through the Roman period in the East Midlands, placing it in the wider context of farming practices, and local and regional exchange networks.

A hierarchy of iron working sites in the East Midlands

The site hierarchy developed here reflects variation in the scale of production, and relates this to other subsistence activities, to distinguish between occasional smelting and smithing for household use only; specialists serving small communities and supported by that community; town-based artisans; specialist production centres focusing on smelting or smithing, and supported by other communities. In the late



1. Location of Outcrops of Ironstone and Distribution of Romano-British Iron Working Sites in Leicestershire, Rutland and Northamptonshire

Iron Age, skilled smiths were obviously active, though in the East Midlands there is little evidence for specialist centres. These developed shortly after the conquest, both as military works-depots, and later civilian ventures, in some cases active to the late fourth century. These sites mark a radical change in the organisation of production; the concentration of specialists and longevity of many sites required complex negotiations between land-owners and artisans for raw materials (ore, timber and charcoal), and supply or exchange networks to provision what must have been full-time specialist communities. It is these sites that highlight Roman Leicestershire and Northamptonshire as an important source of iron.

There is a range of archaeological features that enable estimates of the scale of production to be made. The most obvious evidence is the spread of slag, and size of slag heaps, though the number of hearths and furnaces is also a useful indicator. Where sufficient excavation has been carried out, it is also possible to consider the duration of such activities: furnaces and hearths may have been re-used several times, which can be established from the state of furnace lining. Consecutive re-building in the same area shows lengthy production, and its duration can be secured from associated pottery and other finds (slag cannot itself be dated). Exploring complexity and skill is more problematic, and is best approached by analysing slag (to estimate the efficiency of the smelting process) and iron goods (however, such finds may not have originated at the smithy, but ended up as scraps for reworking). Little analysis has been carried out on slags from the East Midlands, though ongoing research by Irene Schrufer-Kolb at the University of Leicester should shed some light in this area. The exact processes taking place in the East Midlands have been securely identified for a small proportion of sites, though sufficient to build a general picture of iron working.

Four basic levels of production can be seen, based on Peacock's models of Roman period pottery production (in his 1982 *Pottery in the Roman World: An Ethnoarchaeological Approach*). In increasing order of complexity, they are: household production; specialists in larger farming communities; urban artisans; specialist production centres. It is important to note that this hierarchy does not reflect any chronological trends, beyond the first appearance of specialist production sites after the Roman conquest. However, changes through time are considered.

1. Household production

The majority of sites shown on illus. 1 were probably associated with limited, small-scale, occasional production. Iron slags have been found in rubbish deposits of many farmsteads, though more substantial remains are occasionally found. For example, some iron and copper-alloy slag was found in the ditches of a post-conquest settlement at Wellingborough (Foster *et al.* 1977); at Wakerley (Northamptonshire), a small bowl furnace was uncovered, associated with iron slag and 1st century AD pottery (Brown 1974), and a similar one was found at Harringworth, Northamptonshire (Goodburn 1979, p. 302). Bowl furnaces could have been used at several stages of production, though it is possible that these remains represent all stages, from raw materials to finished tools, following a mode of production typical of the late Iron Age. In this scenario, ore, scraps of metal and fuel (wood and charcoal) could have been collected by the local inhabitants. They may also have carried out preliminary stages of sorting the ore and roasting it, and perhaps even smelting. (Pottery production was a common household activity prior to conquest, and such skills continued, though on a reduced scale, into the Roman period despite the appearance of specialist centres).

However, forging and smithing required expertise, and must have been carried out by specialists, repairing and making basic tools. Iron slags associated with early Roman material have been found all over the East Midlands, and this could reflect itinerant artisans serving the needs of farming communities.

It remains unclear how important itinerant smiths were through the Roman period, when specialist smithing centres developed, and widespread fairs and markets facilitated the exchange of goods and services. Fieldwalking has identified many concentrations of later Roman pottery, building debris and iron slag, though without excavation it is not safe to assume the slags belong to this period. There is more tangible evidence to argue that itinerant smiths continued to serve rural communities: at Ringstead (Northamptonshire), a settlement developed into a small villa complex through the first to fourth centuries. In the fourth century, one room of the main building was used for forging or smithing, though only for a short period (Jackson 1980). It is not safe to assume that Ringstead was typical for the region, nor for smaller settlements. As with pottery supply, the development of specialist production centres and increase in markets probably affected all levels of Romano-British society.

2. Specialists in larger farming settlements

Although many farmsteads show continuity from the late Iron Age into the Roman period, they were presumably affected by the appearance of villa complexes and the reorganisation of land ownership into villa-estates. The concentration of a larger farming population at villa-complexes enabled specialists to be supported for longer periods, to maintain farm equipment and provide building materials. There are indications of this at only four settlements: Lynch Farm and Longthorpe Farm (Cambridgeshire), Thorplands and Great Weldon (Northamptonshire). The first three sites were situated in the farming part of villa complexes. At Lynch Farm, Great Weldon and Thorplands single smithies were set up in stone-built structures; the smithy at Lynch Farm is dated to the third-fourth centuries, and that at Great Weldon to the third century (Taylor 1954, 1955, 1956). Scraps and tools from Lynch Farm indicate production for a farming community: a mower's anvil, hammer and hatchet were found (Challands 1974b). Villa-based smiths may have partly replaced the services formerly carried out by itinerant smiths, and served to reinforce links between villa estate-centres and associated farms or villages. Further work is needed to establish the development of this trend through the Roman period, as present data favours a third-fourth century date only.

