3.1 Introduction

This chapter on metallurgy includes both the extraction of mineral resources and the manufacture of metal artefacts. It is the metallurgical pendant of the previous chapter on pottery though the role of metals in economic terms is far more decisive than the ceramic industry as is suggested by the quotation cited above. I acknowledge that the exploitation of the rich ore deposits of Tuscany became important for the position of central Italy in the Mediterranean trading network from the early Iron Age. It is not a coincidence that this region became the home ground of the Etruscan civilisation. Bietti Sestieri in a contribution in *L'Etruria Mineraria*, relates the emergence of this civilisation to the increasing metal production and the advance of settlement nucleation during the 9th century BC. Clusters of relatively densely settled, small villages of probably less than 100 inhabitants concentrated on larger plateaux during the early Iron Age. It is recorded that originally the communities on these larger plateaux were topographically separated. Each community was likely to have had its distinct settlement area on the plateau as well as its own necropolis. On these plateaux the future Etruscan cities such as Veii, Caere, Tarquinia, Vulci, Vetulonia and Populonia would materialise. The nucleation with its aggregation of resources was one of the preconditions for the urbanisation process during later centuries. It also enhanced the subsequent social stratification. The premise is that the concentration of communities as well as the increase in population during the late Bronze, early Iron Age supported the local manufacture of metal artefacts. This is supported by the regional and eventually local typology of metal objects dated to this period. It indicates that metalworking was an economic activity controlled by the indigenous communities. During the previous centuries the typology of the artefacts was related to wider regions and could even include the whole peninsula. The threshold from diffused to local manufacture described by Bietti Sestieri is dated to the late Bronze - early Iron Age. It is reflected in an increased range of copper alloy artefacts such as special tools, weapons and hammered, luxury objects. These metal artefacts represent an earlier stage of local craft specialisation than the evolution of the ceramic industry described in the previous chapter. It eventually induced regulated exploitation of the mineral resources and surplus production. This indicates an increase in regional, interregional and international exchange activities which involved metals and affected the subsistence economy thoroughly. Because economic exchange was predominantly directed by metals and not by ceramics, the local exploitation of the metal resources in central Italy prior to the 8th century BC would have provided a sound base for the indigenous population to engage in systematic exchange activities with foreign communities. In order to support this opinion I will give an account of some archaeo-metallurgical sites in central Italy dated to the late Bronze Age - early Iron Age.

The settlement at Scarceta is an example of an early metalworking site dated to the late Bronze Age. It is

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1 In this section of the *Politeia*, Aristotle reports the development of means of exchange. The exchange of intrinsically useful materials like iron, silver and the like, is presented as an intermediate stage which eventually culminated in the emergence of coinage. This passage of Aristotle is also relevant for the archaeological evidence that is presented in chapter IV where this heading will be discussed in detail.

located near the mining region of Manciano. Metallurgical traces that could be dated to 10th century BC, were found in sectors D and E of the excavations. One structure produced six sandstone moulds for casting axes, arrow points and other artefacts. A floor level related to hut XIII is interpreted as a metallurgical workshop and contained waste products of copper alloy casting, a fragment of a tuyère and fragments of one ceramic and two sandstone moulds. The area around this hut incorporates various structures which were inhabited. This reflects a stable, resident community including a workshop for metalworking. The industrial activities which besides metalworking, involved cloth manufacture and bone working, were combined with agriculture, cattle breeding and fishing. The processing of metals was, therefore, reconstructed as a part-time activity.

Other late Bronze Age, early Iron Age sites in central Italy with evidence for metalworking include Elceto, Sorgenti della Nova and Luni sul Mignone. For example, at Elceto the evidence consists of casting debris of copper, iron ores and pretreated quartz which may have been used as a flux. This material was found in a context dated to the *bronzo finale* period. The copper alloy adhering to the late Bronze Age crucible from Luni sul Mignone contains about 92% Cu and 8% Fe which could indicate the exploitation of the iron-containing copper ores of the nearby mineral deposits. At Sorgenti della Nova the evidence for local metalworking includes a sandstone mould for the casting of a sickle and a fragment interpreted as a copper alloy ingot. This evidence in combination with the range of metal artefacts discovered at the site, indicates that metal was worked by a resident smith on a part-time base.

The archaeo-metallurgical information from the excavations at Gran Carro, a site dated to the 9th and early 8th centuries BC, are included in section 3.6.

The mineral resources available in central Italy include copper, iron, silver and tin ores. The extraction of copper and iron ore deposits has been proven for antiquity. The iron-containing sulphidic copper ores are elemental in the region and it has been suggested that the smelting of these ores and the production of iron are directly related during the early Iron Age (table I).

Some of the production stages represented in Table 1, are optional. For example, it is not necessary to roast some categories of iron ores, though the removal by roasting of sulphur from the sulphidic copper ores is essential. In addition, the hardening of iron can be obtained during smelting as well as smithing. Iron artefacts can be made harder than copper alloy artefacts and this quality is one of the advantages of the metal iron. To what extent this quality was exploited in central Italy is not known because the techniques for hardening metals are intricate. Therefore one of the topics examined in this chapter, is the control over variables which regulate the hardness of metals. Other subjects are an introduction to the various metals, that is gold and silver, copper alloys and iron. This is followed by an account of the ore deposits and the archaeological evidence. As in the previous chapter, the main information reported derives from refuse materials and workshop remains. Bachmann emphasises that refuse materials such as slags should not be seen as isolated evidence but as a component within a metalworking context.

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1. Poggiano Keller 1988, 162-4. The author mentions another large oval hut with traces of ironworking. Bone was worked in sector D where semi-manufactured pieces were recovered. Cloth manufacture is recorded by spindle whorls and loom-weights.

2. cf. Giardino 1995, 114-5; Zifferero 1991, 213-5. At Luni sul Mignone two crucibles were excavated which demonstrate that copper was worked in this settlement during the period 1300 to 1150 BC: Östenberg 1967, 75, 90, 114, 125.


5. The copper alloy artefacts found at the site are not numerous but reflect the range of objects required for agriculture, clothmaking and personal use. The metal artefacts are dated from the 12th to the 8th centuries BC. Absent are weapons if one excludes an axe which could also have been employed as a tool: Negroni Catacchio 1995, 375-82, 403.
As a result, he presented a check list for investigating archaeo-metallurgical sites and this list includes, besides the technical ceramics such as crucibles and tuyères, various types of slags and associated finds such as hammer stones, crushing plates and structures. This wider framework is the basis for this study. As far as possible, the metalworking context of the individual sites discussed in section 3.6 incorporates references to the various items listed by Bachmann. Furthermore, a reconstruction of the metalworking activities is supplemented by experimental archaeology and ethnographic findings.

<table>
<thead>
<tr>
<th>Copper</th>
<th>Production stages</th>
<th>Iron</th>
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<tbody>
<tr>
<td>CuFe-sulphides</td>
<td>Minerals</td>
<td>Fe-oxide/hydroxide/carbonate</td>
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<tr>
<td></td>
<td>Pre-treatment (sorting and grinding)</td>
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<td></td>
<td>Roasting</td>
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<td></td>
<td>Smelting in shaft-furnace with ore, carbon and fluxes</td>
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</tr>
<tr>
<td>Removal of sulphur</td>
<td>Removal of water, carbondioxide</td>
<td></td>
</tr>
<tr>
<td>Black copper + Eisensau</td>
<td>Bloom + iron-silicate slags</td>
<td></td>
</tr>
<tr>
<td>+ iron-silicate slags</td>
<td>Removal of impurities by heating</td>
<td></td>
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<tr>
<td>Reccessing by smelting of the Regulus</td>
<td>and smithing (the Eisensau can also be refined during this process)</td>
<td></td>
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<tr>
<td>Al lightly and casting</td>
<td>Smelting (+ enhancing carbon-content)</td>
<td></td>
</tr>
<tr>
<td>Copper alloy artefact</td>
<td>of iron or smithing iron), hardening</td>
<td></td>
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<tr>
<td></td>
<td>Iron artefact</td>
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Table 1. Production stages of early Copper and Iron Manufacture.

A fundamental reorientation of the metalworking craft in central Italy occurred during the 8th and 7th centuries BC with the extraction of iron ores and the processing and distribution of the metal iron. During the 8th century BC, iron tools gradually replaced copper alloy tools and this meant a considerable investment in labour and resources. The copper which was previously used for tools might have been hoarded, exchanged or employed for the manufacture of ornaments. Simultaneously, a community had to substitute copper for iron. This means that iron ores had to be smelted at an increasing rate depending on the pace with which iron replaced copper alloy artefacts. In a stable community this process would probably have continued until there was a new reserve of iron in the form of a repertoire of iron artefacts. These artefacts would have functioned as a contemporary stock which could be reused once they became scrap metal. However, in a developing economy the demand for iron was affected by aspects such as the increasing population, the value of iron in relation to other metals and exchange activities. These aspects are incorporated in the following sections.

Other metallurgical features and technologies which became apparent on a local scale during the period 800 to

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8 Bachmann 1982, 6-7.

400 BC are:
- ornamentation by granulation,\(^\text{10}\)
- hammering and stamping of gold and silver,\(^\text{11}\)
- mass production of copper alloy fibulae,\(^\text{12}\)
- hammered copper alloy artefacts as, for example, the manufacture of copper alloy basins,\(^\text{13}\)
- specific smelting, alloying and casting techniques of copper alloys,\(^\text{14}\)
- new furnaces\(^\text{15}\) and
- the hardening of iron,\(^\text{16}\)

These aspects are included in this account of the development of metallurgy in central Italy.

I will conclude this introduction with a discussion of the topics itinerant versus sedentary metalsmiths, the degree of specialisation and the status of metalworkers. These topics are related but difficult to assess in a general sense because various options are likely to have co-existed. Thus, Bietti Sestieri and Bartoloni report that metalworkers were originally itinerant in central Italy. On account of the diffused typology of copper alloy artefacts and the existence of metal hoards during the late Bronze Age, Bietti Sestieri suggests that metalworkers were not resident.\(^\text{17}\) Bartoloni implies that they were still not settled during the early Iron Age. This assessment is based on the distribution in various Etruscan centres of specific copper alloy artefacts during this period.\(^\text{18}\) Their remarks on migrant craftsmen depend on assemblages of finished articles while the excavators of archaeo-metallurgical sites which are dated to the late Bronze - early Iron Age, indicate the presence of settled metalworkers. The metalworking evidence from sites such as Scarceta and Sorgenti della Nova is interpreted as debris associated with resident though part-time metalsmiths.\(^\text{19}\) With the advance of settlement excavations and the incorporation of ethnographic findings, one can recognise a preference for sedentary craftsmen. This is a general trend in archaeology.\(^\text{20}\) The controversy between migrant or resident craftsmen is charged by the history of the archaeological discipline itself. A previous partiality for the diffusionist model is counteracted by a more recent favouring of local developments. However a biased approach will not clarify the historical processes involved. Itinerant craftsman function within a given community and in my opinion it should be one of the archaeological principles to examine first this community before introducing migrant artisans. A mere reference to itinerant smiths without an account of how these craftsmen functioned within the communities they visited, makes metallurgical activities in a sense imperceptible or non-existent as a social-economic phenomenon.

The manufacture of metals in central Italy by 800 BC was by the nature of the skills and activities involved,

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\(^{10}\) Nestler and Formigli 1993.
\(^{11}\) Strøm 1971, 207-14.
\(^{12}\) Bietti Sestieri 1992 a, 479-84.
\(^{13}\) Albanese Procelli 1985.
\(^{14}\) cf. Formigli 1993; Wiman 1990.
\(^{15}\) Nijboer 1997 and this chapter.
\(^{16}\) Nijboer 1993-1994.
\(^{17}\) Bietti Sestieri 1981, 226.
\(^{18}\) Bartoloni 1989, 154.
\(^{19}\) Poggiano Keller 1988, 162-4; Negroni Catacchio 1995, 375-82, 403.
specialist labour. Seasonal activity of metallurgists has been implied for many societies and could have existed at
sites in central Italy. In addition, one can differentiate between degrees of specialisation. For metal production
there is a correlation between the level of specialisation, the technical skill required to produce an object and the
distance travelled in trade by the finished metalwork product. Thus resident, part-time metalworkers may have
been involved in repairs, the manufacture of common tools and the production of standardised, mould-made
artefacts. Full-time specialisation is suggested for the production of certain weapons and luxury goods which would
require particular technical skills. These specialist pieces are distributed over a much wider area and may be
correlated to either exchange activities or to itinerant craftsmen who worked on commission. Working on
commission will have continued throughout the period discussed. For example, the casting of large copper alloy
statues during the late 6th and 5th centuries BC was probably commissioned and may have involved itinerant,
master craftsmen. Unfortunately, few early monumental bronzes have survived in central Italy which makes a
technical and stylistic comparison difficult. Large, early statues are known from Arezzo, Todi, Ariccia and Rome.
For instance, it is suggested that the Lupa capitolina in Rome dates to the first half of the 5th century BC though it is
debated whether it could have been cast by a native workshop. The discovery at Marzabotto of a fragment of a
mould for casting a statue which was about 1 m high, demonstrates that there were workshops in central Italy which
made monumental bronzes by the 5th century BC. A parallel of the situation which probably existed in central
Italy as well, is provided by Schneider and Zimmer. They interpreted the 6th and 5th centuries BC workshops at
Athens and Olympia as temporary arrangements for casting life-sized statues. The examination of the debris implies
that the itinerant artisans did not transport other materials besides their tools. In a workshop such as the one
excavated at Olympia, 10 to 12 workmen were necessary, two of whom might have been masters, one for the artistic
execution and one for the casting procedures. It is argued that the group of itinerant craftsmen who travelled from
commission to commission may not have been larger than 4 to 5 people while the other assistants were recruited
locally.

The social difference between master and assistants reflects workshop conditions and distinction in status. The
master blacksmiths may have been independent and wealthy though impoverished circumstances must have
occurred as well. The master-assistant interdependence is only one of the possibilities for workshop relations.
Ancient literary texts refer to large factories during the late 5th, early 4th centuries BC. Demosthenes, for example,
describes the property of his father at a trial: 'My father, men of the jury, left two factories, both large businesses.
One was a sword-manufactory employing thirty-two or thirty-three swordsmiths, most of them worth five or six
minae each and none worth less than three minae. From these my father received a clear income of thirty minae a

21 cf. Rowlands 1973, 595-6. Rowlands suggests that in southern Britain during the middle Bronze Age, smiths worked seasonally when they
would produce a stock of semi-finished artefacts. This stock could be used to meet an estimated demand at a time when the smiths would be
involved in subsistence activities such as agriculture.

22 Rowlands 1973, 596.

23 I refer to Zimmer for an account of itinerant workshops that produced monumental copper alloy statues in Greece: Zimmer 1990.

24 cf. Cristofani 1985, 29-53, 288-300. He reports the development and technical features of Italian bronzes. Craddock mentions that the late
5th century BC Mars from Todi is a leaded bronze while the 4th century BC Chimera from Arezzo contained little or no lead: Craddock 1986,
233. The date of both statues derives from Cristofani: Cristofani 1985.

25 The Lupa capitolina is 83 cm high and 136 cm long: Roma 1992, 57; Grande Roma 1990, 144-5; von Vacano 1973. Von Vacano states
that the Lupa capitolina might be from the second half of the 5th century BC but could also be later. He indicates that the style of the statue is
related to Etruscan art.

26 Rasenna 1986, 102, fig. 53. The context of this mould is presented in section 2.6.7.

27 Schneider and Zimmer 1984. At Olympia these artisans exploited local clays for the manufacture of the technical ceramics. The authors
distinguished two clays which had been processed in antiquity according to the properties required.
year. The other was a sofa-manufactory employing twenty sofa-makers, given to my father as a security for a debt of forty minae. Besides this he left ivory and iron, used in the factory worth about eighty minae; and gall and copper which he had bought for seventy minae. Thus, the owner of a factory was not necessarily a craftsman himself. The workshop was probably directed by a foreman under whose supervision the slave-smiths worked. This fragment also specifies that there were slave metalworkers of different grades. The above reflect possible conditions during the 5th century BC which need not apply to previous centuries. Workshop conditions arose in central Italy during the period examined and are related to the early urbanisation process and emerging markets. Whether circumstances as described by Demosthenes could have occurred in central Italy has to be examined. An increase in the size of the workshops was recorded in the previous chapter but remains to be established for the metalworking craft.

In this study it is assumed for central Italy that servile labour in workshops gradually increased over the centuries. During the 8th and 7th centuries BC slave labour may have been restricted to personal care but probably did not involve the specialised crafts. In relation to status, it is likely that the range of social positions of metalworkers during this early period was more diversified, less restricted than in later centuries. Wason considers that craft specialisation itself is a form of social differentiation and that even part-time specialists differ from non-specialists. He reports that craft specialisation is also widely associated with inequality, but this is largely an empirical observation. The problem is that specialists are not themselves elites though they may gain respect through their skill. This seems to be less relevant for metalworkers than for other groups of artisans. The status of smiths is frequently reported as inconclusive ranging from highly regarded sometimes of chiefly status, to low status. Rowlands for example, recorded that the Basakata metalsmiths in Congo are hierarchically ranked on the basis of the metalwork they can produce. Thus, 'the production of parade objects and insignia could only be done by the master-smith who also happened to be the village chief'. Scott presents documentary evidence which demonstrates that during the Irish Iron Age, at least some of the artisans who manipulated iron enjoyed an elevated social status, while Heidinga and Offenberg present information on the high reverence for elite smiths during the early Middle Ages in Western Europe. Another ethnographic example indicates that the status of Mande blacksmiths in west Africa is ambiguous. They are both respected and feared for their magical powers. This respect and fear for smiths is based on their specific knowledge which is not shared by their fellows. They may, therefore, be credited with superhuman powers. At certain stages of social development, the mastery over metals and especially over iron could result in an important position of smiths in affairs of ritual and magic. The ancient Greeks, for example, believed that ironworking was invented by various demons and elves which corresponds with an originally ambivalent attitude towards smiths who appeared to combine sorcery with craftsmanship.
concluded that the status of smiths varies from:

1. highly regarded, often with eminent status;
2. equal to other craftsmen with no special position, and
3. low status of servile nature.38

The status obtained depends on the society examined. For the situation investigated in this study, option 3 may have occurred during later periods. However during the 8th and 7th centuries BC the status of smiths could have included option 1. It is probable that during the period 800 to 400 BC there was a general transformation of the status of metalworkers which is related to the stratification process itself as well as to the value that is attached to the artefacts they made.39 Since the value of the finished objects decreased so may have their social position. Pleiner implies indirectly for Greece a similar reduction in status of the metalworker as well as in value of the finished metal artefact.40 Some of his deductions appear to be relevant for the transition of the metalworking craft in central Italy. For example, he reports two possibilities for the smelting of iron ores which includes during an earlier period, smelting clans and families living nearby mines while for the classical and later periods, slaves may have operated the mines and bloomeries.41 In relation to a decrease in the status of the metalworker it is relevant to refer to some archaeo-metallurgical sites in central Italy. Poggiano Keller for example, suggests that at Scarceata there was a direct link between political power and metallurgical activities.42 Moreover, the excavation of the stoa-workshop at Poggio Civitate demonstrates the close relationship between the main building and the elaborately decorated workshop.43 The remains discovered at Lago dell'Accesa, are discussed in section 3.6 but it is appropriate to recall at this stage that they illustrate that mining could still be combined with other activities during the 6th century BC. Mining at this site seems to have been a part-time communal activity of several families. Moreover, the site indicates that conditions at mining settlements did not have to be destitute. The archaeological evidence rather suggests that several families combined their efforts and that the community could obtain a relatively comfortable style of living.44 The last example presented, derives from Satricum. At this site some of the metallurgical debris is concentrated in an activity area connected to building AA and hut VII. The context is dated to the 7th and early 6th centuries BC. The associated finds includes bucchero, fine impasto wares, some pottery of depurated clays and a small terracotta head. The pottery indicates that at this site a relatively affluent family was involved in metalworking.45

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38 Tylecote 1987, 12.
39 The value of metal artifacts is discussed further on in this chapter.
40 Pleiner 1969.
41 Pleiner 1969, 14, 34-5.
42 Poggiano Keller 1988, 162-4. Her suggestion is in itself ambiguous since the character of the link is not specified. The implication is based on the location of the metalworking area which is close to an important hut.
44 Etruria Mineraria 1985, 126-78; van Dommelen forthcoming.
45 Nijboer, 1993/1994; Beijer 1991 a; Maaskant-Kleibrink 1992, 92-7, 99-100; The catalogue numbers 2239 to 2541a in Maaskant-Kleibrink, present an illustration of the pottery with which the iron slags can be associated. In addition, slags are found in this area during recent excavations which await final publication. Beijer reports that one of the important families at Satricum occupied this area: Beijer 1991 a, 24. On account of the metallurgical waste material excavated in the 7th century BC strata of hut VII and the timber building, it is probable that at least one of the activities in which this family was involved, was metalworking.
3.2 Gold and silver

The change in the manufacture of gold and silver artefacts during the late 8th and 7th centuries BC is revealing because of its brisk progress. A new metallurgical technique which started to be applied locally, is granulation. Granulation is an arrangement of small globules of metal on a metal surface in an ornamental or figurative design. The manufacture of the granules, the diameter of which could be less than 0.1 mm, involves tiny snippets or filings of gold. These snippets are placed in a ceramic vessel in alternating layers of charcoal powder and filings. The gold particles should not be in contact with each other. The vessel is closed with a ceramic lid and heated to about 1,100°C. Around this temperature, the gold snippets and filings will contract to granules. Subsequently, the granules are arranged on the metal artefact. They are joined to the metal base with a chrysicolla suspension as solder. The copper in the chrysicolla will react with gold at a lower temperature than the smelting temperature of gold. Thus, the granules and the metal base obtain a brazed joint.