There is also evidence for more speculative involvement in iron smelting at one villa: Sacrewell/Thornhaugh (6, Cambridgeshire). In the fourth century several bowl and shaft furnaces were built over demolished out-buildings. The excavator suggested that these belonged to a post-abandonment phase, though earlier finds of 18 furnaces may show longer-term interests in smelting or forging (though these remain undated, Challands 1974a). If these furnaces belong to the latest period of occupation, they could represent diversification of the economic base of the estate, linking into production and exchange networks already established for the specialist production centres to the south-west and north-west (see illus. 1). At present, Sacrewell is unusual in the close association between dirty, polluting iron smelting and high-status residence, which favours interpreting the remains as a smelting and forging centre established over a newly abandoned villa.

3. Urban artisans

Roman towns are generally viewed as multi-functional, serving as specialist production and exchange centres for a surrounding population. As towns became established, there developed communities of artisans supplying goods not available elsewhere. Some industries were later relocated at a distance from town, especially pottery production (Swan 1984). Iron smelting on a large scale was limited to areas rich in ironstone deposits, though smithing was not so constrained. However, current evidence suggests that blacksmiths were not widely represented in towns, unlike workers in precious metal and bronze. Instead, the East Midlands shows widespread rural smelting and smithing alongside small-scale smithing in towns. The role of towns in the supply of iron goods may have been more as exchange rather than production centres. There is an important exception in the case of Water Newton/*Durobrivae*, and in the two smaller settlements at Ashton (16, Northamptonshire) and Sapperton (1, Lincolnshire).

Traces of craft production have been found in early levels of Roman Leicester, including pottery production as well as iron working (Clay & Mellor 1985). A small hearth, possibly used for smelting, was found in Bath Lane in 1978; pottery kilns have been found at Great Holme Street, Southgate Street and High Street (Frere 1977; May 1966; Swan 1984, fiche 429). All have been dated to the late first century (with pottery production possibly extending into the early second century). The decline of such production may have been related to the reorganisation of the *civitas* capital to prepare for construction work on the forum-basilica complex and walled circuit. Pottery production shifted to the Leicester Forest East area (and elsewhere), though Leicester's sources for iron and finished goods remain unclear.

Most 'small towns' in the East Midlands had a minor role as smithing or smelting centres (the exceptions of Ashton, Sapperton and Water Newton are covered below). A smithy has been found at the civilian settlement at East Bridgeford/*Margidunum* (Nottinghamshire); a few tools were found in a second century floor deposit (Todd 1969), and represent the needs of a fairly self-sufficient community (knives, cleaver, sickle, chisel, nails, hipposandal). At Ancaster, some iron slag was found in a building otherwise used to process and store cereals, with no evidence for other smithies (Todd 1978). A small bowl furnace was found at Great Casterton (Leicestershire), though was probably used during the construction of a building. Slag from the upper fill of the defences' ditch and town interior could be medieval (Corder 1961, pp.32-37). Spreads of smithing slag have been found at Willoughby/*Vernemetum* (Kinsley 1993), and High Cross/*Venonae* (Greenfield & Webster 1966), though cannot be associated with any structures. Some slag was found near the *mansio* at Cave's Inn/*Tripontium* (West Midlands), though there is little indication of scale (Cameron & Lucas 1973). At present it is not possible to view the blacksmiths at these towns as offering a wider range of services than those available elsewhere.

There is an important exception in three small towns: Ashton (16, Northamptonshire), Sapperton (1, Lincolnshire) and Water Newton/*Durobrivae* (Cambridgeshire). Water Newton exhibits a degree of complexity on a par with *civitas* capitals, compared with the much smaller Ashton and Sapperton. These are dealt with here. Excavations have been carried out at all three, though detailed reports have not been published. At Sapperton, there was a brief period of intensive iron smelting in the early second century. In the mid second century rectangular houses were laid out on both sides of the Bourne-Ancaster road, and several were fitted out as smithies.

This activity withstood a shift of the settlement and rebuilding of houses/workshops, though in the 4th century smithing gradually gave over to an increase in crop-processing (Simmons 1995). About one sixth of the small town of Ashton has been excavated. At least four smithies have been uncovered; these remained in use as workshops for several generations. Iron slag was spread thickly along the streets, indicating further workshops. Smithing remained an important activity from the later first to fourth century; there was some evidence for pottery production too, taking place in a different part of the settlement. Phosphate analysis shows animals were kept in the settled area, and enclosures, or paddocks, were maintained through the whole of the Roman period - the agricultural base of this settlement was also important. In the absence of detailed records, it is not possible to outline a development of Ashton (Brown 1978; Burnham & Wacher 1990, pp. 279-281). Excavations in the Normangate Field suburbs of Water Newton have revealed both iron and pottery production on a large scale. This was the centre of the Lower Nene Valley industry, though kilns were spread some distance along the Nene. Agricultural land in Normangate Field was given over to iron and pottery production from the early second century (Burnham & Wacher 1990, pp. 81-90). Several workshops have been excavated; in contrast with those at Ashton and Sapperton, these seem to have been converted for different uses in quite rapid succession. Workshop A was initially used for potting, though later fitted out with furnaces and hearths for smithing, and later still converted for another unidentified use; superimposed kilns and furnaces/hearths across the suburbs indicate this was a widespread practice (Dannell 1974). Although this is based on a very small sample of buildings, it may represent different relations between the landowner and artisans, tenancies being held for short periods compared with either tied labour or family-owned units at Sapperton and Ashton. *Simmons'* work at Sapperton has suggested a population in some way tied to the settlement, the land-owner based in the nearby villa and controlling the layout and output of the 'small town' (Simmons 1995). This raises questions about the status of the inhabitants of Ashton, and also of other specialist production centres (discussed below).

4. Specialist production centres

An interesting feature from the later first century AD is the appearance of what can only be termed industrial villages. Ashton and Sapperton may fit into this category. The term covers an important range of settlements, which have been further split into three sub-sets: military works-depots, civilian smelting centres, smithing centres.

i) Military production

A military presence in the East Midlands was established soon after the conquest, though most bases had been abandoned by the mid 70s for ones further north and west. Around A.D. 50 a works-depot was established at the site of the later fort and settlement of East Bridgeford/*Margidunum* (Todd 1969). It had a working life of around 20 years, in which time enclosure systems, smelting debris and other remains had spread over 600m. This represents a brief, exploitative phase of production, presumably to supply the garrisons with architectural fittings and simple tools. Its position along what was established as the Fosse Way, and by the Trent, meant that blooms or finished goods could have easily been transported over large areas. This works-depot contrasts with the one excavated near Longthorpe Fortress, in operation

between *c.* A.D. 49 to A.D. 62. The latter was manufacturing pottery for the fortress, and some smithing and bronze-casting was also taking place, all presumably under the control of a military potter (Dannell & Wild 1987). The excavators considered the Longthorpe depot to have met the needs of the fortress alone; the considerable spread of smelting debris at Margidunum would imply production for several legions and auxiliary units, particularly those along the Fosse. While it is not possible to identify the origins of these artisans, it is reasonable to suggest a mix of military and 'native' labour, under the control of a legionary commander, as has been suggested for other military depots (for example, Holt, Clwyd).

Continuity from military to civilian operations is not seen at either site. Current opinion is moving away from viewing the army as the major agent of technological development; civilian iron objects rarely show the expertise in smithing in contrast with the highly organised production of military weapons and armour (Hutcheson 1997 for a comparison of military and civilian iron tools in northern Britain). This separation of military and civilian was not absolute, as suggested by Swan's study of kiln technology in Roman Britain (Swan 1984), where similarities can be seen between kilns associated with military sites and the new industries at Colchester, and in the production of mortaria. Skilled potters from the continent, perhaps following the legions, brought in new technologies and established potteries with local artisans, some of which became major industries. This serves as a model for the introduction of new iron working technology, though the difficulties in dating the features and debris of iron working sites mean that far less is known in comparison with pottery studies.

ii) Civilian smelting centres

Between the late first and early second centuries, a group of settlements specialising in the smelting of iron developed. Two concentrations emerge, between Kettering (16) and Bedford Purlieus (8, Cambridgeshire), and a more dispersed arrangement between Pickworth (5) and Goadby Marwood (2 in Leicestershire). This difference may be a result of uneven archaeological coverage, though fieldwork around Goadby Marwood and Thistleton (2, 3, Leicestershire) has not reported much slag away from these two sites; production may have been concentrated at these settlements. The brief but extensive smelting taking place at Sapperton may have belonged to a late 1st-early 2nd century phase of establishing smelting sites in this area, though production was short-lived.

Fieldwork at Goadby Marwood (2), Thistleton (3), Laxton (9), Harringworth (11), Wakerley (12), Gretton (13), Bulwick (14) and Kettering (16) has revealed similar working arrangements, of channel hearths for roasting the ore, shaft and bowl furnaces for smelting and possibly forging, and large dumps of slag. These settlements involved several families working at the same time, and over many generations. Rescue work at Thistleton noted 57 furnace bases, and seven stone-founded rectangular structures, though further walls and post-holes must be the remains of other buildings. These were widely spaced along a roadway leading to the elaborate temple complex, which provided a strong focus for this settlement (Richmond & Taylor 1958, 1959; Liddle 1995). At Goadby Marwood some features were recorded by the quarry supervisor. Many bowl-furnaces were seen, (quarry) pits, and twelve wells uncovered (presumably marking the location of buildings). Metal-detecting has recovered hundreds of coins from all periods, and pottery indicates

occupation through the whole of the Roman period. At Laxton production was so intense that the dumps partly filled a small valley, and covered 4,000 square meters. Production was greatest in the late first and early second centuries, though continued through to at least the third century (Jackson & Tylecote 1988). Unfortunately, detailed publications are not available for any of these sites to enable estimates of total or annual ouputs to be made.