The granulation technique reached central Italy during the late 8th, early 7th centuries BC, probably directly through Levantine craftsmen. It is an elaborate and highly specialised process which necessitates a transfer of technological knowledge. Thus, the local application of intricate jewellers’ techniques such as granulation and filigree, supports the hypothesis that techniques diffused from the East to the West during this period. Several scholars support the hypothesis that it were people from the Levant who transferred these techniques to central Italy. The stylistic examination of the artefacts indicates direct influence from the Near East and not through mediation of the Greek communities. The rapid introduction of goldsmithing-techniques to central Italy has been acknowledged since the last century. By the 7th century BC the standard of gold and silver smithing was high which indicates that these new techniques were adopted successfully on a local level.

Another significant feature is that there are no gold deposits in central Italy. Therefore gold had to be imported and obtained through exchange. It could have been imported from various areas in the Mediterranean and central Europe. However the main trade routes with central Italy during the late 8th and 7th centuries BC show that it was probably obtained through Levantine and Greek intermediaries. The relatively substantial increase in gold and silver jewellery and artefacts during the 7th century BC in central Italy reflects, therefore, the nature of at least one of the exchange mechanisms. This exchange was not restricted to gift exchange as will be demonstrated in chapter IV.

Mineral deposits from which silver could be obtained are known in Italy in the area around Serravezza and in the Colline Metallifere though the exploitation of these deposits in antiquity has not been established conclusively.

46 Gold and silver are discussed in combination because it is assumed that during the period 800 to 400 BC, both metals were worked by one craftsman. The specialisation process did probably not evolve into separate craftsmen for either gold or silver.

47 Some golden artifacts that are dated to the early Iron Age are presented by Cristofani and Martelli: Cristofani and Martelli 1983. They present a general account of the development of Etruscan gold artifacts.

48 Nestler and Formigli 1993, 41-54.


50 Filigree is a decoration technique of very slender wires or threads of gold or silver which are soldered in an ornamental pattern onto a metal base. It is often applied in combination with granules: Moorey 1994, 228-9.

51 Nestler and Formigli 1993, 14-5; Strøm 1971, 201-16, 212. Strøm considers that much of the jewellery of the early Orientalising Period is the result of ‘a co-operation of immigrated Syrian and local Etruscan craftsmen: Strøm 1971, 201-16, 212.


The presence of ornaments of Antimony dating to the last phase of the Rinaldone culture, indicates the early exploitation of resources which accompany the silver deposits in Tuscany.\(^{54}\) However this is no evidence that silver was obtained from local minerals during the Orientalising Period. Giardino reports various deposits of galena which contain a small amount of silver.\(^{55}\) Galena has to be smelted first to produce metallic argentiferous lead before the silver can be extracted by cupellation. Cupellation is a refining process involving the heating of the argentiferous lead in strongly oxidising conditions. The lead is oxidised to litharge which can be absorbed by the cupel, that is a porous dish-shaped crucible or by other porous materials placed in the cupel, leaving behind the silver as molten globules.\(^{56}\) The quantity of silver that is obtained by cupellation depends on the original silver content of the lead ores. Generally galena contains 0.05 to 0.25\% silver and the smelted lead about 0.5 to 2\% silver. Therefore 50 to 200 kg of argentiferous lead is required to produce by cupellation, 1 kg silver.\(^{57}\) The process was known in antiquity and it might have been used as a refining process in central Italy though no industrial debris that can be related to this process, has been reported. At Gran Carro, one fragment of probably a lead ingot, contained a small amount of silver. The associated elements suggest that a local mineral deposit was exploited.\(^{58}\) This could demonstrate that the raw material for the cupellation process was available and exploited in central Italy during the early Iron Age but it does not establish that the refining process had been adopted. According to Markoe, the argentiferous deposits were exploited by cupellation during the 7th century BC for a number of reasons. He considers that the ‘sheer number, variety and distribution of Etruscan silver products found in Campania and Etruria point to an active and productive silverworking industry in central Italy from the late 8th century BC on’.\(^{59}\) He continues to report that ‘given the availability of the silver-bearing mineral deposits in Etruria and the necessary technology to work them, it is not unreasonable to conclude that the numerous silver products of Etruscan manufacture were actually produced from locally obtained silver’.\(^{60}\) Moreover, Markoe suggests that this industry ended during the second half of the 7th century BC and that it was originally under direct influence of resident oriental craftsmen who probably worked at Vetulonia.\(^{61}\) It is regrettable that these assumptions cannot be supported by actual metalworking debris as found in southern Spain.\(^{62}\) In central Italy, the activities of gold and silver smelting and smithing are not recorded by factual archaeological traces and, therefore, these metals will scarcely be examined in the remaining sections of this chapter.

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\(^{54}\) Giardino and Gigante 1995, 316; Negroni Catacchio 1981, 98-9; Tylecote 1987, 42, 144-7. The last phase of the Rinaldone culture is dated to the early 2nd millennium BC: *cf.* Östenberg 1967, 184-8; Peroni 1994, 214, Fig. 79.


\(^{56}\) Tylecote 1987, 195-9; Moorey 1994, 232-3.

\(^{57}\) Bachmann 1993.

\(^{58}\) Giardino and Gigante 1995, 319-22.


\(^{60}\) Markoe 1992, 73.

\(^{61}\) Markoe 1992, 68-9, 77-8. Silver vessels were replaced by copper alloy items during the second half of the 7th century BC. In my opinion this implies that the supply of silver decreased during this period. This does not support a large-scale, local exploitation of the argentiferous minerals as suggested by Markoe, because the silver-bearing mineral deposits in Etruria were not exhausted.

\(^{62}\) *cf.* Chamorro 1987, 199, 202 n.24, 223.
3.3 Copper alloys

This section on the copper alloys will report some technical features of copper smelting and alloying after which the manufacture and distribution of some specific copper alloy artefacts is discussed. The exploitation of the rich copper ore deposits of central Italy is presented in the section on mineral resources.63

Ores are usually carefully pretreated before smelting. They were crushed, sorted, ground and washed in order to remove most of the gangue and to concentrate the metal content. Gangue are the inert particles, the unwanted part of the ore which is removed by the mineral pretreatment as well as by successive smelting. Fluxes could be added during the smelting process for a reaction with the gangue. If the ore contained much silica as gangue then iron oxide could be added as flux while iron rich ores required additional silica. Flux and gangue combine as fluid slag which is lighter than the molten copper. The copper will, therefore, settle at the bottom of the furnace. There are numerous copper ores which basically can be subdivided in carbonates, oxides or sulphides.64 During smelting, copper carbonates would be reduced according to the equations:

\[2C + O_2 \rightarrow 2CO\]
\[CO + CuCO_3 \rightarrow 2CO_2 + Cu\]

Copper oxides are reduced according to the reaction:

\[Cu_2O + CO \rightarrow 2Cu + CO_2\]

Copper sulphide ores require roasting for the removal of the sulphur after which it can be reduced with a flux to a matte, that is copper sulphide mixed with iron compounds, and to slags.65 Subsequently, during the secondary smelting process, the matte was roasted and smelted in order to produce a metal with more than 90% Cu.66 The ramo secco bars from Italy provide evidence for this process. These bars are dated from the 6th to 3rd centuries BC and were probably employed as primitive currency. The bars contain a significant amount of iron and metallographic sections revealed inclusions of both copper and iron sulphides. It is suggested that 'the metal was run straight from the smelting furnace into the mould'.67 Therefore the bars represent one of the stages during the smelting process of iron rich copper sulphide ores which occur in various deposits in central Italy. The temperatures obtained in the furnace must have been over 1,400°C in order to produce copper in which 30% of iron is dissolved. In addition, the atmosphere in the furnace needs to be extremely reducing. These conditions can be obtained by increasing the proportion of charcoal in the furnace.68 Usually, under normal conditions the reduction of copper ores requires a temperature around 1,100-1,200°C which is achieved by charging the furnace with charcoal and ore in

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63 The predominance of the copper sulphide ores in central Italy as well as their smelting procedure was described in section 3.1 in relation with early iron smelting.

64 Tylecote presents a table with 19 different copper and copper-related minerals: Tylecote 1987, 11.

65 Bachmann presents a range of possible reactions during the smelting of various copper ores: Bachmann 1982, 21-3.


68 The ramo secco bars that were analysed, contain up to 35% iron. The high iron content was probably intended to increase the weight of the bars. Burnett, Craddock and Meeks report experiments employing primitive furnaces for copper smelting which regularly resulted in copper with high iron contents: Burnett et alii 1986, 128. This high iron content can be moderated by secondary smelting since the iron had to be removed because it renders the copper almost unsuitable for subsequent working.
about a 1:1 ratio, while employing clay tuyères and bellows for excess air. The data that derive from the analysis of the ramo secco bars demonstrate that much higher temperatures could be obtained in antiquity. Rehder reports temperatures up to 1,600°C which were secured in a simple charcoal furnace by increasing the intensity of blowing in combination with a higher ratio of charcoal to ore. It is, therefore, probable that in antiquity the temperature in the furnace was manipulated by both means.

A distinction has to be made between the smelting of the ore and the smelting of the copper bar in a crucible. The heat necessary to reduce an ore into molten metal is much greater than the energy necessary to melt the bar-metal. It is reported that the fuel required for smelting the ore, is about 10 times higher than for melting a copper bar. In order to produce 1 kg copper from copper ores it is stated that 20 kg charcoal is needed. The actual amount of charcoal necessary for smelting the ore or melting the bar depends largely on the quality of the raw materials and on the operating conditions. For example, ethnographic findings of early copper mining and smithing methods from central Africa imply that after a careful pretreatment of the copper ore, 50 kg of this high quality ore produced 12-15 kg copper after smelting. Under these conditions, the amount of charcoal needed for smelting would have been much less than reported by Horne.

During the smelting of the copper bar other metals could be inserted into the crucible in order to obtain specific alloys. Artefacts could have been made from copper that was not alloyed such as a *patera* from the Tomba Regolini Galassi but the analyses indicate that most artefacts were made of copper that was intentionally blended with other metals. Analyses of Etruscan copper alloys of the 7th and 6th centuries BC demonstrates that there was a different alloying practice for casting and hammering. The cast statuettes tended to be leaded while sheet metalwork only contained traces of lead since copper-lead alloys may split during hammering. Also the early cast Etruscan mirrors are unleaded because lead would reduce the reflecting qualities. The analysis of a 7th century BC fibula demonstrates that zinc was added to copper and, therefore, suggests that brass may have been intentionally made by the Etruscans. *Blenda*, that is zinc-sulphide is reported at the 6th century BC mining site at Lago dell’Accesa and, therefore, indicates that zinc ores were exploited. This could suggest that the zinc was used to produce brass though the early manufacture of brass by the Etruscans requires further analyses of copper alloy artefacts since a regular use of brass is of later date.

The smelting of copper ores and the casting and smithing of copper alloys, results in waste materials which can

69 Formigli presents the experimental reconstruction of 5th century BC bellows: Formigli 1993.
70 Rehder 1986.
71 Rehder 1986.
73 Clark 1991.
74 The differences in alloying practices is one of the main reasons for the persistent employment in this study of the term copper alloy.
79 Camporeale 1985, 170. The excavators mention that *blenda* was recovered though it is not reported how these pieces of ore were identified. Craddock states that blende is zinc-sulphide: Craddock 1986, 219-20. Tylecote refers to zinc blende (ZnS): Tylecote 1987, 134.
80 Tylecote 1987, 143-4, 287.
be discovered on archaeological sites. Among these materials are slags and technical ceramics. Slags from smelting copper ores can be chemically distinguished from slags produced during iron manufacture, by a slightly raised copper content.\textsuperscript{81} The technical ceramics include crucibles, melting pots, tuyères, moulds, small furnaces, furnace lining and interior core and exterior mould of individually cast, hollow artefacts made with the \textit{cire perdue} method. Other metallurgical evidence consists of furnaces, copper alloy droplets, working tools, metal bars and scrap metal.\textsuperscript{82} Tools which are probably associated with smithing are found in the San Francesco hoard at Bologna. This famous hoard was found in a large storage jar buried not far from a hut. The copper alloy artefacts in this hoard date from the late Bronze Age to the early 7th century BC. The artefacts in the San Francesco hoard include 4 moulds, 3 small anvils, 1 hammer, 2 files, 10 saws, 6 chisels and a large number of semi-manufactured fibulae.\textsuperscript{83} The excavations of the workshop of Phidias at Olympia and the workshop on the Agora in Athens have resulted in a wide range of debris materials.\textsuperscript{84} A comparable context has not yet been reported for central Italy during the period 800 to 400 BC. The evidence presented in section 3.6 is based on a smaller range of workshop debris.

Ethnographic information can provide information for reconstructing the activities at foundries. Some of these accounts are relevant for the workshops of the 6th and 5th centuries BC. A foundry might be a small individual workshop which could be a station for a travelling craftsman or a factory employing many skilled craftsmen. They occupy a range of locations from a hut in the outskirts of a village to the yard of an ordinary house in a town. Foundries can also be attached to a yard in a separate building or they could be entered from a street. As a rule foundries produce to order and only a few workshops hold stock. The customer may have to pay in advance for the metal and the charcoal or he has to purchase these materials himself. On the other hand the workshop could be large enough to employ a number of craftsmen while having artefacts in stock. The layout may incorporate a shop and storage room apart from furnaces, open rooms and outer workshop areas.\textsuperscript{85} Besides casting copper alloys, activities in a workshop can include hammering and decorating. A vivid description of a small modern metal workshop at Chania on Crete is given by Wiman.\textsuperscript{86} Several functions were combined in this workshop. The foundry was located at the rear of the workshop and contained some minor smelting furnaces. The workshop itself incorporated a room which opened onto the street. In this room the artefacts are finished by polishing and final decoration. In addition, the objects were sold in this area. A similar combination of functions probably existed in the major Etruscan towns and will be illustrated by the workshops at Marzabotto.\textsuperscript{87}

The remaining part of this section on copper alloys will present an account of the evolution of specific copper alloy artefacts. These include Italic fibulae, statuettes, basins and mirrors. The development of the manufacture of these artefacts marks the changes in metallurgy during the period 800 to 400 BC. A principle point of departure is that the Tuscan ores were exploited long before the appearance of the Etruscan culture. This is demonstrated by the analyses

\textsuperscript{81} Sperl 1981, 40-4. The slags might also be classified microscopically. Tylecote as well as Bachmann emphasise that it is difficult to distinguish between slags from copper and iron working without chemical analysis: Tylecote 1987, 300; Bachmann 1982, 4.

\textsuperscript{82} Furnaces for smelting copper ores and for working copper alloys are discussed by for example, Coghlan and Tylecote: Coghlan 1975, 26-37; Tylecote 1987, 106-33, 179-83. Some furnace designs are presented in the section 3.4.

\textsuperscript{83} Bentini and Mazzeo 1993.

\textsuperscript{84} Zwicker 1984; Schneider and Zimmer 1984; Zimmer 1990; Mullwitz and Schiering 1964; Schiering 1991.

\textsuperscript{85} Armbruster 1993, 155.

\textsuperscript{86} Wiman 1990, 228.

\textsuperscript{87} Moorey presents some archaeological examples of metal workshops from Mesopotamia and the Near East: Moorey 1994, 265-9. Lucas reports evidence for copper working in Egypt while Zimmer describes the archaeological evidence for the production of copper alloy artifacts from Greece: Lucas 1989, 199-224, 460-2; Zimmer 1990.
of early copper alloy artefacts. In Etruria during the 9th and first half of the 8th centuries BC, particular traits of the material culture imply the existence of local metal workshops. This development is correlated to the emergence of polities. The developments indicate an increase in the output of the metal workshops. In *Latium Vetus*, metallurgical analyses of fibulae from Osteria dell’Osa established an intensification of the local production during the 8th century BC. The fibulae of the 9th and early 8th centuries BC were individually reworked after casting. The metallographic structures demonstrate intensive hammering and reheating. This thorough reworking was absent from the metallographic structures of the fibulae that are dated around 750 BC. It indicates that these fibulae were manipulated to a lesser extent after casting. Casting in moulds with limited processing afterwards implies a production in series and a standardisation of the manufacturing process when compared with the manufacture of fibulae during the previous period. The time involved in the production of one fibulae around 750 BC would, however, still be considerable because the spring, needle and needle holder of each fibula required individual handling. Repairs to these delicate parts of the fibulae are abundant and mending broken artefacts was one of the tasks of the local smith. The numerous semi-manufactured fibulae of the San Francesco hoard illustrate the production process. From this hoard, 360 fibulae dated from about 750 to 700/675 BC, were examined for details on their manufacture. Two techniques could be distinguished. The fibulae were either made in a piece-mould or by the lost wax method. The clasps which were made in a piece mould are characterised by casting-seams at the closure of the moulding pieces and by excess metal from the header, that is the gate in the mould into which the metal was poured. After casting, these fibulae were decorated and processed individually though their manufacture can be classified as production in series. The second technique is known as the *cire perdue* method. The fibulae which are made with this method are unique and could be either solid or hollow. Most of these fibulae were cast from a wax model that had been decorated. Therefore the decoration process of these fibulae was more efficient than of the mould-made clasps though this efficiency was counterbalanced by the uniqueness of the pieces. When a hollow fibula was produced with the *cire perdue* method, the position of the core of the fibula was secured by a pin. While removing this pin from the cast clasp, the fibula was occasionally damaged. Defaults could be mended by inserting a precut piece of copper alloy sheet which was decorated with a pattern corresponding the decoration of the cast fibula. Moreover, the examination of the 360 fibulae from the San Francesco hoard revealed 10 fibulae which were cast in a piece-mould but which were hollow. The core of these clasps would have been made of a clayey paste which was held in position in the mould by a pin. This pin fell into a recess carved in the mould. In addition to the manufacture of fibulae, the local smith would mend damaged fibulae. Numerous repairs to the delicate parts of the clasps were noted among the 360 fibulae. This involved various intricate techniques as, for instance, renewal of the spring or catch by inserting a prefabricated component into the broken clasp.