It is worth exploring smelting technology in further detail, to gain some insight into different practices across the region. Following approaches in kiln studies, basic forms of shaft furnace have been identified, primarily by internal dimension: very large (over 1m), large (1m), and small (*c.* 0.3m). These dimensions are useful indicators of smelting technology as the large furnaces would have required almost constant blasts of air from bellows to raise the temperature to the melting point of slag, though for smaller furnaces this was not essential. Details are available for a few sites only. The early shaft furnaces at Laxton (late first-early second century) were exceptionally large, with an internal diameter of *c.* 1.35m; Jackson & Tylecote (1988) found possible parallels on the Danube, at Klostermarienburg und Unterpullendorf, near Vienna. At Fineshade (Northamptonshire), slag similar to that from Laxton was found, though no furnace, and it is unclear whether this relates to the unusual early furnaces (Frere 1989, p. 290). Two large furnaces were excavated at Byfield (south Northamptonshire) with an internal diameter of *c.* 1m. These were similar to others found at Bulwick and Wakerley (north-west Northamptonshire), and seem to have a general second-third century date (Jackson & Tylecote 1988). Such large furnaces would have required blasts of air from bellows to raise the internal temperature sufficiently to melt the slag. Later furnaces at Laxton had a smaller internal diameter of around 0.3m, similar to those found at Pickworth (5, Leicestershire), also of second century date. Other undated furnaces of a similar style have been found at Oundle, King's Cliffe, Bulwick and Wakerley (all in Northamptonshire). Finally, the large hearths found at Bedford Purlieus, with diameters of 2.05 and 2.1m respectively, may have been used to roast ore, but not for smelting. They have been dated to the second-early third century (Wilson 1966).

The large furnace found at Laxton (and possibly one at Fineshade) belongs to an early period of smelting, furnace technology seemingly inspired by Continental practices, which made little impact on smelting practices in the region. The early production at Laxton may have been established by entrepreneurs, possibly taking advantage of increasing demands for iron with the growth of the new towns (as has been suggested for pottery industries). The two other styles of furnace seem to represent a later stage in iron production, and show a consolidation of iron working in the East Midlands which remained strong from the second to early fourth centuries. Both styles were found in the same area, and could indicate two parallel traditions continuing alongside each other, rather than different stages of production. To expand on this picture, it would be useful to compare slags from Laxton and the military works at East Bridgeford and Longthorpe, to confirm differences between military and civilian ventures. Also, more detailed information from the smelting sites in west Leicestershire is needed to identify possible origins and developments.

Unfortunately, it is not possible to estimate the amount of iron being produced at any of these sites, nor volumes of slag, as detailed plans and sections are not available. However, the concentration of at least twelve specialist smelting centres

between the lower Nene and Welland, and a further four to the north are strong indication of a considerable industry. For comparison, extensive fieldwork in the Weald has identified over sixty iron working sites, though a large proportion were discovered in the past thirty years (Cleere & Crossley 1985).

iii) Smithing centres

Only three centres specialising in smithing have been identified, and have been covered above, under urban settlement. Smithing produces far less debris, and in the absence of detailed excavations is difficult to identify. Excavations at Ashton revealed a complex nucleated settlement with formal burial grounds and possible industrial zoning; this was not apparent from surface finds, and further smithing centres may await discovery in the region. Willoughby/*Vernemetum* is a possibility.

Ashton and Sapperton, with several smithies in operation at the same time at each, were meeting more than local needs, though surplus goods may not have been marketed from these small towns. In contrast, the development of the small town at Water Newton, with its extensive suburbs, provided more opportunities for individual artisans. As the centre of the lower Nene Valley pottery industry (which developed from the mid second century), its trade networks extended over a large area, which must surely have included exchange of iron goods as well as pottery vessels and their contents.

Smithies needed to be supplied with blooms, though iron would also have been reworked. Ashton and Water Newton must have used blooms from smelting sites to the west, though the mechanisms of supply are unclear. Sources of iron for Sapperton presumably came from further west. If smithing at *Vernemetum* was considerable, Goadby Marwood is a reasonable supplier. Negotiations between smelter and smith may have been organised by those in charge of production. If villa-owners had control over the origins and development of smithing centres (Simmons 1995 on Sapperton), they may equally have had interests in smelting, and ownership may have been in the form of a dispersed estate. Different arrangements seem to have operated at Water Newton. In the absence of epigraphic and documentary evidence, these remain suggestions only.

Having explored the various ways of organising iron production in the region, it is obvious that close connections extended between smelting and smithing sites, and land-owners. Raw and partly worked materials were moved between settlements, and finished goods across the region. Iron ores, blooms and finished tools cannot be closely provenanced, but it is possible to suggest the direction in which goods were moved by following existing models for Romano-British pottery. By the early second century pottery as well as iron production was a largely rural industry; in many cases both activities were taking place on the same site (for example, Water Newton, and also Bulwick (14), Kettering (17), Wellingborough, and Ashton (16)). Close links can be safely assumed.

Production and supply of iron in Leicestershire Rutland and Northamptonshire, and beyond?

With the onset of civilian rule, and from the second century the emergence of many iron (and pottery) production settlements working for many generations, there must have been large stretches of managed woodland. Coppicing must have been widespread, to provide the wood for kilns and ore-roasting; odd pieces were suitable

for charcoal-burning; more mature trees were needed for building (the typical aisled barns of the Midlands needed large trees). Cleere, using sites on the Weald, has suggested up to 100 acres of managed woodland (coppiced on a 12 year cycle) were needed to provide fuel for a typical bloomery output of 4 tons per year (Cleere & Crossley 1985, pp. 99-100). While it is not possible to estimate output for any of the East Midlands sites, this does give some indication of the needs of iron (and to a lesser extent, pottery) production.

The concentration of smelting sites in the region may not have been accompanied by specialist charcoal burners. Iron smelting may have operated in cycles, and slotted into the farming year (Cleere has suggested this for some of the Wealden sites). Coppiced wood is best cut in the winter, at which point it could have been turned to charcoal. Smelting and forging may have fitted around other slack periods in the farming year, enabling some food to be grown and processed by the inhabitants of smelting sites. Excavations at Ashton and Sapperton show both cereal farming and animal rearing, and this may also have been the case at smelting sites.

The period for the emergence of many of the industrial villages, late first-early second centuries, coincided with the emergence of villa estates (though villa-complexes were at their most elaborate in the late third and fourth centuries). The landscape was undergoing considerable changes in the organisation of tenure – land was taxable; it became recognised as a commodity, and opportunities for exploitation were seized. Where production centres were in close proximity to villa complexes, it is possible to suggest links. Thus Simmons has implied control over Sapperton by the nearby villa-owner (Simmons 1995); whether this holds for other settlements remains unclear. Todd has suggested that some unwalled small towns were occupied by *coloni*, the owners living in nearby villas (Todd 1970). While this cannot be established for the 'industrial villages' of Leicestershire, Rutland and Northamptonshire, it remains a feasible option. A second possibility is the establishment of production centres by *civitas* authorities, under the auspices of the gods. Temple land could not be owned by individuals, though could be exploited to the advantage of the temple. At Thistleton the close association between temple complex and smelting workshops suggests this situation; less evidence is available for the scale and duration of smithing at Willoughby, though the place-name *Vernemetum* means 'sacred grove', suggesting an association between iron working and the gods.

The rise of specialist sites situated close to road and river networks shows considerable organisation, and therefore the possibility of controlled extraction, production and trade in ferrous commodities. The movement of blooms and finished goods operated over longer distances. Specialist smithing centres such as Ashton, Sapperton and Water Newton needed blooms, as did smiths situated in other towns. Not all smithing was based in towns or specialist centres, though these may have been the major markets for the majority of the population.

The crucial issue is whether there was a surplus of iron being made in the region, which was traded over longer distances. Cleere has outlined a convincing argument for the movement of iron blooms made in the Weald to the Northern garrisons, and also to military units based at the mouth of the Rhine, neither of which are rich in iron ore (Cleere 1974; Cleere & Crossley 1985). *Publicani* arranged with those in charge of Wealden production, and blooms were worked into tools and weaponry on military workshops. (Hutcheson's recent study of some iron hoards from military and civilian sites in northern Britain showed that the military were using different smelting and

smithing technologies to other sites in the area (Hutcheson 1997)). Production in the Weald declined from the third century, the region perhaps no longer supplying northern garrisons. The Forest of Dean was another important source of iron, and richly worked in the Roman period (Fulford & Allen 1992; Jones & Mattingly 1990, pp. 179-195), though less work has been carried out.

It is possible that surplus iron from the East Midlands was being moved to military units in the north of Britain, possibly serving as a new supply as the Weald declined in importance. Distribution networks existed for the supply of lower Nene Valley wares to the northern garrisons from the late second to late third centuries; it is possible that iron followed similar routes, though being worked by military smiths and therefore not visible in the archaeological record. Water Newton/*Durobrivae* may have acted as the distribution centre, with a concentration of potters and smiths providing goods for exchange (other items must have been made, though are not documented archaeologically). Prior to drainage and canalisation, the Nene was navigable by small sea-going vessels up to this point, providing easy transport. The cluster of smelting sites in north Northamptonshire and west Cambridgeshire were linked to Water Newton by roads, and iron blooms could have followed this route. There may have been an overland route too, extending to the west. Several lead seals have been found at Leicester, documenting the movement of military consignments through the town (Clay 1980). Products from Goadby Marwood and perhaps Thistleton may have been transported westwards through Leicester, though this is a tentative suggestion.