The technical inspection of the fibulae from central Italy during the 9th to early 7th centuries BC indicates various production techniques and methods for repair. The local smiths were aware of these techniques which implies a high degree of specialisation during this period. The production process altered slightly during these

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88 cf. Craddock 1986, 214. The analyses of copper alloy artefacts and archaeo-metallurgical sites dated to the late Bronze Age, early Iron Age, are presented in sections 3.1, 3.5 and 3.6.5.

89 Bietti Sestieri 1992 b, 35-45.


91 Bentini and Mazzeo 1993.

92 This is one of the reasons why I consider the concept of efficiency difficult to use for manufacturing processes in antiquity. The employment of this concept in historical research requires a knowledge of all variables involved before and after the introduction of new techniques.

93 Bentini and Mazzeo 1993, 128.
centuries. The manufacture appears to have been directed towards production in series though the artefacts still required considerable individual handling after casting. Another illustration of the craftsmanship of smiths during the early 7th century BC is the deposit of exquisite copper alloy artefacts found at Tarquinia. The shield, axe and lituus (Fig. 3) are luxury items while fibulae had become common. It is, therefore, probable that in the major centres one could distinguish the master smith from his more average colleagues.94

Stylistic analyses of copper alloy statuettes which were either intended as an individual artefact or a decorative element of a larger metal object, implies that their production became increasingly assigned to local workshops.95 It is suggested that during the 8th century BC, Tarquinia and Bisenzio may have been production centres of these small bronze figurines. During the next century their manufacture has been accredited to smiths working at Vetulonia, Arezzo and Satricum while the archaeo-metallurgical evidence from Poggio Civitate demonstrates that decorative statuettes were also made in relatively small centres.96 During the 6th century BC, the figurines display a remarkable stylistic diversity which is interpreted as a diffusion of the production process over a large number of sites. This suggests that these artefacts became incorporated in the repertoire of local smiths. Deposits of similar statuettes at Arezzo, Fiesole, Rome, Gabii, Lavinium and Satricum, show that the Korai and Kourai were produced in series during the second half of the 6th century BC. Moreover, the deposits imply that production may be allocated to these sites and that manufacture was possibly related to the sanctuaries where the statuettes were amassed.97 During the late 6th and 5th centuries BC the production of copper alloy figurines seems to shift to northern Etruria and Umbria. At Vulci and Chiusi the production appears to be restricted to the casting of decorative elements. During this period Praeneste is considered to have been a production place of high quality copper alloy artefacts in Latium Vetus.98

The account of the stylistic investigation of the cast copper alloy statuettes is difficult to correlate with the technical examination of the fibulae. The establishment of local workshops producing amongst others large amounts of fibulae during the 8th to 6th centuries BC makes it probable that these smiths made the statuettes as well, since there are no technical restrictions. The statuettes were cast and afterwards moderately worked. The manufacture of these small copper alloy figurines was technically less complicated than the working of fibulae for which delicate components such as the spring, pin and catch had to be manipulated separately after casting. In addition, the quantity of statuettes produced during these four centuries are a mere fraction of the fibulae. Therefore it is probable that the local workshops started to produce statuettes when demand emerged. There is, however, a major difference between both types of artefacts. Small Italic copper alloy statuettes are chiefly found in votive deposits and were intended as votive offerings. Fibulae were also found in votive deposits but are described as personal ornaments and are, therefore, mainly known from tombs and hoards. The difference in context reflects a difference in date as well as in cultural significance because it can be associated with monumental sanctuaries.99 At this stage it is noteworthy that the intricate manufacturing techniques of the fibulae dated to the 8th and 7th centuries BC can be distinguished from the fairly average production process of the statuettes which are primarily discovered in contexts dated to the 6th

94 Bonghi Jovino and Treré discuss the manufacture of the items in this copper alloy deposit at Tarquinia in detail while emphasising the craftsmanship of the master smith: Bonghi Jovino and Treré 1987, 66-77.

95 cf. Galestin 1987, 157-70; Cristofani 1985. Galestin implies frequently that stylistic analysis might not be the most appropriate method for allocating production centres.

96 See section 3.6.8.


99 The increasing role of sanctuaries is for example, stressed in the sections 1.7, 4.1 and 4.2.
This development of the metal production of two specific types of copper alloy artefacts corresponds with a similar transition in the ceramic craft recorded in the previous chapter.

A related change was noted by Albanese Procelli for the copper alloy bowls and basins. With increasing production during the 7th century BC, the character of these vessels transformed from luxury to semi-luxury items. This transformation is, in my opinion, correlated to a general reduction of the value ascribed to artefacts that were increasingly made within the workshop mode of production. The decline in value is noticed in the context of the depositions and may communicate a depreciation of the factor labour. Originally, during the 8th and early 7th centuries BC the production of these basins was limited. The intensification of their manufacture during the second half of the 7th and early 6th centuries BC is associated with an increasing demand of the elite and emerging classes as well as with typological diversification. This indicates an increase in the number of workshops involved in their manufacture. It is probable that in addition to vessels, these workshops produced other metal artefacts.

The bowls and basins were made from hammered copper alloy sheet and decorated along the rim with a punch. The diameter ranges from 15 to 40-45 cm. In time the small bowls became gradually larger and evolved into basins. The function of these vessels was probably related to various activities such as banquets, washing or preparing food. The bowls and basins are known mainly from Etruria but are also found in Latium Vetus, southern Italy, Sicily, the Faliscan area and in southern France. They have been found in princely tombs and votive deposits as well as in tombs of the lower echelons of the elite once the bowls began to be produced in series. The vessels are widely dispersed throughout the second half of the 7th and early 6th centuries BC when in particular the production at Vulci is attested. It is assumed that at Vulci and Tarquinia manufacture continued from the 8th to the early 5th centuries BC. An early production centre is attributed to Latium Vetus. In addition, Albanese Procelli considers that during certain periods, basins were produced at Populonia, Caere, Marsiliana d’Albegna, Vetulonia, Orvieto, Chiusi or environs, the Faliscan territory and possibly at Gela. These attributions are based on distribution and stylistic analyses. In combination with the production of the cast fibulae and votives, I assume that casting and hammering of copper alloys was practised in almost every polity in central Italy. The production of statuettes and basins probably supplemented the repertoire of the established local workshops. Craft specialisation for individual types of copper alloy artefacts during this stage, seems to me unlikely. However a reconstruction of this craft in central Italy is made clearer in section 3.6 where the primary evidence on metalworking is presented.

The manufacture of the Etruscan mirrors during the 5th century BC is in contrast with the devaluation that was noticed in the production of the above mentioned copper alloy artefacts. Craddock reports, however, that the high quality control during the early production of mirrors abated in later centuries. The production of the well-known Etruscan mirrors was limited during the 5th century BC and consists mainly of tang-type items which were cast from an alloy of about 90% copper and 10% tin. During this period the mirrors were probably still status symbols and had not yet become as popular as in later centuries. In addition, there was no experimentation with mirror alloys or disc sizes during the 5th century BC. It is not likely that scrap bronze was employed during the smelting of the alloy because it would have complicated the control over the composition of the metal. For alloying the artisans apparently employed metals which had not been previously used and which might have derived directly as ingots from the mining regions. The reflecting qualities are achieved through polishing which was the last phase in the manufacturing process. The various production phases during the manufacture of mirrors require collaboration.

100 This does not apply to the corpus of so-called, high quality, decorative copper alloy statuettes: cf. Galestin 1987; Cristofani 1985.


which is best obtained within one workshop. Wiman suggests that mirrors may have been produced in Marsiliana d'Algbagna, Vulci, Orvieto, Caere and Volsinii.\textsuperscript{105}

It is noteworthy that the account of specific types of copper alloy artefacts produced in central Italy during the period 800 to 400 BC is restricted to the development of categories such as ornaments, statuettes, vessels, decorative elements and implements for personal care. In the centuries before the 8th century BC, copper alloys had an additional function as weapons or tools for agriculture and other activities. This use of copper alloys was transferred to iron during the 8th and early 7th centuries BC partly because the cutting edge of an iron tool could be made harder and sharper than the cutting edge of a copper alloy tool. I will not digress on the advantages of harder cutting edges for agricultural purposes, but to make a harder and sharper cutting edge, knowledge of carburisation and quenching is essential to the smith. These skills became gradually available in central Italy from the 8th century BC as was demonstrated by metallurgical examinations.\textsuperscript{106} As a result of the replacement of copper alloy tools by iron tools, the employment of copper alloys became increasingly restricted to decorative elements, luxury items and precision implements. Iron became the predominant metal for manufacturing weapons and tools necessary for the primary economic sector, that is agriculture. The decrease in the number of copper alloy hoards in central Italy during the 8th century BC is associated with metalsmiths who settled permanently within communities.\textsuperscript{107} Another hypothesis is that this decrease was associated with the shift from copper alloy to iron tools. Copper and tin had to be imported by many local communities in central Italy and, therefore, their administration was essential as long as they were required for subsistence activities. This might have resulted in hoarding.\textsuperscript{108} Iron could in most cases be obtained from nearby sources since iron ore deposits are numerous and occur in most regions. Minerals that contain iron are common when compared with copper and tin ores. Eventually this resulted in a vast devaluation of iron.\textsuperscript{109} Once the technology of smelting and smithing iron was mastered on a local level, the need for hoarding base metals probably decreased.

3.4 Iron

In this section I will first present the technology of iron manufacture after which the social-economic impact of its introduction is discussed.

The technology of iron manufacture depends largely on the empirical knowledge of the individual smelter and smith since the quality of the iron artefact can be manipulated at both production stages. The properties of a specific

\textsuperscript{105} Wiman 1990, 227-9, 243-5.

\textsuperscript{106} See section 3.6.2.

\textsuperscript{107} Bietti Sestieri 1992 b, 45; Bartoloni 1989, 32-5.

\textsuperscript{108} Hoards may be interpreted in various ways depending on assemblage and context: cf. Hoekstra 1997. It is not relevant for this research to list the options, variables and contexts of the numerous hoards in central Italy since most of these hoards are dated prior to the 8th century BC. A merely economic interpretation of hoards is a minimal approach towards a complex topic which incorporates features such as ritual depositions of metals, treasure-trove, hoarding and accumulation. For example, the interpretation of the San Francesco hoard at Bologna as a metal hoard of a smithy is probable but does not explain the quantity nor the supervision over this hoard: Bentini and Mazzeo 1993. The economic hypothesis that I presented, is therefore one of the options for interpreting hoards. However, it is a probable interpretation for those hoards which incorporate metallurgical tools and debris. Part of the 8th century BC hoards might actually have been formed at smithies by exchanging copper alloy artefacts for iron items. Bietti Sestieri suggests that the disappearance of copper alloy hoards is related to the transition from itinerant to sedentary metal craftsmen since hoards became increasingly associated with settlements during the late Bronze Age - early Iron Age: Bietti Sestieri personal communication and forthcoming paper in the 1997 issue of the Proceedings of the Prehistoric Society.

\textsuperscript{109} See section 3.4.
Fig. 43. Production stages during the processing of iron ores.
1. mining iron ores, 2. roasting the ore, 3. pretreatment of the ore, 4. production of carbon, 5. construction of a shaft furnace, 6. firing of shaft furnace, 7. smelting the ore while charging the furnace with additional carbon and ore, 8. and 9. removal of the bloom from the furnace, 10. primary smithing.

Iron object depend on a number of variables which could be controlled.\textsuperscript{110} These variables are examined here.

The origin of iron production in central Italy may have been associated with the smelting of copper ores.\textsuperscript{111} It is

\textsuperscript{110} The presented account on the metallurgy of iron is predominantly based on: Tylecote 1987; Bachmann 1982; Sperl 1980; 1981; Moesta 1983 and Coghlan 1977.

\textsuperscript{111} See Table I in section 3.1.
probable that during the Bronze Age, iron was occasionally produced as a by-product while smelting copper ores. The distinct characteristics of iron will, however, have prevented its exploitation during this period. For example, iron did not smelt at temperatures normally obtained in ancient furnaces while a contamination with sulphur makes it unsuitable for further processing. Moreover, the carbon content of iron requires close control. Specifications such as these will have reduced the practical value of iron retrieved as a by-product during the smelting of copper ores.

A discussion of the development of iron metallurgy during the Iron Age involves a distinction between the smelting of iron ores to wrought iron and the manufacture of a steel. The separate steps leading to the production of a bar iron which can be forged into an artefact are presented in Figure 43. The manufacture of steel depends on the percentage of carbon in iron. Figure 44 presents a table of the carbon content in iron with its nomenclature and properties.

Fig. 44. Table of the carbon content in iron with its nomenclature and properties.

Pure iron smelts at a temperature of 1534°C, a temperature that was normally not obtained in ancient furnaces. Therefore iron did actually not smelt in the furnaces but was produced in a solid state, directly as a result of the reduction of the iron ore. This reduction is labelled iron smelting and the solid state reduction of iron-oxides to bloom is known as the bloomery process. The reactions involved depend on the type of ore. From about 400°C the following reactions occur in the furnace:

\[
\begin{align*}
2C + O_2 & \quad \longrightarrow \quad 2CO \\
3 \text{Fe}_2\text{O}_3 + \text{CO} & \quad \longrightarrow \quad 2 \text{Fe}_3\text{O}_4 + \text{CO}_2 \\
\text{Fe}_3\text{O}_4 + \text{CO} & \quad \longrightarrow \quad 3 \text{FeO} + \text{CO}_2 \\
\text{FeO} + \text{CO} & \quad \longrightarrow \quad \text{Fe} + \text{CO}_2
\end{align*}
\]

From about 800°C direct reduction can occur:

\[
\begin{align*}
\text{FeO} + \text{C} & \quad \longrightarrow \quad \text{Fe} + \text{CO} \\
\text{Fe}_3\text{O}_4 + 4 \text{C} & \quad \longrightarrow \quad 3 \text{Fe} + 4 \text{CO}
\end{align*}
\]

The carbon content which is important for hardening the wrought iron can be increased by two processes during

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112 Rehder as well as Burnett, Craddock and Meeks report extremely high temperatures which could be obtained in antiquity: Rehder 1986; Burnett et alii 1986. Moreover, they independently speculate that in theory cast iron could have been produced much earlier than historically attested. Blomgren and Tholander present explanations why cast iron was not produced in Antiquity even though the required temperatures were obtained: Blomgren and Tholander 1986. They indicate that this is mainly due to the early slag formation during smelting which prevented the necessary diffusion of carbon in the iron.
smelting:

1. Iron carbide is produced:

\[
3 \text{ Fe} + 2\text{CO} \quad \longrightarrow \quad \text{Fe}_3\text{C} + \text{CO}_2
\]

\[
3 \text{ Fe} + \text{C} \quad \longrightarrow \quad \text{Fe}_3\text{C}
\]

2. Simultaneously carbon dissolves in iron.

Less than 2% carbon by weight can be absorbed in the bloom at about 1,140°C.

Thus, ore, charcoal and possibly a flux coalesce in the furnace to a sponge-like mass, a bloom with a high percentage of iron, a variable carbon content and a fluctuating amount of slags (Fig. 45). The bloom can be produced at raised temperatures in various types of furnaces. The high temperatures required are mainly obtained by forced-draught with the aid of tuyères through which air is forced with one or a pair of bag bellows. Two types of furnaces are the bowl furnace and the shaft furnace which can be both slag tapping or non-slag tapping (Fig. 46).\(^{113}\) Sperl mentions that the shaft furnace was employed by the Etruscans.\(^{114}\) During smelting, the furnace is gradually filled with alternating layers of prepared ores, possibly sand or other fluxes and charcoal. The height of the shaft furnace is one of the variables which can direct the effectiveness of the smelting. Low furnaces will not utilise productively the gasses emitted in the furnace. Therefore a low furnace may require 400 to 500 kg charcoal in order to produce 100 kg bloom while a taller shaft may require about half the amount of charcoal. In general, the reduction of iron-oxides requires more energy as well as a larger zone of high temperature in the furnace than necessary for the smelting of copper oxides. This is provided by using a moderately higher ratio of charcoal to oxide. The usual smelting ratios by weight of charcoal to ore ranges from 0.5 to 2.0 measures charcoal to 1 measure ore (Table 2).\(^{115}\)

<table>
<thead>
<tr>
<th>Resource</th>
<th>Moesta(^{116})</th>
<th>idem</th>
<th>Moorey(^{117})</th>
<th>Crew(^{118})</th>
<th>Tylecote(^{119})</th>
<th>Cleere(^{120})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ore</td>
<td>3800 kg</td>
<td>19,000 kg</td>
<td>180</td>
<td>7.6 kg</td>
<td>7 to 15</td>
<td>90 kg</td>
</tr>
<tr>
<td>Charcoal</td>
<td>4000 kg</td>
<td>20,000 kg</td>
<td>300</td>
<td>28 kg</td>
<td>7 to 15</td>
<td>120 kg</td>
</tr>
<tr>
<td>Iron bloom</td>
<td>360 kg</td>
<td>2,000 kg</td>
<td>18</td>
<td>1.7 kg</td>
<td>1</td>
<td>9 kg</td>
</tr>
</tbody>
</table>

\(^{113}\) I refer to Cleere for a classification of early iron-smelting furnaces: Cleere 1972.

\(^{114}\) Sperl 1985, 40.

\(^{115}\) Rehder 1986. This article predominantly presents data for a possible early production of cast iron. Sperl reports the ratio in weight of ore to carbon as 1 to 2: Sperl 1985, 40.

\(^{116}\) Moesta 1983, 160. He describes first the resources required by a random workshop with 18 furnaces and subsequently those necessary for a systematic workshop with 95 furnaces. These data refer to the workshops excavated at Wiesensboden in Polen dated from 150 BC to AD 150.

\(^{117}\) Moorey 1994, 282. Moorey presents a relevant description by Hamilton of iron smelting near Trebizond in Turkey. Hamilton made this account in 1842 and used the local measures which are not presented in this table.