Thus the scale and longevity of iron production in the East Midlands identifies the region as an important supplier of iron goods for other parts of Roman Britain. Many sites have been excavated, though further work is needed to improve our understanding of the nature and quality of iron production, and its relation to other activities in the region. Five areas of research can be highlighted:

i) Types of production (smelting, smithing), and the location of sites across the region. This is important for all sites, but particularly for household production and specialist centres.
ii) Scale of production, particularly for the specialist centres, to enable detailed comparisons to be made with the Weald, Forest of Dean, and other regions on the Continent.
iii) Quality of production (recognised through analysis of furnaces, slags and finished tools). Were specialist production centres, presumably housing dedicated artisans, making a better quality product more suited to the high demands of a distant (military) market, than other sites?
iv) Relation between iron production and other activities (particularly specialist and agricultural production) taking place on-site/nearby. An important area of research across the full range of sites.
v) Transport and exchange of iron goods – the model suggested here, of iron goods following the same routes as the archaeologically more visible ceramics, remains to be tested.

Future work has the potential to undertake a detailed analysis of specialist and household production in the East Midlands, focusing on the integration of iron working alongside the production of ceramics, textiles and agricultural goods so well attested on archaeological sites. This can be used to build up complex models of overlapping networks of local, regional and long-distance exchange linking rural settlements, specialist production centres, towns and military sites within and beyond the region.

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Gazetteer of iron working settlements (excluding those with scant information):

Quarrying

Goadby Marwood, Leicestershire SK 7827 Abbott 1956; Leics SMR under Goadby Marwood
See below. The site overlies suitable ironstone deposits, and many pits were noted during quarrying in the 1950s.

Kettering, Northamptonshire SP 8780 RCHM(E) 1979, pp. 102-3; Dix 1987
Numerous pits were found during excavations, re-used to dispose of rubbish, but originally cut down to suitable ironstone deposits.

Lynch Farm, Cambridgeshire TL 1497 Dannell & Wild 1987, p. 65
Late Iron Age or early Romano-British quarry pits were cut into gravels, presumably to obtain the ore for smelting testified by iron slag. This is not related to the later smithing at Lynch Farm (see below).

Smelting

Bedford Purlieus, Cambridgeshire TL 0499 Wilson 1966; Tylecote 1969; Cambs SMR 115; Nthants SMR 261
19th century references to Romano-British buildings (Artis). Fieldwalking has identified extensive spreads of iron slag, and rescue work in the 1960s uncovered two bowl furnaces and second-early third century pottery. The bowl furnaces had a diameter of *c.* 2.05m and 2.1m and were too large to be used for smelting.

Brigstock, Northamptonshire SP 9283 Brown 1971; Hall in Miles 1982
Numerous quernstones were found, presumably used to grind ore prior to smelting.

Bulwick, Northamptonshire SP 9293 Jackson 1970, 1979; Swan 1984, fiche 517
Large scale production, with several clusters of slag pits, channel hearths, bowl hearths and shaft furnaces uncovered prior to ironstone extraction. There was also evidence for pottery and lime production.

Byfield, Northamptonshire SP 5153 Jackson & Tylecote 1988
Two furnaces uncovered in rescue excavation. They had an internal diameter of *c.* 1m, and had been re-used many times (for smelting). One was partly sunken into the bedrock, and the taphole was probably higher than the surviving structure. In style they are similar to those from Bulwick and Wakerley. Post holes were found nearby, perhaps anvil bases for preliminary treatment of the bloom.

Clipsham, Rutland SK 9815 Liddle 1982, p. 42
Thick spread and dumps of slag and Roman pottery found through fieldwalking and minor excavation.

Collyweston, Northamptonshire TF 0000 Taylor 1955
Complex of at least five shrines and further building debris. Slag was found all over the site, and floor E contained a hearth and iron slag (possibly relating to earlier use).

Corby, Northamptonshire SP 9089
Romano-British settlement covered several hectares, with evidence for agricultural production and slag spreads.

Duddington, Northamptonshire SK 9900 Brown 1978, p. 181 ?Romano-British smelting furnace

East Bridgeford/Margidunum, Nottinghamshire SK 7041 Burnham & Wacher 1990, pp. 260-264; Oswald 1927; Todd 1969
Iron slag covered up to 200m along Ermine Street, associated with the military depot established shortly after conquest. This smelting did not continue after the departure of

the military around AD 75; the civilian settlement housed at least one smithy (second century), presumably meeting the needs of the small town population.

Fineshade, Northamptonshire SP 9797 Frere 1989, p. 290
Occupation debris and iron slag, similar to Laxton, found during development.