\(^{118}\) Crew 1991 b. The high amount of charcoal used during this smelting experiment might be due to the high blowing rate of the bellows.

\(^{119}\) Tylecote \textit{et alii} 1971, 345, 353, fig. 32, Table XIII.

\(^{120}\) Cleere 1970, 17-9. The figures derive from his most successful trial.
The accounts of the ratio ore to charcoal to bloom presented in Table 2, derive from diverse ores and different smelting procedures while employing dissimilar furnaces and operating conditions. These variations are reflected in the ratios. Variables that affect the ratios are, for instance, roasting and grinding of the ores because they enhance the smelting process. In general hydrated ores, such as limonite or bog-ores, are easier to smelt at lower temperatures than massive ores such as magnetite and hematite\textsuperscript{121} while hematite is easier to reduce than magnetite.\textsuperscript{122} On average, the ore appears to yield roughly 10% of metal and for the production of 1 kg iron bloom about 10 kg ore is required as well as 10 to 15 kg charcoal.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{fig45.png}
\caption{Section of a shaft furnace while smelting iron ores.\newline
1. furnace wall,\newline
2. air flow through shaft furnace that is filled with carbon and ore,\newline
3. slag formation along furnace wall,\newline
4. smelting process: reduction of iron ore and formation of bloom,\newline
5. slag formation,\newline
6. base of furnace with no slag tapping facilities,\newline
7. opening for tuyères.}
\end{figure}

\textsuperscript{121} Avery 1982, 206.

\textsuperscript{122} Blomgren and Tholander 1986, 158.
Ethnographic reports from Africa record that one smelting procedure may involve about four men who would have to be available for eight days before the bloom could be removed from the furnace.\textsuperscript{123} This is an indication of the labour necessary for one smelting process. Experimental archaeology provides different estimates. According to Crew the whole cycle from ore to fully smithed bar iron could require about 25 man-days' work for the manufacture of 1 kg bar iron.\textsuperscript{124}

\textbf{Fig. 46. Reconstruction of some smelting furnaces.}
1. bowl furnace, non slag tapping,
2. shaft furnace, non slag tapping,
3. bowl furnace, slag tapping,
4. shaft furnace, slag tapping.

\textsuperscript{123} Moesta 1983, 159. This figure includes the production of charcoal, the mining of ore and the building of a furnace which took about 2 days. See also van Nooten and Raymaekers and McNaughton: van Noten and Raymaekers 1988; McNaughton 1993, 18, 31-2.

\textsuperscript{124} Crew 1991 b, 35. A comparison between the various figures is not possible because the conditions diverge. Different ores, furnaces and operating conditions are represented. For example, Crew employed a low shaft furnace while the ethnographic data indicate that tall shaft furnaces were used. In the experiment by Crew the manufacture of charcoal is estimated while it took the African team about 2 days to produce and transport the charcoal. Moreover, the 25 days that are reported by Crew constitute the whole cycle from ore to bar iron while the 32 mandays labour of the African team represents the process from ore to the recovery of the bloom from the smelting furnace. Voss reports that 40 kg bar iron from ore can be produced in 12 days employing a slag-pit furnace but his calculations are based on estimates: Voss 1995. Moreover, this type of furnace is not attested for central Italy during the period examined.
Approximately 1/3 or less of the iron-oxides originally present in the ore is reduced to iron. The smelting slag absorbs most of the iron-oxides and thus ancient technology appears to be inefficient to us. In fact, the result could not have been more productive considering the smelting conditions and the desired result. Under different conditions the carbon content in the bloom could rise and this was inconvenient. A carbon content of more than 1.5% would render the bloom unsuitable for subsequent smithing because it would be too brittle. Iron which can be forged easily contains up to 0.9% carbon. From 0.1% carbon, iron can be hardened to steel (Fig. 44). Therefore the seemingly unproductive process results in a bloom with a low carbon content which can be forged and hardened at a later stage of the production process.\textsuperscript{125}

Waste materials such as bloom, smelting slags, cinder and furnace-lining with slag-residues, are formed at a smelting site of iron ores. The morphology of smelting slags is determined by the type of furnace and the process used. For central Italy tap-slags and furnace bottoms appear to be common.\textsuperscript{126} Cinder can have a number of textures and is the result of fusion between charcoal, slag and furnace lining.\textsuperscript{127}

Once the bloom is removed from the furnace, it has to be forged into bar iron or steel. Besides iron, the bloom contains various amounts of carbon and slag material. Tylecote mentions that raw bloom may contain as much as 20% slag which had to be removed by primary smithing.\textsuperscript{128} During this process the carbon is more evenly distributed and the slag is removed as much as deemed necessary. Smithing will result in bar iron which eventually can be forged into an iron artefact. Moesta reports that for the manufacture of an iron sword, roughly 1.8 kg bloom is required.\textsuperscript{129} Smelting and smithing may occur at different locations. During the primary smithing, the bloom is refined by re-heating and hammering which could be carried out at the smelting site. It has been demonstrated that the process of primary smithing is time consuming. Crew reports 'that this first stage of smithing took 2.5 hours needing 24 heats and consumed about 10 kg charcoal'.\textsuperscript{130} In his experiment the bloom was first forged into a billet, subsequently into a short, and eventually into a long, bar. This sequence required 33 kg charcoal and resulted in 1.6 kg smithing slags as waste materials. The original 1.7 kg of bloom was reworked to about 0.5 kg bar iron.\textsuperscript{131} Voss indicates that during primary smithing, 60 kg bloom is reduced to 40 kg bar iron. These figures are open to debate because the reduction in weight by primary smithing depends primarily on the amount of slag present in the bloom, the grade of the bloom and the quality of the bar iron. For a good quality bloom the loss by forging may have been less than 50%. Nevertheless, primary smithing is labour intensive and could involve almost as much energy and resources as the smelting procedure of iron ores.

After refining the bloom into bar iron, it is forged into an artefact during a process that is known as secondary smithing. This could be done immediately after the primary smithing. Another option is that the bar iron was transported, exchanged and smithed elsewhere at a local smithy. Secondary smithing includes repairs and the reuse

\textsuperscript{125} Cleere for example, reports that a bloom with a relatively high carbon content was discarded at a metalworking site in Roman Britain because it 'was obviously beyond the technical capacity of the smith'; Cleere 1970, 2.

\textsuperscript{126} Cucini Tizzoni and Tizzoni 1992; Sperl 1981.

\textsuperscript{127} Bachmann 1982; Sperl 1980.

\textsuperscript{128} Tylecote 1987, 249-53.

\textsuperscript{129} Moesta 1983, 160.

\textsuperscript{130} Crew 1991 b, 29-30.

\textsuperscript{131} Crew 1991 b, 35. His experiment is presented as an example of the effort and resources required for the manufacture of bar iron. The figures given, provide an indication of the time involved. Other types of furnaces or smelting conditions than those employed for his experiment, will give different results.
of scrap iron. Forging occurs at high temperatures and the hearths employed may be simple though more complicated structures are illustrated on Greek vases.\textsuperscript{132} The simplest smithing hearth is the bowl hearth on ground-level. Forges could be built on a base of stone or bricks in order to improve working conditions for the smith. Tuyères and bellows are employed at the forge to control and increase the temperature range. Waste materials produced during smithing include smithing slags and ceramics such as hearth lining. The slags comprise hearth bottoms, smithing slag lumps, cinder, fuel-ash slags and hammer scale.\textsuperscript{133} The hearth bottom with its typical plano-convex shape is an accumulation of slag formed at the bottom of the hearth. It is formed by fusion of iron-oxides with flux, mostly sand. Fluxes such as sand were used during smithing for the formation of fluid slag. In the process the unwanted components of the iron were removed. Moreover, sand prevents oxidation. A smithing slag lump is smithing slag which was discarded from the hearth and has, therefore, an irregular shape. Cinder, fuel-ash and hearth lining are characterised by their higher silica content. Finally, hammer scale is ejected from hot iron during working at the anvil either as globules or as flakes. They are usually highly magnetic and minute in size, not exceeding a couple of millimetres. Therefore hammer scale is likely to be preserved near a forge or anvil and can be easily discovered due to its magnetism. In addition to these waste products, a smithy can be identified by associated finds such as hammer stones, tools and building remains.\textsuperscript{134}

The manufacture of steel requires a separate account because steeling is an intricate process. Steel is an iron with specific properties combining hardness with flexibility. An equilibrium is required to make steel not too brittle due to excessive hardness and not too soft due to deficient hardening properties. The essential quality of steel is the possibility to manipulate its hardness. This manipulation is made possible by a carbon content by weight of 0.5 to 1.5%. The empirical assessment of the properties of steel is one of the achievements of the ancient smith. Quenching, that is emersing a hot carburised iron artefact in a cold fluid, increases the hardness of steel considerably. Emersion of the hot blade in cold water for a short moment makes it possible to obtain a hard surface with a tough interior. This results in a blade which is resilient enough to absorb mechanical stress while the cutting properties are improved by a harder exterior. In ancient iron, the carbon content is often less than 0.2 % which makes the wrought iron less suitable for hardening.

After smelting the ore, the carbon content of the bloom is unequally distributed. Prolonged smoldering of the forged bloom diffuses the carbon content more evenly. Specific techniques may have been employed to increase the carbon content.\textsuperscript{135} One method is to place an artefact made from a low carbon iron in a sealed vessel filled with

\textsuperscript{132} Oddy and Swaddling 1985; Tylecote 1987, 115-6, 154-7. Besides for forging iron, the same ancient illustrations have been interpreted as furnaces for smelting copper ores or for the heating of copper alloys: cf. Bol 1985, 129-30. Experiments that were reported in Formigli, indicate that this type of furnace was less effective for smelting copper alloys; Formigli 1993. The two furnaces that are illustrated on Greek vases, might have been employed for smelting iron. In both illustrations the shaft of the furnace is sealed by a type of cauldron. This vessel itself is also closed. A hypothesis is that the cauldron contained carbon and iron artefacts for the process of surface carburisation. The fact that in both illustrations the furnaces are sealed by a cauldron implies a functional meaning. Tylecote presents a different explanation without acknowledging that on both vases the design of the furnaces or forges is compatible. Other explanations for the cauldron include:
1. functional part of the furnace for controlling the air flow,
2. crucible for preheating tin and lead before alloying with copper from the furnace,
3. crucible for pretreating bronze,
4. for extinguishing the fire in the furnace,
5. for heating water in order to smelt wax and

\textsuperscript{133} cf. McDonnell 1986.


\textsuperscript{135} For methods of carburising iron, see for example: Tylecote 1987, 258-80.
charcoal powder.\textsuperscript{136} The carbon will gradually diffuse into the surface of the artefact. Tylecote mentions that it requires 6 hours at a temperature of 900°C to get the carbon to penetrate 2 mm into the iron artefact.\textsuperscript{137} The same technique that was used for surface hardening iron, has been proposed for the production of \textit{bucchero}.\textsuperscript{138} \textit{Bucchero} was made from the late 8th, early 7th centuries BC onwards and its manufacture indicates that this specific production-method which could also produce surface carburisation of iron, was probably known to the communities in central Italy. A close relationship between metal artefacts and \textit{bucchero} is implied by stylistic similarities but this correlation could extend to specific production techniques employed by both the potter and smith. Unfortunately, this technical interdependence of both materials remains hypothetical and requires further support from workshop excavations as well as from detailed metallographic analyses.\textsuperscript{139}

A review of the impact of iron technology on the social-economic conditions in central Italy depends partly on whether it was produced locally prior to the 8th century BC or not. There are some indications that iron ores may have been processed in central Italy during the late Bronze Age - early Iron Age but the evidence is not conclusive.\textsuperscript{140} The corpus of early iron artefacts dated before the 8th century BC is small and, therefore, implies that either the local production of iron was confined or that these artefacts could have been imported.\textsuperscript{141} If they were imported, than the discussion arises as to who the intermediaries were and whether the contacts were such that transmission of technological knowledge could have occurred.\textsuperscript{142} The issues relating to the dispersion of the technological knowledge for the processing of iron are not examined in this research since the discussion is based on opposing views while simultaneously too many findings are disputed. Transmission of technology during the 8th century BC is attested for techniques such as wheel-throwing pottery and granulation. Nevertheless, it cannot be excluded that the knowledge necessary for the processing of iron was available in central Italy prior to the 8th century BC.

Snodgrass described in general terms the development of iron technology as a process in three stages:
- the first stage constitutes the production of iron ornaments;
- the second stage is marked by the introduction of iron tools with sharp cutting edges though in a smaller quantity than similar copper alloy tools;
- the third and final stage is identified by the prevalence of iron tools over copper alloy tools.\textsuperscript{143}

In the same article, Snodgrass reports in a review on the introduction of iron in various regions of the Mediterranean, that \textquoteleft\textsc{Etruria may have moved to the adoption of iron somewhat later (from onwards 800-760 BC) than parts of Southern Italy but in the end more comprehensively}\textquoteright. Hartmann, who examined the early iron artefacts of southern Etruria noticed that during the first half of the 8th century BC, iron was almost exclusively used for ornaments at Veii. He underlines not only the importance of the 8th century BC iron ornaments from Veii but also

\begin{footnotesize}
\begin{enumerate}
\item[137] Tylecote 1987, 271.
\item[138] Section 2.1. Moreover, the production of granules for the granulation process is described as a similar technique: Nestler and Formigli 1993, 41-54.
\item[139] For a hypothesis explaining the ancient illustrations of forges or furnaces that are closed by a sealed vessel, I refer to the previous pages.
\item[143] Snodgrass 1980, 336-7.
\end{enumerate}
\end{footnotesize}
those from Tarquinia and Rome. In his opinion, iron technology was introduced by the Greeks which was shown by the excavation of a metal-working quarter at Pithekoussai dated to the second half of the 8th and early 7th centuries BC.

A recognition of the early phase of iron metallurgy in Latium Vetus is less clear than in southern Etruria due to the smaller numbers of iron objects published. According to Snodgrass, 'the adoption of iron in Latium seems to have occurred detectably later: working iron is rare before the 7th century, and even then it only slowly displaces bronze as a practical metal'. This view can no longer be supported by the evidence from Satricum, nor from other sites in Latium Vetus such as Castel di Decima, Osteria dell'Osa and Caracupa. The quantity of iron artefacts steadily increased in Latium Vetus during the 8th century BC and did not start with stage I, that is the emergence of iron ornaments. From the 8th century BC, iron knives were available as well as iron ornaments. The combined use of iron for both tools and ornaments is also characteristic for the 7th century BC. The range of iron artefacts found in tombs at Castel di Decima dated to the late 8th and 7th centuries BC, include swords, daggers, components of chariot wheels, lances, knives, spits, horse bits, cylinders and fibulae. Tomb 15 for example, which dates to the late 8th century BC, contained knives, a sword, spearheads, a spit and parts of a chariot, all made from iron. The quantity of iron artefacts at Castel di Decima and other sites in Latium Vetus such as those found in the votive deposit at Satricum, imply local manufacture. Moreover, they demonstrate that copper alloys were replaced by iron during the late 8th and 7th centuries BC in Latium Vetus. This statement is illustrated by the copper alloy to iron ratio in the tombs discovered at Caracupa. These tombs are dated from the 9th to the 7th centuries BC and the incidence of iron artefacts gradually increases during this period. The iron axe found in tomb I is a socketed axe with an eyelet attached to it. It copies in iron exactly specific copper alloy axes though the manufacture of an eyelet in iron is labour intensive and technically complicated. Therefore this type of iron axe reflects a specific moment in the transition from copper alloys to iron. It seems that within about 50 years the eyelet in iron was abandoned by the smith. The distribution of iron artefacts in the extensive, Latial Iron Age necropolis at Osteria dell'Osa, is recorded in detail by the publications of Bietti-Sestieri. This site, the quantity and range of iron artefacts increased consistently during the 8th century BC and, therefore, supports the hypothesis that in Latium Vetus the transition from stage II to III occurred during the 8th and early 7th centuries BC.

Two aspects remain to be discussed in this section; the close relationship between copper and iron working and the devaluation of iron.

The early development of the iron industry in central Italy cannot be separated from the production of artefacts made from copper alloys. In the introduction, the close relationship between copper and iron manufacture from the
prevalent chalcopyrites or CuFe-sulphide ores in central Italy was reported.\footnote{Table I; Sperl 1981, 32-4.} In addition, it is generally accepted that a labour division between copper-smiths and iron workers had not yet been established during the Orientalising Period.\footnote{cf. Pleiner 1988, 35-6; Hartmann 1982, 154-5; Ampolo 1980, 173-9.} The combined use of copper and iron in the local metal workshop could explain the close parallels during this period of objects made from either a copper alloy or iron. Moreover, there are several sites in central Italy, such as Poggio Civitate and Acquarossa, where simultaneous working of both copper alloys and iron is attested.\footnote{See sections 3.6.4 and 3.6.8.} On Elba and at Populonia, copper and iron slags were found side by side.\footnote{Crew 1991 a, 113-4; Fedeli 1983; Sperl 1985, 39.} Thus, slags from smelting copper ores were discovered on Elba while ancient iron slags were found in significant quantities which shows the early working of both metals on the island.\footnote{Sperl 1985; Giardino 1995, 119-22.} The close relationship between copper and iron working during the 8th and 7th centuries BC is substantiated in section 3.6 when the archaeo-metallurgical sites of central Italy are presented.\footnote{For example, in the workshop of Phidias at Olympia iron was smithed as well: Zwicker 1984, 66.}

The notion of the value of iron and especially its devaluation during the period 800 to 400 BC has been mentioned before. The process of devaluation would have affected the economy of central Italy profoundly and may explain in fact the fall off in crafts. The argument is circumstantial because price lists dating to this period do not exist for central Italy. Value can, however, not be determined in a pre-monetary society by fixed prices but has to be deduced from the contexts in which artefacts are found, their desirability and an assessment of the resources and labour involved. The working conditions are pivotal for an examination of value since a reduction in labour costs by for example, employing assistants or slaves, could counterbalance the devaluation of iron. An assumption in this thesis is that slavery became gradually a component of workshop conditions. This is substantiated by some of the archaeo-metallurgical sites where living-conditions could be recorded.\footnote{See for example, the conditions at Lago dell'Accesa, Acquarossa and at the industrial quarter at Populonia: sections 3.6.6, 3.6.5 and 3.6.7. I refer also to section 3.1.} Another option for counteracting devaluation is an increase in production which was established for various categories of artefacts such as bucchero vessels and copper alloy basins from about 650 BC onwards. A deterioration in working conditions and an increase in output per craftsmen probably occurred simultaneously. This process was encouraged by a lack of major technological innovations after the 7th century BC. It is a central theme of this research that from about 650/600 BC, a progressive devaluation of artefacts made in workshops by craftsmen affected the status and social position of workers employed in these crafts.\footnote{It is intriguing and simultaneously cynical for the development of Mediterranean Archaeology as a discipline, that this devaluation is still reflected in the prices on the Antiques market. One could ponder on a subconscious, well tuned system of valuation that remained valid for various periods of the western history. Also excavations have often resulted in a selection of recorded finds that is correlated to the prevailing valuation system and not to quantity. For example, the pre-eminence of Greek pottery in publications on archaeological sites in central Italy is not related to their quantity but rather to their exquisiteness and rarity when compared to the quantity of impasto fabrics. In addition, prices on the Antiques market bring about clandestine excavations as witnessed during the present archaeological project of the University of Groningen at Francavilla Marittima in Calabria. Guided by this subconscious system of value, the clandestini select those artefacts which were probably valued in Antiquity as well, leaving us with partially mutilated areas and scattered piles of ordinary wares.}

The vast necropoleis in this region present ample opportunities to relate iron artefacts to other status markers. It was
established that, during the 8th century BC, iron was considered a luxury material associated with warriors or women of high status. During the first half of the 7th century BC, iron is a component of wealthy graves though the range and quantity of iron artefacts increases. The Tomba Bernardini, for example, contained in addition to many prestige goods, iron axes, lances, spearheads, spits, hilts, cylinders, blades, a bar, plate, components of a chariot and other iron artefacts. This assemblage of iron objects indicates that iron was still valued since it otherwise would not have been deposited in this princely tomb but at the same time the assemblage shows that iron had become obligatory for tools and reinforcements. It, therefore, was considered a metal necessary for subsistence items and in this process was devalued as a luxury. During the subsequent period, the substantial accumulations of iron at, for example, the deposit at Brolio in the Val di Chiana or in the Tomba <dei flabelli di bronzo> at Populonia imply that iron as a material further decreased in value and in line with other categories of artefacts, had presumably become a semi-luxury and subsistence good.