Goadby Marwood, Leicestershire SK 7827 Abbott 1956; Leics SMR under Goadby Marwood
This industrial village was uncovered during topsoil stripping prior to ironstone extraction. It covered several hectares, with 12 wells marking the location of buildings, numerous pits presumably dug to obtain ore, and 'hundreds' of simple bowl furnaces. Finds from metal detecting indicate settlement from the mid first to late fourth centuries.

Great Weldon, Northamptonshire SP 9289 Taylor 1954, 1955, 1956.
Romano-British villa complex. In the third century a small circular workshop housed a small furnace and two to three hearths; no other evidence for iron working was found.

Gretton, Northamptonshire SP 9094 Brown 1971, p.19; Jackson 1979
Two sites found, *c.* 100m apart. At the first, rescue excavation uncovered ditches, Romano-British pottery, one shaft furnace, several channel hearths and much iron slag. At the second, fieldwalking identified extensive mounds of slag, presumed to be Romano-British.

Harringworth, Northamptonshire SP 9398 Goodburn 1979, p. 302; Jackson 1981
Topsoil stripping prior to quarrying uncovered two buildings associated with much iron smelting activity (hearths, furnaces, slag, ash). Roman period. About 100m to the south, a bowl furnace was found, possibly in use prior to conquest.

Higham Ferrers, Northamptonshire SP 9570 Meadows 1992
Settlement covers 8ha, with occupation from the late Iron Age to the late Roman period. Supposedly extensive iron working took place, though only one building has been published.

Kettering, Northamptonshire SP 8780 RCHM(E) 1979, pp. 102-3; Dix 1987
Notes of archaeological finds were made during quarrying in the 1910s, though more recently controlled excavation has added to this picture. The industrial village was aligned along a south-east - north-west street, with buildings constructed both in timber, and with stone foundations. As well as farming activities, quarry pits, hearths and slag spreads attest to extensive iron smelting; several pottery kilns were also noted. There may have been a break in occupation in the third century. Quarrying and smelting may have continued after the third century, though the pottery kilns belong to the late first or early second century.

King's Cliffe, Northamptonshire SP 9996 Brown 1973
Extensive spreads of iron slag and limestone found. Presumed to be a centre of iron smelting.

High Cross/Venonae, Leicestershire SP 4788 Pickering 1935; Greenfield & Webster 1965
Some iron smelting slag was found in the main area of the small town, though any smelting was probably on a small scale.

Laxton, Northamptonshire SP 9496 Frere 1986; Jackson & Tylecote 1988
Although much of the site was destroyed in the 19th century, salvage excavations in 1985 recorded several furnaces and extensive slag dumps. Iron smelting appears to have been particularly intensive in the late first and early second century; a line of five furnaces may have been in use simultaneously. The earlier furnaces were unusually large, with internal diameters of *c.* 1.35m, compared with later furnaces with an average internal diameter of 0.3m. The furnaces had sunken floors, cut *c.* 0.4m into the ground. The early furnaces did not have tap-holes; to obtain the bloom, the walls had to be broken. Production was so extensive that the slag covered an area of 4,000 square metres, in a layer deep enough to fill a shallow valley. The early furnaces were constructed in a similar style to contemporary pottery kilns. The later furnaces have parallels at Wakerley, Northamptonshire.

Medbourne, Leicestershire SK 8093 Liddle 1982, p. 33
Slag has been recovered from the area of the small town, though much of this may relate to post-Roman production. One Romano-British shaft furnace has been found nearby.

Milton Ernest, Bedfordshire TL 0356 Beds SMR 6749
Fieldwalking recovered a range of Romano-British wares, and extensive spreads of slag in an adjacent field. Presumably smelting slag.

Pickworth, Lincolnshire TF 0014 Tylecote 1969
Three shaft furnaces were excavated (dated to the early second century). The furnaces had an internal diameter of *c.* 0.3m, and were *c.* 0.9m tall. They were set up in a line, *c.* 3m between each. A simple post-hole constructed shelter was found nearby. Nodular ore was being used.

Sacrewell, Cambridgeshire TF 0705 Challands 1974a; Norwich 1974; Peterb' museum 1992
Roman villa complex (there seems to be some confusion with this site, as it is listed both as Thornhaugh and Sacrewell, though grid references indicate that they refer to only one villa). Excavations in the 1940s uncovered eighteen furnaces. In the 1970s a further eight were found in a 120m long excavation trench. Details for the later excavations state that they were simple bowl furnaces, though one was a substantial stone-built shaft furnace; a possible ore-roasting chamber was also found. The furnaces were built over levelled outbuildings of the villa; iron smelting took place in the final stages of the villa's occupation, or may have been post-abandonment.

Sapperton, Lincolnshire TF 0132 Simmons 1976, 1995; Burnham & Wacher 1990
This small town has been the focus of a long-term field project by Simmons since 1972. Prior to the laying out of the settlement, there was a phase of intensive iron smelting in the early second century, though only an extensive spread of slag has been found. The small town was established some time after, in the second century; smithing was an important activity throughout the lifetime of this settlement.