This transition in value is recorded in other regions of the Mediterranean. An account of these regions is relevant due to the significance of trade in iron during the Orientalising Period. The analogous decrease in the value of iron in Greece and the Near East is likely to have had an effect on the economy in a wider context. Pleiner reports that in Greece certain types of iron artefacts, semi-products and iron bars became important for exchange during the 8th to 6th centuries BC. He describes that from the 8th century BC, iron became a common metal but probably remained a valuable material. An increasing productivity is attested by the establishment of manufactories during the 5th century BC. From at least the 5th century BC the existence of qualified slave craftsmen in the larger urban workshops is recorded for the iron industry. In my opinion, the increase of iron production in combination with a deterioration of the working conditions marks decreasing value. This process is illustrated by the employment of substantial quantities of structural iron for the construction of monumental buildings during the Classical period.

The most detailed evidence for the decline in value of iron in relation to other metals, derives from Mesopotamia and the Near East. Moorey reports for stage 1, which he dates during the second millennium to 1250 BC, ratios of iron to gold ranging from 1 : 8 to 1 : 10. The ratio for iron to silver would have been about 1 : 90. This indicates that iron was considered a precious metal in this region during stage 1. During stage 2 which he dates from 1250 to 850 BC, iron was still considered relatively valuable since it is listed in royal inventories. To indicate its value, Moorey mentions that around 1000 BC, one 'iron dagger was worth two full-grown rams' or 2 shekels of silver. He reports for stage 3 which is dated from about 850 to 350 BC, ratios of iron to silver ranging from 240 : 162

163 Canciani and von Hase 1979, 60-4. They report 22 catalogue entries of iron artifacts from the Tomba Bernardini. Various catalogue entries consist of two or more artefacts which have not all been identified.
164 Romualdi 1981; Minto 1943, 139-59, Tav. XXXIII.
165 The considerable trade in iron is reflected by the lines in the Politeia of Aristotle, quoted as a theme at the beginning of this chapter. Aristotle notes that trade became dependent on exchange of materials which were intrinsically useful and mentions specifically iron and silver. I refer also to: Stroum 1992.
168 The working conditions were probably still humane because slaves in metal workshops were qualified as is documented in texts. They could represented considerable assets for their owner: cf. Pleiner 1969, 32; Garlan 1988, 35-6; 64-5; 148-55.
169 Moorey 1994, 287-8. Moorey employs the phases of development in the use of iron as proposed by Snodgrass: Snodgrass 1980. These phases have been summarised in this section.
1 to 840 : 1, probably depending on the quality of the iron. These records which reflect the development in the value of iron from stage 1 to 3 show an enormous devaluation of the metal. They demonstrate the transition from precious to base metal and a comparable decline will have occurred in central Italy during the transition from stage 2 to 3. This transition is partly linked to the exploitation of the substantial iron ore deposits of central Italy. Once the technology of iron smelting and smithing was mastered at a local level, the devaluation of iron became unstoppable. Consequently, this modified the economic significance of the mineral resources of central Italy which mainly consist of copper and iron ores.

3.5 Resources

The mineral resources of central Italy were mentioned in the previous sections in relation to specific metals. Nevertheless, the extensive range of metal resources require a review for a general assessment.

The mining region of Etruria is part of a wider area with metal resources. This area extends from the Monti della Tolfa in southern Etruria to the Alpi Apuane in northern Italy. The resources are of diverse genetic types and include various minerals from which metals could be extracted. Figure 47 illustrates the distribution of ore deposits in Latium Vetus, Etruria and northern Italy along the Tyrrhenian coast. This figure presents possible locations of mines but the exploitation of individual deposits in antiquity remains to be ascertained. For example, the map includes deposits of magnetite bearing sands while it is doubtful if these deposits were exploited in antiquity. It excludes, however, bog ores. Nevertheless metallurgical analyses of a billet/bloom, slags and of iron artefacts from Satricum indicate that these items may have originated from bog ores though the ore itself was not found. The fact that bog ores are omitted in Figure 47 is based on their present economic insignificance as well as on the reclamation of marshes in central Italy which complicates the detection of ancient bog ore deposits. Most of the bog ores occur in small, heterogeneous deposits and are nowadays of minor economic interest. The deposits may nonetheless, have been important to the communities in central Italy during the period 800 to 400 BC. The quantity of bog ores which could be processed, was limited since deposits rarely exceed half a metre in depth. It is, however, possible that these deposits occurred on various locations in central Italy. Many stream-valleys, lakes and marshes would have been bordered by bog ore deposits which after exploitation, could replenish themselves within 30 years. The renewal of the deposits is based on the formation of ore horizons of insoluble iron compounds. These horizons appear along lakes and bogs due to precipitation. The bog ore is an impure limonite, often with varying amounts of manganese oxides. The deposits can range from bog iron to bog manganese deposits. The presence of various iron-manganese compounds at Satricum and other settlements in central Italy indicates the

175 See section 3.6.2.
178 Zitzmann 1977, 24-5. At this stage I would like to mention that Arnoldus-Huyzendveld wonders whether bog ore deposits were abundant in Italy: personal communication. According to her limonite is formed in certain soils under specific conditions. She recalls limonite concretions, with or without associated manganese, in the area around Cures Sabini and Satricum. I have seen similar limonite concretions in the area around Lavinium.
favourable circumstances in this region for the formation of limonite deposits.\textsuperscript{179} It is unfortunate that these deposits could not be included in Figure 47 since they are relatively easy to smelt and might, therefore, have been sought after.\textsuperscript{180}

Fig 47. Ore deposits in Italy; the black circles with numbers indicate mining areas and mineral deposits. The grey circles with black outline and chemical elements represent mineral deposits without specification of the location. Sb: antimony; Hg: Mercury; Pb: Lead; Zn: Zinc; Fe: Iron; Cu: Copper and Ag: Silver.

\textsuperscript{179} Kamermans 1980. See also Schweitzer and Rinuy who describe the use of manganese black as an Etruscan pigment: Schweitzer and Rinuy 1982.

\textsuperscript{180} Avery 1982, 206.
The mineral resources of central Italy are important for the processing of the metals lead, iron, copper, tin and silver. The major concentration of resources is located in the district around the Colline Metallifere while the distribution of the ores in Figure 47 demonstrates that Latium Vetus has a few iron ore deposits. In addition, the metal resources in Latium Vetus are not as diverse as in Tuscany which demonstrates that metals such as lead, tin and copper had to be imported to this region. The Colline Metallifere contain amongst other ores, sulphidic copper ores. These ores require a pretreatment which includes roasting. This process was previously discussed in Table I, but it is important to note that the exploitation of sulphidic copper ores requires a high degree of technical skill. According to Sperl, the indigenous population had mastered this skill during the late Bronze Age.

The exploitation of local silver and tin ores is ambiguous because metallurgical waste which is related to the smelting of these ores during the period 800 to 400 BC, is not reported. Consequently, the origin of tin and silver in central Italy is a subject of debate. Tin in the form of cassiterite occurs in Campiglia. This cassiterite is unusually rich and contains up to 72% tin. Warden suggests that these resources were exploited in antiquity while Formigli questions the abundance of tin in Campiglia. However there is circumstantial evidence which makes it probable that tin was processed in central Italy. The employment of threads of tin to decorate Villanovan pottery demonstrates that it was available locally during the early Iron Age. There is also evidence at Gran Carro that tin was employed in a workshop context while most of the analysed metals found at this site, indicate that they derive from local resources. In addition, it is reported that copper alloy artefacts in central Italy contain on average, about 2% more tin than copper alloy artefacts in Greece. Therefore it is probable that in central Italy, tin was relatively common and possibly less valuable than in Greece. In my opinion these findings indicate that tin ores were exploited either in central Italy or Sardinia.

A problem while discussing resources in antiquity is that scarcely any ores or smelting residues have been discovered during excavations of settlements. Thus, the relationship between particular ore deposits and ancient metal artefacts is hardly ever established. Therefore Bartoloni could record that almost nothing is known of the exploitation of the metal resources in Etruria. Recent publications by Zifferero and Giardino relate specific mineral deposits to settlement patterns while incorporating the available archaeo-metallurgical evidence. Both authors subscribe to the opinion that actual evidence relating to mining and smelting is scarce but that the evidence

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181 Bietti Sestieri 1981, 227. Other mineral deposits are reported for this region such as Zinc and Mercury deposits, but it is unclear whether these deposits were processed during the period 800 to 400 BC.


184 Tin in the form of cassiterite occurs in Campiglia. This cassiterite is unusually rich and contains up to 72% tin. Warden suggests that these resources were exploited in antiquity while Formigli questions the abundance of tin in Campiglia. However there is circumstantial evidence which makes it probable that tin was processed in central Italy. The employment of threads of tin to decorate Villanovan pottery demonstrates that it was available locally during the early Iron Age. There is also evidence at Gran Carro that tin was employed in a workshop context while most of the analysed metals found at this site, indicate that they derive from local resources. In addition, it is reported that copper alloy artefacts in central Italy contain on average, about 2% more tin than copper alloy artefacts in Greece. Therefore it is probable that in central Italy, tin was relatively common and possibly less valuable than in Greece. In my opinion these findings indicate that tin ores were exploited either in central Italy or Sardinia.

185 For the exploitation of silver ores, I refer to the section 3.2.


188 Giardino and Gigante 1995.

189 Craddock 1986.

188 It is reported that per talent tin was valued at 233 drachma while copper costed 35 drachma per talent in Greece around the middle of the 5th century BC: Zimmer 1990, 162.

189 I refer to Giardino for a presentation of the mineral resources on Sardinia: Giardino 1995.

190 Bartoloni 1989, 188.

that is at hand, indicates local exploitation during the Bronze Age and later.\textsuperscript{192} When one compares the spatial relationship between settlements and ore deposits there are distinct concentrations during certain periods. The exploitation of the mineral resources around the \textit{Valle del Fiora} for example, appears to be earlier than those in the Tolfia region. In the Tolfia area, the late Bronze Age is characterised by an increase in the number of settlements around the mineral resources. This implies an intensification of mining activities during this period.\textsuperscript{193} The evidence, moreover, suggests primary smelting at the mines. During the Etruscan period the settlement pattern in this region appears not to be so closely linked to the mineral deposits. Mining may have continued in this region but the local economy did not basically depend on metallurgical activities.\textsuperscript{194} It appears that mineral deposits in central Italy were exploited during specific periods after which they might have been abandoned. This may reflect preferences for specific ore deposits during particular periods but this hypothesis remains to be investigated. The periodic exploitation of resources might have affected a general shift of industrial activities during the 6th and 5th centuries BC to northern Etruria and north Italy. It is suggested that the industrial export of Elban hematite does not predate the middle of the 6th century BC.\textsuperscript{195} Elban ores are reported in Genoa in a context which is dated around 450 BC.\textsuperscript{196} These ores were, therefore, transported by ship to coastal areas around Populonia, northern Italy and Corsica.\textsuperscript{197} This shows a regional trading network for their distribution. Moreover it implies that the size of mining activities on Elba was substantial. The Elban ores are characterised by a high percentage of iron and their transport overseas demonstrates that this asset could be marketed by the 6th century BC.

The presentation of the archaeo-metallurgical information in the next section, will support the close relationship between the metal deposits and individual sites. Nevertheless, this relation varies from site to site. The impression that emerges is that for central Italy the metallurgical development can be explained in general, macro-economic terms but that the actual situation at individual settlements is extremely diversified.

3.6 \textit{Archaeological evidence}

In this section I will present sites with archaeo-metallurgical features. A number of these sites were previously introduced in chapter II on pottery production. I will refer to these introductions where appropriate. As in the foregoing chapter, the sites are presented according to their geographical location. Thus, the most southern site is examined first and the most northern site last.\textsuperscript{198}

3.6.1 \textit{Pithekoussai}

Several settlements in Italy such as Sorgenti della Nova and Cran Carro, show evidence for metalworking prior to the establishment of \textit{Pithekoussai}. These settlements are dated to the late Bronze - early Iron Age, thus before the

\textsuperscript{192} There are indications that cinnabar was exploited from the Eneolithicum. Prehistoric mining tools were recovered in the mine of Cornacchino; Zifferero 1991, 207-9.

\textsuperscript{193} Zifferero 1991, 212-5.

\textsuperscript{194} Zifferero 1992, 88-9.


\textsuperscript{196} Milanese 1996, 70-1.

\textsuperscript{197} Jehasse and Jehasse 1985; Cucini Tizzoni and Tizzoni 1992, 47-51.

\textsuperscript{198} This arrangement is directed by the location of \textit{Satricum}, the site I could examine in most detail.
arrival of foreign communities. The metallurgical evidence from Pithekoussai is dated to a later period and the location of this port of trade is south of the region examined in this study. Nevertheless, a discussion of the remains of the metal workshops at Pithekoussai is essential for it is, at the moment, the oldest building in Italy which can be related to metallurgical activities. Moreover, the excavations at Pithekoussai have guided the debate on the diffusion of technologies and, therefore, an examination of the evidence is necessary.199

Zimmer classified house IV at Pithekoussai as a Greek metal workshop even though it is reported that Italic type fibulae were manufactured here.200 The discovery of the early workshop at Pithekoussai is exceptional not only for Italian but also for Greek archaeology. In comparison to other workshop remains from Greece, the evidence for metalworking at Pithekoussai is extensive as well as advanced.

The workshop in building IV on the Mazzola site had originally, during the second half of the 8th century BC, a double apse and measured 8 by 4 m (Fig. 48). The south-east side of the building may not have been covered and could have functioned as an open area for industrial activities. Around 700 BC this house was reconstructed as a rectangular building which could have incorporated an open courtyard in which the furnace was located. This furnace was constructed of mud bricks which had been exposed to extremely high temperatures. Large flat pieces of hard, bleuish stones, phonolithes, must have functioned as anvils. Along the north-east wall of this building, debris was found which included iron slags, copper alloy snippets of sheet and wire, lead and a fragment of a copper alloy ingot. In addition, the debris contained a weight which will be discussed in chapter IV and a fibula which was discarded during production (Fig. 48). The bow of the fibula would have been decorated with elements of bone and amber. Some pieces of bone from which these elements had been sawn were discovered as well. Therefore it is probable that not only metals were processed in this workshop but also other materials such as bone and amber. The


fibula represents a type which is known in Campania but which is also reported from Greece. Buchner considers it to be an Italic type. Buchner considers it to be an Italic type. In addition to the copper alloys, iron was worked in this workshop as is shown by the iron slags. The debris is dated to the first quarter of the 7th century BC.

Another workshop with metallurgical debris is building III. It is a rectangular building and measures 7.5 by 6 m. It incorporated an open area with a floor that was scorched. The open courtyard contained a fireplace which was probably the forge. This interpretation is supported by the charcoal found nearby. Fragments of iron, slag and hammer scale demonstrate that building III was a blacksmiths' workshop.

Other remains of metalworking at Pithekoussai were discovered in the Scarico Gosetti. Several slags were found which indicate smithing but not smelting. The bases of two large ceramic vessels were covered with a substance that was analysed as hammer scale combined with chalk and smelt. Hammer scale and slag is ejected from the hot iron when it is emersed in cold water. Zimmer, therefore, interprets these vessels as containers in which the smith quenched the iron.

The workshop remains at Pithekoussai are frequently presented as the confirmation for the hypothesis that the Greek trading communities came to Italy in search for metals. One piece of Elban ore especially has confused the argument. Hartmann notes that the lack of early iron and imported Greek artefacts in the area around Populonia does not support the hypothesis that the Greek colonists at Pithekoussai were primarily interested in the Elban iron ores. Moreover, the emporion at Pithekoussai is used as a convenient illustration for the profound influence of Greek society on the indigenous population of Italy. However with respect to metals, especially the copper alloys, it is questionable as to who influenced who. In this context, a remark by Buchner is revealing. He reports that the dress ornaments, the copper alloy fibulae excavated at Pithekoussai, correspond with fibulae types known from Etruria, Latium and Campania. This has prompted him and Coldstream to argue in favour of widespread influence.

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202 Zimmer 1990, 16-9; Klein 1972; Ridgway 1992 a, 83-96; 99-100. Pithekoussai is mentioned in various sections throughout this study.
203 See section 1.7.
204 Hartmann 1982; 1985.
205 cf. Cornell 1995, 86-7. It is not my intention to belittle the Greek influence on Italian society but a merely Hellenocentric bias is insufficient for the complex transformations that occurred in central Italy. This bias perseveres by the habit to single out in excavation reports the Greek imported pottery. The transitions in this region reflect, however, an amalgam of cultural traits, local as well as Levantine and Greek while the direction and control over the organisation of the social-economic conditions were definitely regulated by the indigenous communities. The methodology of my research that is the analysis of primary evidence, generates predominantly data on these local arrangements and less on the role of the Greeks or any other ethnic immigrant group in central Italy since their presence is hardly documented by inscriptions or by other data in the industrial complexes that are recorded in this study.

206 I make a distinction between the metals involved, to allow for one of the hypotheses that was formulated by Bakhuizen: Bakhuizen 1976, 65-9. This hypothesis concerns the early phase of iron smithing in Italy. He argues that The nucleus of the first group of Chalcidian emigrants to settle near the Bay of Naples consisted of traders in iron products and of iron smiths. They came to the West because they expected to find a market for their products in Italy. They based their expectations on the knowledge that they were able to offer a superior product. One could find arguments in favour of this hypothesis. However, iron was introduced to a society which had achieved a high level in the manufacture of copper alloy artefacts. Moreover, Giardino as well as Zifferero present evidence for the processing of iron prior to the arrival of Greek communities: Giardino 1995, 183-4; Zifferero 1991, 228-9. See also Delpino 1988 and Betti Sestieri forthcoming.

207 Buchner 1979, 133-5; 1983, 271. See for example, Toms for similar fibulae at Veii: Toms 1986, 81. The important notion on the origin of the metals at Pithekoussai demands a detailed examination which can not be included in this study. An examination would have to incorporate the typology and distribution of the metal artefacts, the workshop activities as well as wider implications such as the exchange mechanisms and the mixed descent of inhabitants at Pithekoussai. The extensive presence in the Pithekoussai tombs of pottery that was produced according to Greek models, might have resulted in an inflated notion on the role of the Greek trading communities. In this context, I recall that this region of Campania which included settlements like Pithekoussai, Kyme but also communities in the interior such as Capua and Suesula, was characterised by an amalgam of Italic and Greek features. Frederiksen for example, concludes that 'the social and cultural diversity of the region
intermarriage between the first Euboean colonists and women from the Italic populations. Intermarriage may have occurred but is not sufficient as a model for the substantial interactions between the various communities in this region. Intermarriage, for example, does not account for aspects such as internal political organisation, external exchange mechanisms, the actual control over land and the exploitation of the rich mineral resources in central Italy. Moreover, it was reported that at Pithekoussai males wore fibulae of Italic type as well. Following the argument by Buchner and Coldstream would imply that these males were also Italian. In my opinion, the adoption of ornaments of Italic type at Pithekoussai merely suggests that at least part of the exchange with the indigenous communities involved metals and metal artefacts. The location of the emporion on the offshore island of Ischia and the character of the settlement at Pithekoussai combining local manufacture with trading activities implies that the settlers were originally restricted in their pursuits by regulations that were laid down by the Italic communities. Furthermore, the production of artefacts at Pithekoussai indicate that the indigenous demand controlled the manufacturing and trading activities at this port of trade.

The confined report of the metallurgical evidence from Pithekoussai illustrates the confusion of the implications of the data. In this study Pithekoussai is basically a port of trade where various communities lived together and manufactured goods for their own consumption as well as for the Italic population on the mainland. The presence of foreign residents in Italy accelerated the internal development and could partly account for the acculturation process. Acculturation is, however, not the equivalent for colonisation or domination since it is primarily a cultural phenomenon and does on the whole not involve the internal social-economic conditions. Moreover, Pithekoussai emerged during a period in which the Villanovan polities of central Italy had already established important communications routes towards the north as well as towards the south.

3.6.2 Satricum

The proto-historic settlement at Borgo Le Ferriere which is referred to by its ancient name Satricum, was introduced in the previous chapter. Besides evidence for local pottery manufacture, the excavations have revealed information for the processing of iron artefacts from the middle of the 7th century BC. This metallurgical activity at the settlement cannot be related directly to products or to a range of iron objects since the number of iron artefacts from the settlement excavations is confined. However the excavations of the necropolis and votive deposit I give an impression of the range of iron artefacts that were available at Satricum. In this section, I intend to relate the evidence for iron working at the site to the iron artefacts that are actually known. This will illustrate the metallurgical development at the site.

During excavations at Satricum a century ago, many iron objects were excavated from both the Iron Age necropolis and votive deposit I dated from he 8th to the 6th century BC. The necropolis was recently published by Waarsenburg. Unfortunately he did not record the iron artefacts comprehensively due to their state of was very great: Frederiksen 1984, 136. Conflicts over the control of this territory are reflected by the battle of Cumae in 524 BC and the battles with the Samnites who captured Capua in 423 and Cumae in 421-420 BC: Frederiksen 1984, 95-9, 136-9, 163-9. This exemplifies that the Italic population and their interests had always been pivotal for the historical development of this region. See also: Cristofani 1984.

208 Buchner 1979, 135; Coldstream 1994.
210 See section 1.7. I introduce in this section characteristics of emporia.
211 Bietti Sestieri forthcoming.
preservation. Waarsenburg writes that "although the Northwest Necropolis has produced a fair amount of iron weaponry and utensils, most pieces have decayed beyond recognition."\textsuperscript{213} The complete content of votive deposit I was never published but is catalogued at the moment and will be printed in the near future.\textsuperscript{214}

\textsuperscript{213} Waarsenburg 1994, 432.

\textsuperscript{214} Waarsenburg forthcoming. In this publication I will present the catalogue of the iron artefacts ascribed to votive deposit I. The iron artefacts are illustrated in Figures 50 to 56 of this section.

\textbf{Fig. 49.} Satricum, excavation plan and distribution map of iron slags that were excavated on the acropolis.
The distribution of the iron objects in the various contexts, that is votive deposit, necropolis and settlement in a period when iron was still considered valuable, is significant.215 Hardly any metal artefacts are found in the settlement, while in the Iron Age necropolis copper alloy artefacts are found side by side with iron objects though from 725 BC, iron weaponry was fairly common at Satricum.216 The majority of iron artefacts are found in votive deposit I (Figs. 50 to 56). Among the objects in this deposit are iron daggers, swords, knives, axes, sickles, spears, arrowheads, shafts, pins, bars, nails, rings, fibulae, pendants, bracelets and other items. The amount of iron tools is indicative since scarcely any copper alloy tools were found in this deposit. Iron tools are by far in the majority. This means that by at least the middle of the 7th century BC, iron tools had replaced copper alloy implements.

The introduction of iron knives is considered to reflect a transitional stage towards a fullfledged Iron Age when iron tools supersede copper alloy tools. This intermediate stage is recorded at excavations of the necropolis at Osteria dell'Osa. Bietti Sestieri noticed that from 770 BC all knives were of iron. In the previous period from about 900 to 770 BC, iron knives are rare and appear to have been part of exceptional tomb inventories. During the following periods iron knives dominate.217 This indicates that the transition to a fullfledged Iron Age in Latium Vetus roughly corresponds to the 8th century BC. The fullfledged Iron Age, a term which marks the dominance of iron implements, is for Latium Vetus represented by the evidence from Satricum.

The metallurgical evidence at Satricum consists of slags discovered during excavations on the acropolis. These slags can be classified as:218
a. plano-convex smithing hearth bottoms that are magnetic;
b. smaller, relatively light and porous, non-magnetic slags. Cinder or metallurgical waste products of slag, ash and sand/vitrified fuel ash;
c. smithing slag lumps;
d. molten slag with traces of furnace or hearth lining.

The distribution of these slags on the acropolis at Satricum is illustrated in Figure 49. Two aspects should be mentioned. First, the map presents the concentrations of iron slags and shows three major concentrations. The oldest concentration of slags was recovered from a context dating to the second half of the 7th century BC. Secondly, I would like to emphasise the continuity of metallurgical activities at the site which is demonstrated by the various stratigraphical layers from which the slags originate. These could be dated from the 7th to the 4th centuries BC. Most of the slags are found in concentrations located in squares B11 and E19 and are dated to the late 7th and early 6th centuries BC. In B11 the slags are associated with hut VII and the wooden building AA. The building is a direct continuation of the previous activity area. This 7th - early 6th centuries BC context is associated with bucchero, fine impasto wares, some fine drinking vessels of depurated clays and a small terracotta head. The pottery suggests a relatively affluent family though the interpretation of this area awaits final publication.219 An assessment of the relationship between hut VII and building AA with the metallurgical debris has to include the evidence of the recent

215 The iron artefacts from these contexts are each listed in the Appendix.
217 Bietti Sestieri 1992 a, 398.
218 Sperl 1980, 14-9; Bachmann 1982, 1-6, 30-4; Tylecote 1987, 310-21.
219 Nijboer, 1993/1994; Beijer 1991 a; Maaskant-Kleibrink 1992, 92-7; 99-100; The catologue numbers 2239 to 2541a in Maaskant-Kleibrink 1992, present an illustration of the pottery with which the iron slags can be associated. In addition, slags are recovered from this area during recent excavations which await final publication. Beijer reports that one of the important families at Satricum occupied this area: Beijer 1991 a, 24. On account of the metallurgical waste material that was found in the 7th century BC strata of hut VII and the timber building, it is suggested that at least one of the activities in which this family was involved, was metalworking. I would like to thank my colleague Arnold Beijer for discussing this context with me.
excavations. At the moment area B 11 represents the only context on the acropolis with both structural remains and metallurgical debris. The other two concentrations of slags are found either as refuse used probably for a foundation layer of a road or appear to have been deposited in votive deposit II.

In addition to slags, the excavation of an area south of the temple in square B18 yielded a metal and pottery deposition that included copper alloy vessels and jewellery as well as iron axes, knives and a piece of raw, unworked iron (Figs. 68 and 69). The piece of unworked iron is a bloom or billet. The associated pottery is bucchero, a black burnished carinated impasto bowl, fragments of a stand of impasto rosso, impasto jars and an impasto amphora decorated with a double spiral, all dated to the second half of the 7th century BC (Fig. 70). These objects were deposited in the settlement area, though the exact context is not known. The assemblage implies, however, trade and production of metal artefacts.

Several of the iron objects from the settlement excavations were examined metallographically. Two knives and two axes were analysed as well as the raw iron nodule. Except for one knife, these items were part of the metal concentration in square B18 mentioned above and are, therefore, dated to the second half of the 7th century BC. The iron knife which does not belong to this concentration is dated to approximately 650 BC. The results of the metallographic examination are presented per artefact:

- Knife S4607 has a core which consists of a medium to high carbon steel with a hardness of 280 Hv, Vickers micro hardness test. Two samples from the back of this knife had a lower carbon content and were less hard, 150-167 Hv.
- Knife S5030 had a medium to high carbon steel cutting edge with a hardness of 292 Hv.
- The cutting edge of axe S5030 was made of a medium to high carbon steel while the hardness varied from 245 to 290 Hv. In one of the samples from this axe evidence for quenching was found. The blade and the socket consisted either of ferritic or phosphoric iron and had a hardness that was considerably lower.
- Axe S5099 had a low carbon steel and ferrite cutting edge and was relatively soft, 135 to 187 Hv.

It can be deduced from the metallographic examination that during the 7th century BC not all the constraints of smelting and smithing were under full control though the smiths were working with considerable skill. Various types of iron or steel were used for different parts of the object. This differential use of grades of iron can be observed in knife S4607, where the core, tang and probably the cutting edge consisted of a medium carbon steel as these parts have to be hard, while the back of the blade was constructed of phosphoric and ferritic iron as this part had to be more flexible and tough. Nevertheless, a general absence of evidence for quenching was observed, though one sample, Axe S 5030, did indicate relatively rapid cooling.

The hardness of the artefacts was regarded as sufficient for their function. Various parts of the iron artefacts had a hardness of around 280-290 Hv, which is harder than most copper alloy artefacts. Moorey mentions that a copper alloy which contains 6 to 10 % tin, can be work-hardened to 275-300 Hv but these figures are usually not achieved. Therefore the hardness figures of the iron tools from Satricum indicate that the smith manipulated iron to produce a harder working tool than was normally obtained for copper alloy items. Simultaneously, it can be

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220 Nijboer 1994, 6. See sections 4.2 and 4.3.
221 Iron artefacts from this context are represented by the numbers S 5030 and S 5099.
222 This is knife S4607.
224 Scott 1991, 82-3; Coghlan 1975, 75-83.
deduced that full control over the constraints which affect the hardness of iron, was absent. Quenched steel can obtain hardness figures up to 800-900 Hv but this cannot be shown for the early iron from Satricum.

Fig. 50. Satricum, votive deposit I, iron ornaments.
Fig. 51. Satricum, votive deposit I, iron tools.
Fig. 52. Satricum, votive deposit I, iron weapons.
Fig. 53. Satricum, votive deposit I, iron weapons
Fig. 54. Satricum, votive deposit I, iron weapons, shafts and rods.
Fig. 55. Satricum, votive deposit I, iron rods, spits and nails
The metallurgical evidence from *Satricum* corresponds with the results from similar studies elsewhere in Europe. During the early period of iron technology, different grades of iron were employed to forge iron. Some ancient Italian iron objects were examined for their metallographic characteristics by Follo *et alii* and by Panseri and Leoni. The results of these studies can be compared with the analyses of the iron tools from *Satricum*. Among the iron implements analysed are a the blade of a dagger, a sword and an axe from Vetulonia. These objects are dated to

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226 Pleiner 1980.

the 7th and 6th centuries BC and were forged from different grades of iron. Only the axe from Vetulonia was quenched with an hardness ranging from 560 Hv to 125 Hv, depending on the quality of the iron and its relative position within the axe.228

The analyses of the bloom or billet S5030-3, demonstrated that parts were of a hyper-eutectoid steel with more than 0.8% carbon. SEM-EDX analyses of two slag-inclusions in the bloom established that phosphorus, as well as manganese, oxides were present up to 2%. These quantities indicate that the bloom/billet was produced from smelting iron ores which contained phosphorus and manganese.229 XRF and SEM-EDX analyses of the smithing slags excavated on the acropolis at Satricum, revealed that almost every slag contained manganese. The phosphorus and manganese content of the smithing slags resembles the content in the bloom/billet. Tylecote reports that the composition of the smithing hearth bottoms is not very different from the smelting slags and that these contain information about the ores smelted. Especially ‘manganese and phosphorus are useful from this point of view although some of the latter element can come from the fuel ash’.230 Thus, the smithing hearth bottoms from Satricum as well as the slag inclusions in the bloom/billet indicate at least the use of manganese bearing ores.

Relating slags to the provenance of iron ores is complicated on account of the variables involved such as the use of fluxes during smelting or post-depositional changes. For central Italy the ores from Elba have obtained an almost mythical status. However the Elban iron ores constitute only a fraction of the iron ores available in central Italy.231 Moreover, there are various iron ore deposits on Elba which have diverse compositions.232 Without specifications and a relevant archaeological context, an attribution of the provenance of iron ores to Elba is of little significance. In relation to the metallurgical residues from Satricum, Elban iron ores appear not to be a likely source since they contain no phosphorus and manganese or merely traces of these elements.233 The relatively high proportion of manganese in the metallurgical residues from Satricum could indicate the smelting of bog iron ores or other manganese bearing iron ores.234

The account of the slags and the bloom/billet from Satricum establishes that iron was forged at the site while the metallurgical examination demonstrates the technological level of smithing around 650 to 600 BC. An indication of the range of iron artefacts that may have been produced at the settlement is provided by votive deposit I. This deposit has always been considered exceptional when compared to other early votive deposits in Latium Vetus. The assessment is based on the enormous quantity of artefacts that were found, their high technical quality and the variety of objects. Therefore the oldest votive deposit from Satricum is considered to be the richest deposit of Latium Vetus.235 Unfortunately this deposit has not been published completely although it was excavated about a century ago.

Votive deposit I is dated from the 8th to 6th centuries BC.236 Thus, the dating of the iron artefacts from this

228 Panseri and Leoni 1960.
229 Tylecote 1987, 313. For a complete account on the metallographic examinations of Satricum see Abb ingh et alii. forthcoming. Avery reports the production of a bloom of medium carbon level ranging from 0 to hypereutectoid (> 0.8%) but on the average between 0.2 and 0.6 % carbon: Avery 1982, 212.
230 Tylecote 1987, 313.
232 Bodechtel 1965; Zitzmann 1978.
235 cf. Satricum 1985, 97; Bouma 1996 chapter II and IV; Waarsenburg forthcoming.
deposit fall within these centuries (Figs. 50 to 56). In general, dating iron objects is difficult due to various reasons such as the longevity of tool and weapon forms and their ill-defined typology which is primarily caused by the poor state of preservation of iron. Nevertheless the initial phase of the deposit is recorded by some of the jewellery, lance heads, axes, swords and daggers while the final stage is represented by the iron rings. For example, the iron rings number 12 and 13 in Figure 50 are similar to silver and copper alloy signet rings found in votive deposit I which shows that they were manufactured in various metals. Similar rings are dated elsewhere to the second half of the 6th century BC and thus they relate to the final stages of this deposit at Satricum.237 Most of the other iron objects in votive deposit I probably date to the second half of the 7th and the early 6th centuries BC. The dating of the various artefacts will be discussed in more detail below.

All iron artefacts attributed to votive deposit I are illustrated in Figs. 50 to 56. At present, most of these objects are stored in the depot of the Museo di Villa Giulia in Rome while a small selection is exhibited in the Satricum room of the museum.238 The iron artefacts from votive deposit I appear to confirm the exceptional character of the deposit. In central Italy, I do not know of any comparable deposit though the Archaic deposit excavated at Anagni and dated from the 7th to the early 5th centuries BC, contained some similar iron artefacts such as a fibula, bracelet, lances and rods.239 Another deposit in central Italy with some related iron items is the deposit of Brolio in the Val di Chiana.240 This deposit dates from the late 7th to the early 5th centuries BC. The majority of the artefacts in the deposit of Brolio date to the late 7th - early 6th centuries BC. It contains some lances and axes similar to those found at Satricum in votive deposit I.241 Though both the deposits at Anagni and Brolio contain comparable iron artefacts, they do not exhibit the quantity nor the variety of iron objects found at Satricum.

The iron artefacts from votive deposit I at Satricum may be correlated with the evidence for smithing near the sanctuary presented above. There are several other deposits in central Italy with evidence for smithing. For example, a votive deposit at Grotta Bella (Terni) included slags and tools for iron working such as hammers and a pair of tongs. It was suggested that artefacts were produced in the sanctuary for the use of pilgrims.242 Also in Rome various slags are recorded from a layer with offering material found against the circular foundation platform of the Vesta temple. This layer was dated from the middle of the 6th to the late 3rd centuries BC.243 Neither the deposits at Grotta Bella nor at the Vesta temple disclosed a comparable range of iron artefacts to that found at Satricum. To my knowledge, the closest parallel both in quantity and context is a deposit at Philia in Thessaly, Greece. At this site, offerings of iron artefacts as well as evidence for iron working, are recorded.244 The difference between the deposits

237 Satricum 1985, 112.

238 These objects are attributed to votive deposit I and are therefore presented as such in this section. However, it is necessary to report that about 10% of the illustrated artefacts, many of which minor fragments, are registered as NN numbers. This means that they cannot be correlated directly to the field records. These NN numbers were at one stage in the past, assigned to votive deposit I. The majority of the illustrated iron artefacts are securely attributed to votive deposit I as is documented in the Appendix that presents their inventory at the moment of excavation about a century ago. A detailed report of the actual excavations around 1900 AD and of the complicated post-excavation history is published by Waarsenburg in his thesis: Waarsenburg 1994, chapter 2.

239 Gatti 1993 a, 61-97.

240 The deposit at Brolio was recovered in 1863 and was originally considered to be a hoard of a metal workshop on account of the associated semi-manufactured products. This interpretation is expressed in a letter by Scipione Corradini which was published by Romualdi: Romualdi 1981, 64. Nowadays it is considered to be a deposit: Romualdi 1981, 35.


243 Boni 1900, 172-83; Gjerstadt 1960.

is that during the late 8th and first half of the 7th centuries BC, the deposit at Satricum contained a fair amount of imports from foreign communities while the deposit at Philia is considered to be a local or regional sanctuary. At Philia, the majority of iron offerings such as tools, obeloi, knives, arrows, lances, butt-spikes, swords, semi-manufactured products, waste products and a bar were excavated in the vicinity of the sanctuary. In addition, waste-products demonstrating the processing of copper alloys were found at Philia together with debris of a smithy. Some metalworking tools were excavated near the sanctuary and testify to the existence of a metal workshop. Kilian reports that in Greece dedications of iron artefacts are fairly common in many Geometric and Archaic sanctuaries though not often published. He associates these offerings with local production on account of accompanying evidence such as semi-manufactured artefacts and waste products. Similar correlations are likely to have existed in Italy. For example, the archaic votive deposits of Anagni and Satricum revealed a large amount of iron offerings which at Satricum can be related to waste products of smithing. This pattern may well have lasted into the Republican period as is suggested by the deposit at Grotta Bella.