Thistleton/Market Overton, Rutland SK 9018 Hewlett 1979; Richmond & Taylor 1958, 1959; Liddle 1995
Greenfield excavated the site in the 1950s, though only the temple complex has been published. The industrial village grew up by the Iron Age and Romano-British temple complex. Several stone buildings and traces of numerous timber and stone-founded structures were loosely arranged over several hectares (the site may cover a total of 33 hectares). Fifty-nine 'ovens' with stone flues (furnaces) were noted, and more bowl hearths. The temple was in use through the whole of the Roman period, though the chronology of the industrial village remains unknown. Smelting was taking place on a large scale, and possibly smithing.

Wakerley, Northamptonshire SP 9498 Brown 1972, 1974
Iron Age and Romano-British settlement. Two furnaces were excavated, similar to the smaller ones found at Laxton. Other finds include a 'corn-drying' oven and settlement debris. Pottery production (3rd century) was not associated with this phase of settlement. Other finds of slag and iron working debris in this area prior to quarrying.

Weekley, Northamptonshire SP 8782 Jackson & Dix 1987
At least two Iron Age to Roman period settlements have been identified (though now removed by ironstone quarrying). Both associated with extensive smelting.

Smithing and/or forging

Ashton, Northamptonshire TL 0589 Brown 1971, 1978; Hadman & Upex 1977
Several smithies have been excavated at this industrial village by the Nene. Workshops remained in use as smithies from the second to fourth centuries; some pottery kilns have been found in a different part of the settlement. Unfortunately, little has been published on the site, and the range of goods being made remains unknown.

Colsterworth, Lincolnshire SK 9224 Hannah 1932
A small clay-lined box with room for bellows was interpreted as a very early blast

furnace. Its dimensions are 91.4cm long, *c.* 58cm wide, 38-53cm deep. It was found in a dense spread of slag and charcoal. Another find was a possible anvil.

Durobrivae/Water Newton, Cambridgeshire TL 1197 Brown 1971; Dannell 1974; Perrin & Webster 1990; Wilson 1970

Pottery production and smithing is well attested in the Normangate Field suburbs of this walled small town, from the early second century. Stone-founded workshops have been excavated, as well as individual furnaces, wells and hearths. Individual workshops were converted to and from potteries to smithies (for example, workshops A, B), perhaps as tenure changed from one family to another. The major activity was smithing; ore possibly came from Bedford Purlieus, and was smelted at Wansford. However, some smelting was also taking place. This concentration of craft activities was in decline by the mid fourth century, though pottery continued to be made to at least AD 400, and perhaps iron tools as well.

East Bridgeford/Margidunum, Nottinghamshire SK 7041 Oswald 1927; Todd 1969

See above. Smith's tools were found in a second century floor deposit. They represent the needs of a self-sufficient community (knives, cleaver, sickle, hipposandal, chisel, nails).

Longthorpe, Cambridgeshire TL 1697 Todd & Cleland 1976; Dannell & Wild 1987, p. 65

A pre-conquest farmstead was taken over by the military of the nearby fort and converted to a pottery production centre. Some iron working has been identified. Slags from this phase show highly skilled smelting typical of early military sites. Ores had been obtained from elsewhere, and were probably smelted near the quarries. Later civilian occupation of the area saw farming and some iron forging. A furnace of late second-early third century date was excavated. Its base cut into the soil; the chamber had internal dimensions of *c.* 0.64m by 1.22m, and had been used many times. Close parallels have been found at Ashton, Lynch Farm and the Normangate Field suburbs of Water Newton. Other roughly contemporary finds include a 'corn-drying' oven, stone buildings and enclosures. Pollen evidence shows a well-cleared area with both cereal cultivation and arable.

Lynch Farm, Cambridgeshire TL 1497 Challands 1974b; Manning 1973

Pre-conquest iron smelting has been identified within an enclosure. Ore was obtained from gravels. In the Roman period, a farmstead developed (with origins in the second century). In the third or fourth century a barn was set up, and used as a smithy. It housed several furnaces (some substantial, stone-built structures, others simple bowl-furnaces). Scrap tools indicate production for a farming community (mower's anvil, hammer, hatchet).

Nassington, Northamptonshire TL 0596 Challands 1979

A Roman anvil was found in the centre of a spread of iron. Associated with forging rather than smelting?

Sapperton, Lincolnshire TF 0132 Simmons 1976, 1995

Several smithies have been uncovered, though through the fourth century the hearths and furnaces were replaced by 'corn-drying' ovens and other features associated with crop processing.

Thorplands, Northamptonshire SP 7965 Hunter & Mynard 1977

Fieldwalking and excavation identified a late first-fourth century settlement. Several timber-built round buildings and a stone-founded rectangular building were uncovered, and fieldwalking identified a more substantial building. Some iron smithing was taking place in the rectangular building. Other finds indicate a farming base.

Willoughby/Vernemetum, Nottinghamshire SK 6425 Kinsley 1993

Only a small part of the small town has been excavated. A thin spread of smithing slag was found over most of the excavated area, though it is not possible to estimate the scale of production.

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