The dating of individual iron artefacts from votive deposit I is based on iron objects found in other contexts at Satricum. To a certain extent, the iron artefacts from the deposit resemble those found in the necropolis and the settlement. Several tombs at the site contained iron objects which can be compared with the iron artefacts from the votive deposit.

- Tomb XIV for example, is dated to approximately 675-650 BC and contained an iron sword similar to the fragments 64 to 66 on Figure 52.
- Some of the pendants from tomb XXV, dated to 640-620 BC, resemble the pendants 18 to 22 and 27 in Figure 50. This corresponds with the date of the iron pendants excavated at Osteria dell'Osa in tomb 401. Several of the pendants found in this tomb are related to the pendants from Satricum, numbers 14 to 27 illustrated in Figure 50.
- Tomb II is dated to between 700/685 and 620 BC and contained many lance heads with corresponding shafts and butt-spikes similar to the lance heads, butt-spikes and shafts from votive deposit I illustrated in the Figures 52 and 53. The blades of two swords from tomb II can be related to the blade of sword number 58 in Figure 52. Similar blades of swords were excavated at Osteria dell'Osa in the tombs 54, 76 and 227 dated from 660 to 580 BC.
- Tomb XVIII, dated from 750/725 to 620/610 BC, contained several fragments of blades from swords and daggers which are comparable to the blade-fragments numbers 63 to 66 in Figure 52.

A few iron objects were found in the settlement. These objects can be dated to the middle of the 7th century BC. Both the knives and the axes from the settlement area are comparable to the knife fragments and axes from votive deposit I illustrated in Figure 51.

245 The iron bar that was recovered at Philia, is similar to the bar excavated at Satricum (Fig. 56, no. 148).
246 For a description of these tombs see: Waarsenburg 1994.
249 Undoubtedly more iron artefacts from the necropolis resemble iron objects from votive deposit I. However Waarsenburg did not fully document the iron from the necropolis and consequently it is not possible to relate every iron item from the necropolis to iron artefacts from votive deposit I. Waarsenburg 1994. Compare also the iron that is illustrated in Figures 50 to 56 with iron objects from Satricum that are published by: Ginge 1996.
250 See Appendix.
251 The catalogue of the Satricum 1985 exhibition contains two entries of lances that are reported to have been found in huts (no. 11800 and 11850): Satricum 1985.
The range of iron objects found in votive deposit I contribute to the difficulties in examining some of them. The diversity is unsurpassed in Latium Vetus and Etruria. Thus, several artefacts in votive deposit I are without parallels. Therefore they can only be dated by the general date given to the deposit. For example, the iron artefacts that look like spindle-whorls illustrated in Figure 50, numbers 32 to 37, cannot be compared to similar iron objects from other sites nor can the bracelets with copper alloy inlay, numbers 28 and 30 in Figure 50.252 The iron sickles, Figure 51, numbers 47 to 49 are, as far as I know, difficult to relate to excavation reports from central Italy but are known in Southern Italy.253 At Francavilla Marittima several iron sickles were found which all belong to a type with socket shaft dated to the 8th century BC.254 However the iron sickles from Satricum do not resemble the sickles from Francavilla Marittima. Copper alloy sickles of similar form to the iron sickles from Satricum are known from the late Bronze Age.255 The 412 copper alloy sickles found in the San Francesco hoard at Bologna provide an analogy in form and possibly date.256

Besides the complications due to the range of iron artefacts from votive deposit I, another obstacle in dating these artefacts is the wide date of the deposit itself. Many iron tools cannot be dated precisely when they do not derive from accurately dated contexts. This problem is illustrated by the group of axes in Figure 51 numbers 50 to 57. These axes are relatively rare in Latium Vetus during the 7th century BC. They appear to be more common in Etruria during the 7th and 6th centuries BC.257 The prevalence of iron axes is demonstrated by the deposit of Brolio in the Val di Chiana and the tomba dei fabelli di bronzo at Populonia.258 Iron axes similar to those from Satricum were found in several necropoleis in central Italy with dates ranging from 760 to the early 6th centuries BC. Hartmann catalogued early iron artefacts from Etruria and records:
- two iron axes from Veii dated from 760 to 720 BC,
- one axe from Tarquinia dated to approximately 725-700 and
- five from Vulci mostly dated between 720 and 690 BC.259
For example, an axe from Veii in tomb II JJ 19 resembles the axe from Satricum illustrated in Figure 51, number 52.260

The closest parallel in Latium Vetus for the axes from Satricum is the tomba Bernardini at Palestrina where two square socketed axes similar to Figure 51, numbers 50 and 52, as well as one shaft hole axe resembling Figure 51, number 57, are reported.261 The tomba Bernardini is dated to the beginning of the 7th century BC. A square socketed axe from tomb 43 at Caracupa dated to approximately 650 BC, also resembles the axes from votive

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252 Bietti Sestieri reports lead spindle whorls in tomb 322 which were stolen from the excavation storeroom: Bietti Sestieri 1992 a, 709, fig. 315. Falchi documents an early copper alloy bracelet twined with an iron inlay that was recovered in Tomb III on the Cima del Poggio alla Guardia at Vetulonia: Falchi 1891, 78-80.

253 Hartmann for example, does not present any sickles from Etruria: Hartmann 1982. In Gli Etruschi in Maremma it is reported that copper alloy and iron sickles dated to the 6th and 5th centuries BC, are known from Populonia: Cristofani 1981, 181. Pleiner mentions that iron sickles are frequently dedicated at sanctuaries in Greece; Pleiner 1969, 15-7.

254 Gualtieri 1982, 163.

255 cf. Bartolini 1989, 72, fig. 3.9.

256 Zannoni 1888; see for example, page 31, Tav. XXXI.


258 Romualdi 1981; Minto 1943, 139-59, Tav. XXXIII.

259 Hartmann 1982.


261 Canciani and von Hase 1979, 62-3.
This detailed account on iron axes from central Italy demonstrates that these axes can only be dated precisely by their contexts. The dates of these axes vary from the 8th to the 6th centuries BC, more or less the period ascribed to votive deposit I. Nevertheless, I suggest dating the iron axes from this deposit to the 7th century BC. This is based on the examples from Palestrina and Caracupa and on the iron axes found in the settlement at Satricum. The axes from the settlement derive from a context dated to the second half of the 7th century BC. Unfortunately, both an earlier as well as a later date for these axes cannot be excluded considering the features of votive deposit I.

The evidence for iron manufacture at Satricum in combination with the information on the production of pottery at the site which was presented in chapter II, establishes that at least from around the middle of the 7th century BC industrial production accelerated at the site. Evidence for production activities, such as slags and kiln remains, continues into the 4th century BC. This means that workshop production was maintained at the site although the settlement did not develop into a primary urban centre. Nucleation of workshops is not demonstrated and it is probable that the main sanctuary directed the economic development of the site. In addition to the local manufacture of iron and pottery, it is suggested that other materials were also processed. The evidence for local copper working and amber carving is circumstantial.

There is indirect evidence for the repair of copper alloy vessels and the casting of fibulae, since several of the fibulae types which were found in votive deposit I, are identical and cast from the same mould. Thus, 7 boat fibulae are exactly equal in size and decoration. Sets of the same type of fibula, each set decreasing in size, occur in this deposit as well. This suggests a local production from the 7th century BC. Other indications for copper smithing at the site, are the metal scraps and the enormous amount of aes rude from votive deposit I.

Around the middle of the 7th century BC the activities at the settlement may have included the carving of amber. Tomb VI which is dated to 650/640 BC, is known as the 'amber burial tomb' and contained over 500 pieces of amber artefacts. On the basis of quantitative and stylistic analysis Waarsenburg suggested that a carver and his apprentice worked at Satricum around 650 BC. A combination of activities such as carving and metalworking is common for workshops during this period. Carving hard substances was the craft of the faber which has meant throughout antiquity, the processing of materials such as wood, horn, bone, ivory, amber and even metals. The processing of metals and bone was attested at Pithekoussai in the metal workshop and similar activities are recorded at Poggio Civitate. It is, therefore, probable that at least during the Orientalising Period various materials were processed at Satricum in a single workshop.

The workshop activities at Satricum reflect the changes examined in this thesis. The workshop conditions around Satricum were likely conducive to the production of a wide range of artefacts, including iron axes, fibulae, and amber artefacts. The evidence suggests a complex and diverse workshop environment that was responsive to the needs of its community and the broader cultural context.

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262 Savignoni and Mengarelli 1903, 325; Angle and Gianni 1985, 200.
263 Nijboer et alii 1995.
266 No. 10658, Museo Villa Giulia.
267 I refer to Waarsenburg for the copper alloy artefacts in votive deposit I: Waarsenburg forthcoming. Haeberlin mentions the relation between aes rude and workshop activities: Haeberlin 1910, 3.
269 Blümner 1879, 164-86.
270 On Pithekoussai see section 3.6.1. For Poggio Civitate I refer to: Nielsen 1995; sections 2.6.6 and 3.6.8.
the middle of the 7th century BC as reported in the activity area of hut VII and building AA, appear to be relatively affluent. At *Satricum* the early workshop activities are located in a settlement that consisted chiefly of huts. Workshop production was directed towards the manufacture of luxury goods and included the processing of various materials. During the 6th century BC, the second kiln at the site implies that workshop activities are related to substantial buildings but that production became increasingly associated with subsistence goods. The workshop conditions at the site during the 5th and 4th centuries BC, indicates moderate circumstances. The religious gatherings at *Satricum* became essential for the continuance of industrial activities, albeit on a reduced scale. The output of these late workshops is reflected by the artefacts excavated in the necropoleis and votive deposits. To judge from this output, I propose that the pottery was made by a few craftsmen, possibly one or two family workshops. The potting activities were probably combined with agriculture which would account for the low degree of specialisation that is revealed in the ceramics.²⁷¹ The pottery reflects the progressing marginalisation of the local crafts at *Satricum*. During this same period, metalworking was probably managed by a single person in what might be described as a small, local workshop.²⁷²

### 3.6.3 *Caere*

The evidence for metalworking at *Caere* is scarce when compared with the information on pottery production presented in chapter II. The recent publication of the excavations on the settlement plateau which were directed by Cristofani, has presented proof for metallurgical activities within an urban context. It is reported that 76 fragments of refractory material were discovered in a huge basin which contained pottery from the 7th to the early 5th centuries BC.²⁷³ Some of these fragments derive from crucibles and others from moulds for casting copper alloys. The surface of the crucibles is occasionally vitrified and covered with slag-like material. One of the fragments of a mould is decorated on the inside with an impression of four petals. The refractory materials are waste products of casting copper alloys and demonstrate that a metallurgical workshop existed nearby within the urban centre.²⁷⁴ The workshop itself was not found.

Other evidence for metalworking at the site is circumstantial. For example, it is suggested on account of stylistic details and distribution that a jewellers workshop existed at *Caere* from the early 7th century BC.²⁷⁵ Albanese Procelli implied that *Caere* was a production centre for hammered copper alloy bowls and basins during the 7th century BC on account of the refined execution and the ancient repairs of metal vessels found at the site. It is suggested that this production increased and that goods may have been exported to Sicily and southern Italy.²⁷⁶ Wiman considers that the town incorporated a workshop for the manufacture of copper alloy mirrors.²⁷⁷ I personally would not hesitate to assign some of the *Caeretan* copper alloy artefacts which are kept at the archaeological museum in Florence, to a local workshop.²⁷⁸ The production of metal artefacts in the urban workshops of *Caere*

²⁷¹ I refer to Bouma for an impression of the output of the pottery workshops during the 5th and 4th centuries BC: Bouma 1996.

²⁷² Nijboer *et alii* 1995.

²⁷³ Cristofani 1993, 503-4, fig. 737.

²⁷⁴ Cristofani 1993, 503-4, fig. 737.


²⁷⁶ Albanese Procelli 1985, 186-91.

²⁷⁷ Wiman 1990, 227-9, 243-5.

²⁷⁸ For a catalogue of these artefacts see: Cianferoni 1991, 108-31. This publication signifies the relatively limited preservation of copper alloy artefacts from antiquity.
must have been considerable but this is not directly reflected in the archaeological record. The output must have incorporated a wider range of artefacts than basins and mirrors. For instance, an indication of the iron production at the site depends entirely on the few assemblages with iron discovered in the early tombs. This makes it impossible to elaborate on this aspect of the craft of metal working during the period 800 to 400 BC.\textsuperscript{279}

The excavations by Cristofani and his team have established that a portion of the central plateau was assigned to workshop activities at least to about 500 BC. In addition to metalworking, the production of ceramics is recorded. A large pottery workshop was discovered nearby which might have existed on the same site for several centuries.\textsuperscript{280} The activities in this section of the town included bone, antler and horn working since off-cuts were reported.\textsuperscript{281} Therefore the refuse material records the same range of activities as in smaller centres such as Poggio Civitate and Satricum though at Caere these activities were organised on a larger, more intense scale.\textsuperscript{282}

3.6.4 Acquarossa

Acquarossa is located near some ore deposits (Fig. 57). Within about 3 km of the site there are two mining districts and the exploitation of these mineral assets contributed to the development of the settlement during the 7th and 6th centuries BC. The sulphide-iron ore deposits nearby were probably worked and reduced at the site. In addition, local limonite deposits may have been exploited.\textsuperscript{283} Metals were processed at Acquarossa prior to the urban development from the middle of the 7th century BC. Metal waste products were found in a context dated to the late 8th and 7th centuries BC. Iron slags and metal artefacts were discovered at the floors of huts A and B. These huts belong to a compound of structures which are located in zone K of the excavation plan. Moreover, semi-manufactured copper alloy artefacts indicate that copper was locally worked.\textsuperscript{284} Zifferero reports that slags, semi-manufactured iron, iron artefacts, fragments of crucibles and deformed or semi-manufactured pieces of copper alloy were found in these huts which establishes that metals were processed here. The findings imply that more than one family was involved in metallurgical activities which indicates that this might have been a communal pursuit. Similar evidence is recorded from the nearby settlement at M. Piombone.\textsuperscript{285} As at Satricum, the early evidence from Acquarossa on craft specialisation and the processing of metals is associated with a settlement which consists of huts. An intensification of these activities undoubtedly assisted the early urbanisation of the site. The extensive excavations that revealed the urban buildings at Acquarossa, have unfortunately not produced primary evidence for workshop activities. The buildings demonstrate the considerable impact of construction works on the ceramic craft.\textsuperscript{286} The lack of workshop remains and industrial debris from the late Orientalising and Archaic period has prompted the excavators to suggest

\textsuperscript{279} cf. Hartmann 1982.

\textsuperscript{280} See section 2.6.4.

\textsuperscript{281} Clark 1993, 481-7.

\textsuperscript{282} See for example: Haynes 1985, 66-71; Maffei and Nastasi 1990.

\textsuperscript{283} Zifferero 1991, 219-21.


\textsuperscript{285} Nardi 1972, 106; Zifferero 1991, 219-20. In the nearby vicinity of Acquarossa there were other settlements of which at least one was associated with the manufacture of iron. The settlement traces around Acquarossa are dispersed which probably implies the existence of various communities in this mining area. Wikander estimated that about 4,000 to 7,000 people inhabited Acquarossa during the first half of the 6th century BC without including the existence of nearby settlements. This circumstance should caution those who are trying to minimise the size of the habitation around these mineral resources: cf. Wikander 1993 a, 137-9; Person 1994, 293-4.

\textsuperscript{286} See section 2.6.5 where data on the ceramic industry at Acquarossa are presented.
that manufacturing activities were located outside the urban centre even though less than 4% of the urban area was excavated.\footnote{Wikander, C., 1988, 73-4; Wikander, Ö., 1993 a, 137-9. See section 2.6.5.} One detail of the ware analyses of the architectural terracottas, indicates that metallurgical activities continued at or near the site during the 6th century BC. Ore and slags are recorded as temper in a specific ware group for tiles that are dated from about 640/20 to 550/525 BC.\footnote{Ware group a consists of pan tile type I and II: Wikander, Ö., 1993 a, 36-40, 164-70.} On account of the presence of ores and slag in local ceramics, it is likely that the processing of ores continued at the site well into the 6th century BC.

Fig. 57. Aquarossa, mineral resources and settlement traces around the site. 1. Aquarossa; 2. Ferento; 3. M. Piombone; 4. ore deposit of Solfatara; 5. ore deposit of Macchia Grande.

The prosperity of the site, its location within walking distance of mining areas, the early metallurgical debris and its fast economic growth during a period when increasing quantities of iron became indispensable, demonstrates, in my opinion, that the economy at Acquarossa was in part based on the exploitation of the nearby mineral resources. The evidence from the buildings at Acquarossa, which have a mean size of about 60 square metres, can be related to buildings at other sites where metals were processed, such as the settlement at Lago dell'Accesa and the workshops in the industrial quarter of Populonia. In comparison with the 5th century BC metal workshops of Marzabotto, the structures at Acquarossa are even relatively small. However the buildings at Acquarossa are living quarters and cannot be classified as workshops. They may be associated with families who were involved in mining and smelting ores. This could have been combined with other activities as will be recorded for the settlement at Lago dell'Accesa. It is likely that the construction of the buildings at the site is related to an intensification of the metallurgical industry at or near the site. This will have increased the income of the community that lived at Acquarossa.
3.6.5 Gran Carro

Gran Carro is an early Iron Age site and located along the borders of the Lago di Bolsena, approximately 40 km north-east of Vulci. The lake settlement is included in this study because it illustrates the position of metallurgy prior to the arrival of overseas communities.

Three settlement phases can be distinguished during the 9th and early 8th centuries BC. The last settlement phase consists of rectangular buildings constructed on platforms, pile dwellings, probably to counteract the effects of a rising water level which eventually caused the abandonment of the settlement during the first half of the 8th century BC.\(^{289}\)

The metallurgical evidence from Gran Carro was analysed by Giardino and Gigante.\(^{290}\) A small but significant amount of metal artefacts, casting debris, ingots and unfinished products were discovered at the site. Among these are threads of tin found in a workshop context and a two-piece stone mould for making small objects. The findings establish the existence of a local foundry. Various scientific methods were applied to samples of the metal artefacts including some ingots and residues of casting. On the basis of the archaeometric results, the metalworking activities at Cran Carro can be related to the exploitation of the mineral resources in central Italy.

Analysis of decorative ringlets from Gran Carro showed them to be of tin. A metal thread originally considered to be a silver alloy, appeared also to be tin. Similar threads were used to decorate villanovan pottery. This and the ringlets demonstrate that tin was available locally and employed for purposes other than the necessary alloying with copper. It implies that tin was probably obtained by exploiting the mineral resources in central Italy.\(^{291}\)

The presence of a small amount of silver in the alloys of some of the metal artefacts is associated by the authors to the exploitation of galena deposits from which lead was obtained.\(^{292}\) One ingot was analysed as lead with small amounts of silver, copper, antimony and tin. Considering the associated elements, the lead ingot could have derived from smelting local ores. The lead ores in central Italy contain varying amounts of silver and in my opinion, the metallurgical evidence from Gran Carro indicates that at least the raw material for extracting silver was known to the local communities. It does not, however, mean that silver was extracted nor that the cupellation technique was controlled.

Various ingots were analysed as copper alloys, a few of which contained tin. The presence of antimony in some of these ingots indicates that the ores contained this element as well. Antimony is also attested in other copper alloy artefacts from central Italy. Sulphidic copper ores which contain small quantities of antimony are reported from the mining district at Manciano which is located near the Lago di Bolsena. The elemental analyses of the copper alloys from Gran Carro, therefore, does not contradict the possibility of the exploitation of local resources. Giardino and Gigante suggest that the ingots from the mining region could have been transported to Gran Carro in order to be used in the local metal workshop for the production of copper alloy artefacts.\(^{293}\)

Moreover, the analyses of the ingots demonstrates that varying amounts of iron were present in the copper. One ingot and the casting residue contained a significant quantity of iron which indicates the smelting of sulphidic copper ores which are associated with iron. The exploitation of these ores in later centuries has been established by the analyses of the \textit{ramo secco} bars.\(^{294}\) However the metallurgical examination of samples from Gran Carro suggest


\(^{290}\) Giardino and Gigante 1995.

\(^{291}\) See also section 3.5.

\(^{292}\) Giardino and Gigante 1995, 321.

\(^{293}\) Giardino and Gigante 1995.

\(^{294}\) Burnett \textit{et alii} 1986.
that the elaborate technology for smelting these ores had been mastered at least by the early Iron Age.

Archaeometric investigation of the metals from Gran Carro imply that various ore deposits in central Italy were mined for the processing of a range of metals. The composition of the lead and copper goods are related to the composition of ore deposits in central Italy. This indicates that local resources were exploited which is also supported by the local economic characteristics of this lake settlement. The evidence from Gran Carro and from other early metalworking sites in central Italy such as Scarceta, Luni sul Mignone and Sorgenti della Nova, establishes that the local mineral resources were exploited prior to the arrival of foreign communities in Italy. During the 8th century BC, central Italy became incorporated in a trading network which encompassed nearly the whole Mediterranean and an intensification of the metalworking activities provided opportunities for economic growth. The Levantine and Greek intermediaries opened new markets, favouring increased exploitation of the local resources and stimulating the conditions for a cultural integration which is known as the Orientalising koinè.

3.6.6 Lago dell'Accesa

Lago dell'Accesa is located about 30 km to the east of Populonia on the border of an ore region with lead, silver, copper and iron-containing minerals. An early Iron Age settlement is recorded in the necropoleis. The evidence that establishes mining activities, is dated to the Archaic period and is found in the settlement of Macchia del Monte near the Lago dell'Accesa. It is a rural settlement which is situated adjacent to the Massa Marittima mining region (Fig. 58). The mines of Serrabottini and Fenice Capanne which were exploited in antiquity are located some hundred metres from the buildings. The settlement is considered to be one of the minor economic centres in the countryside around Vetulonia. It is dated to the 6th century BC and exhibits three phases. The pottery found inside and near the houses includes some bucchero but comprises mainly domestic wares similar to the wares excavated at Poggio Civitate. Within the wall structures some smelting slags were found while pieces of minerals were discovered in the central open area and within complex IV. According to Camporeale and others the economy of the settlement was based on mining the local ores in combination with subsistence activities. For instance, hunting, fishing and agriculture is illustrated by the implements that were found at the site. It is suggested that women were involved in domestic activities such as weaving and the production of ceramics. This is deduced from the number of ceramic weaving tools, such as spindle whorls and loom-weights, and the low degree of specialisation that was reflected in the pottery. The reconstruction that is presented by these authors, is one of part-time specialisation.

The settlement illustrates the living conditions of people who were involved in mining on a part-time basis. In ancient literary texts and in modern textbooks mining is primarily associated with slavery but nothing at the settlement of Maccia del Monte indicates that the inhabitants were servile. The buildings as well as the associated finds represent relatively comfortable conditions for some families who combined mining with a range of other activities for subsistence. Mining was probably a communal pursuit and the resources might actually not have been 296 See section 3.1 for the metallurgical data at Scarceta, Luni sul Mignone and Sorgenti della Nova.


298 Camporeale 1985, 126-78; van Dommelen forthcoming.

possessed by one or two families. In my opinion, circumstances at the settlement displays features of communal ownership of resources rather than of private propriety rights. This does not indicate that I deny the existence of social hierarchy but actual appropriation of resources is a slow process and probably developed differently at individual sites depending on the social-economic context. It is possible that the community at *Macchia del Monte* had to compensate individuals with tribute for the use of the mines and land but this remains hypothetical.\(^{300}\) The desertion of the settlement at Lago dell’Accesa and other sites in central Italy by the late 6th century BC implies increasing social-economic tensions in which the confiscation of resources played a role.

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3.6.7 *Populonia*

*Populonia* is located along the Tyrrenhenean coast, less than 20 km to the north-east of the island Elba. The necropoleis from various periods and the settlement features that were excavated at Populonia are illustrated in Figure 59.

The site is positioned in between the rich mineral deposits of the Campiglia area, the Colline Metallifere and the

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\(^{300}\) I refer to section 1.8 and the Epilogue for the slow evolution of appropriation of resources by individual families during state formation processes. Due to this gradual development various degrees of control over resources will have existed in central Italy during the period 800 to 500 BC.
deposits on Elba.\textsuperscript{301} Therefore, it had in theory access to a range of metal ores which could derive from various locations. In the ancient literature, Populonia is only associated with the smelting of ores from Elba.\textsuperscript{302} The settlement has long been accepted as one of the most important, early iron production centres in antiquity. Nonetheless, it should be noted that other metals were processed as well. The area immediately around Populonia is characterised by metal processing in general and not just by iron working. It is recorded that copper slags and several tons of litharge were found in the vicinity of the settlement.\textsuperscript{303} However the dating of the various metallurgical activities at Populonia is complicated since the enormous slag deposits around the site contain scarcely any stratigraphic information.\textsuperscript{304}

Fig. 59. Populonia, archaeological features in the immediate vicinity of the settlement.

The most detailed account of an archaeo-metallurgical context at Populonia is provided by Martelli who

\textsuperscript{301} Giardino 1995, 119-33.

\textsuperscript{302} Rasenna 1986, 122. Archaeo-metallurgical evidence demonstrates that ores from Elba were smelted in pre-Roman times on various locations on the mainland of Italy opposite the island Elba: Cucini Tizzoni and Tizzoni 1992, 47-51. These authors demonstrate that Elban ores were employed on the mainland throughout history.

\textsuperscript{303} d’Achiardi 1929, 399-402.

\textsuperscript{304} cf. Crew 1991 a.
excavated a building complex associated with the processing of metals (Fig. 60). This complex is interpreted as the remains of an industrial quarter and exhibits four phases. The first phase is dated to the late 6th century BC. Some tuyères and much iron slag together with *bucchero grigio*, were found in a pit which is interpreted as a smelting furnace for iron ores. The upper part of the furnace was missing but a cavity for tapping the smelting slags was preserved. The architectural remains of the second phase of the complex are presented as several connected rooms and resemble the layout of other Archaic houses in central Italy. This building complex establishes that iron was processed at Populonia from at least the 6th century BC. Considering the reports on comparable complexes nearby and the scale of the iron production at Populonia during the 6th and 5th centuries BC, it is likely that several of these buildings were located in this section of the town. This indicates nucleation of workshops.

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**Fig. 60. Populonia, building remains in industrial quarter.**

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305 Martelli 1981 a. See also Sperl 1981, 45-9; Cuccini Tizzoni and Tizzoni 1992, 47, 50. Figure 60 is based on the illustration on page 182 of *Etruria Mineraria*; Camporeale, 1985. This illustration presents the excavated building complex in colour according to each building phase represented. Thus all the phases are positioned on top of each other, each in a different colour. However, the reading of this illustration is almost impossible because the printing process has interfered with the individual colours. The orange walls, for example, turn into brown. For clarity Huib Waterbolk and I tried to disentangle the individual building phases of this complex. This exercise was complicated since a full publication of the excavations is missing. Therefore Figure 60 is a reconstruction based on the publications available. These publications are not always consistent especially not for the features dated to the 6th century BC: Martelli 1981 a and Cristofani and Martelli 1985. Consequently I would like to emphasise that Figure 60, particularly the reconstruction of the situation during the 6th century BC, is hypothetical and probably requires readjustments once the final publication has been printed. Also the dating of the furnaces is not definite though Cristofani and Martelli mention that these should be dated to the 6th and 5th century BC: Cristofani and Martelli 1985, 84.

306 Martelli 1981 a; Camporeale 1985, 84-8.

Metalworking remained an important economic activity in this region during the 5th century BC and later. In general, the advanced economic development of Populonia and the northern region of the Tyrrhenian coast during this period has been related to iron working. At Aleria on Corsica for instance, economic progress was recorded from the 5th to the 3rd centuries BC while the excavators indicate that iron working contributed to this development. Furthermore, it is reported that Elban iron ores were processed at Genoa and along the Gulf of Follonica during the pre-Roman period. Therefore it appears that these ores had become a commodity for external trade by at least the 5th century BC.

The period prior to the 6th and 5th centuries BC is less clear. Bartoloni records that Populonia had an open character during the early Iron Age. This is recorded by the imports from Sardinia and Phoenicia. Some Phoenician pottery is recognised in the necropoleis. Overseas contacts were stimulated by the available, rich mineral resources. Originally, iron production does not appear to have been important for the development of this district. Minto indicates that the processing of iron is scarcely documented in the 8th century BC but that it intensified significantly during the 7th century BC. The copper alloy to iron ratio was completely reversed during the Orientalising Period. Therefore it is possible that during the 8th century BC metals other than iron were processed at Populonia. According to Hartmann, the lack of early iron and Greek imports in the area around Populonia indicates that the Greek intermediaries were only interested in the ores. This deduction is primarily based on the hypothesis that Pithekoussai directed the iron industry in central Italy. However this hypothesis cannot be substantiated. I think that the scarcity of Greek imports implies rather that Greek intermediaries rarely visited this region during the 8th century BC. This brief account of the early development of Populonia shows that the evidence for metalworking in this region before the 6th century BC is circumstantial. However the immense quantity of slags found at the site establish that it had been an industrial site. These enormous amounts of slags were quantified and this figure was subsequently used by scholars to estimate the metallurgical output. The assessments indicate the significant scale of the iron production at Populonia. However the exercise is almost futile since the slags represent various periods or could be associated with different smelting processes. I will illustrate the speculative nature of these calculations by presenting two estimates which give a high and low figure. However even the low figure still represents the substantial extent of metalworking at the site and supports the view that various metal workshops existed simultaneously.

Wertime reports that copper and iron were worked at the site and that these activities produced 2 to 4 million tons of slags which are mainly dated from the 5th to 1st centuries BC. The smelting would have involved 4 million tons of ore and 1.5 to 3 million tons of charcoal. The production of this quantity of charcoal would have consumed 1.5 to 3 million acres of trees. It is mentioned that these raw materials generated 500,000 tons of iron. The

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309 Cucini Tizzoni and Tizzoni 1992, 47-51; Millanese 1996, 70-1.
313 Minto 1943, 70.
314 Gualtieri 1982, 222.
315 Hartmann 1985, 292.
316 The development of Populonia and its territory is for example, presented by: Fedeli 1983; Fedeli et alii 1993.
317 Wertime 1983, 450-2. Wertime and Wertime report for Populonia a slag heap of 2.2 km² which was produced during five centuries. This
hypothetical figures by Wertime imply that on average, about 1,000 tons of iron was produced per year.

Crew reports a fraction of this figure without underrating the importance of Populonia as a metallurgical centre. He readjusts the estimations because the high figure of Wertime and others does not quantify variables such as:
- the type of iron produced;
- the total amount of slag involved;
- the uncertainty of the period assessed, and
- the quantity of slags which derive from smelting copper ores.

He indicates, more-or-less, that the data on which the calculations are based are inadequate. According to Crew, a mean yearly production of 1 ton iron and 1 ton copper during the period 600 to 100 BC is more acceptable than the high estimate by Wertime. He reports that a mean yearly production of 2 tons of metal would still be significant for any early metalworking site. It still indicates the industrial scale of the metalworking activities at the site.

Both assessments are based on immense heaps of metallurgical slags. Whatever the exact yearly production, nucleation of workshops is probable from at least the 6th century BC. It is likely that the industrial quarter at Populonia whose remains were excavated, consisted of various metal workshops because small scale production would not have resulted in these quantities of metalworking debris.

3.6.8 Poggio Civitate

The buildings at Poggio Civitate and their context were introduced in the previous chapter. In addition to evidence for ceramic production, the site produced some archaeo-metallurgical information. Metalworking debris is scattered over the excavated areas though two concentrations are reported. At the north-western end of the plateau, an accumulation of slags was found associated with technical ceramics such as fragments of crucibles. A second concentration is located along the southern flank of the plateau. Excavations in and around the stoa-workshop (Figs. 36 and 37) have revealed bellows and crucible fragments together with large quantities of bone and antler in various stages of preparation. Thus, the primary evidence records a range of activities in and near this building. The western section of the stoa-workshop appears to have been employed for the manufacture of terracottas while the eastern half may have been used for the production of smaller objects in copper alloy and in bone, antler and ivory. Copper alloy smelting in this area is indicated by the various bellows and crucible fragments.

The technical ceramics at Poggio Civitate include tuyères for portable bellows which were used to generate the high temperatures necessary for metalworking. The tuyères had a flat bottom and are slightly vitrified. It is suggested that small portable braziers or furnaces were employed by the craftsmen for small-scale operations. The amount of slag would represent 4 million tons of ore, 2 million tons of slag and possibly 500,000 tons of smelted iron. The smelting of this quantity of ores would have consumed 1 million acres of consumed forest: Wertime and Wertime 1982, 135. See also: d’Achiardi 1929.

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320 See section 2.6.6.
323 Nielsen 1993, 31. Similar furnaces were experimentally used by Formigli and others to melt copper alloys in small crucibles but this did not have a satisfactory result: Formigli (a cura di) 1993, 109-22 (Resoconto dei gruppi di lavoro). In a previous publication on the impasto from Poggio Civitate, Bouloumié suggested that the objects which are now interpreted by Nielsen as small furnaces, were cooking wares: Bouloumié 1972; 1978.
Technical ceramics furthermore comprise a thick terracotta pipe, the end of which was heavily vitrified. This pipe was identified as a bellow pipe. Moreover, Nielsen mentions the existence of furnaces at Poggio Civitate. These furnaces are provisionally interpreted as furnaces for roasting ore. They are located about 300 m to the west of the Piano del Tesore on one of the natural terraces along the northern face of the hill. The remains are not well preserved since they were discovered close to the surface. The furnaces consist of a ring of stones with a diameter of approximately 1.5 m. The interior is plastered with a lining. A concentration of fine carbon may suggest the position of the opening of the furnace. Several slags were found in this area but no ores or technical ceramics.

An experimental reconstruction of an ancient metal workshop for casting small copper alloy artefacts was based on the technical ceramics from Poggio Civitate and on iconographic representations on Greek vases. The technical ceramics were made from a clay that was dug in the vicinity of Poggio Civitate. Crucibles, tuyères and small portable ovens were made according to the models that were excavated at the site. The size of the ancient crucibles for example indicates that they could not contain more than 200 g copper. This experiment was elaborated with the reconstruction of a vertical furnace as depicted on Greek vases. The furnaces on these vases are interpreted as being for smelting copper. The reconstructed furnace had a diameter of 55 cm and a height of 140 cm. During the experiment it was employed both as a forge for heating iron during smithing as well as a furnace for placing crucibles to alloy and smelt copper. It was established that it was inconvenient to smelt copper in this furnace because the conditions inside the kiln were difficult to control. The reconstructed furnace was, however, satisfactory as a forge. Neither were the experiments with the small portable furnaces successful since it was difficult to position both the crucible and the tuyères. This could suggest that the ceramic vessels interpreted as small furnaces or ovens for working copper alloys are not related to the processing of metals but may have had another function. Similar ceramic ovens are, for instance, recorded and used for the granulation technique.

Some of the metallurgical debris from Poggio Civitate was examined in detail. Several slags enclosed green and blue specks which indicate that copper was smelted at the site. Moreover, the slags contained a high amount of iron which could have resulted from smelting iron-rich, copper-sulphide ores. A prill of copper was entrapped in a slag adhering to a crucible. This prill did not contain any tin which means that copper was smelted in the crucible but not a copper-tin alloy. The slags found near the furnace include smithing slags while one slag may indicate the casting or smelting of copper. It is reported that one of the copper smelting slags contained pieces of metallic iron, some of which were previously smithed and partially carburised. The metallic iron in the slag is difficult to explain in metallurgical terms. Warden suggests that it may be an experiment to recycle iron. He implies that at

325 Nielsen 1993, 34.
326 The furnaces are published in an interim report and still require metallurgical examination and interpretation. Warden reports that the slags which are associated with the furnaces, have a high iron content: Warden 1993, 42.
327 Formigli (a cura di) 1993, 109-22 (Resoconto dei gruppi di lavoro).
328 Formigli (a cura di) 1993, 109-22 (Resoconto dei gruppi di lavoro).
331 Scott describes a prill as follows: 'In the extraction of copper from primitive smelts, the metal is produced as small droplets or particles in a slagggy matrix. These small metallic particles are called prills and were often extracted by breaking up the smelted product and sorting the metal. In crucible processes, prills are small droplets of metal adhering to the crucible lining': Scott 1991, 143.
332 Warden 1993, 43.
Poggio Civitate an attempt was made to process iron locally by trying to extract it from iron-rich, copper slags or by trying to recycle iron scrap. However iron was normally recycled by resmithering and the addition of iron scrap in a copper smelt does not make sense to a contemporary metalworker unless it was introduced to increase the carbon content of the iron. After smelting the copper, the carburised iron might have been retrieved from the slag. All these possible explanations for the presence of metallic iron in a copper smelting slag remain highly hypothetical.

The charcoal at Poggio Civitate was derived from a red-oak, probably a *Quercus cerris* which is the most common type of oak in Italy. It is, therefore, likely that the charcoal necessary for the metalworking came from local sources.

The copper ores that may have been processed at or near Poggio Civitate, could derive from local sources. The site is situated on the eastern edge of the Colline Metallifere, not far from rich deposits of copper, silver and lead. Copper ores, for instance, are found in its vicinity and may have been mined at the Crevole lode at Vescovado di Murlo which is about 1 km from Poggio Civitate. Iron was probably imported as bar iron since the nearest iron ore deposits are located about 30 km from the site. Another possibility is that it was extracted from the iron-rich slags that were produced during the smelting of copper ores. The report on the metallurgical debris from Poggio Civitate establishes that metals were worked adjacent to the main building. However the preliminary character of the publications hampers a full account of the metalworking activities at the site and it remains unclear whether the ore deposits located in its vicinity were actually processed at or near the settlement.

I have presented the evidence for the manufacture of ceramics at Poggio Civitate in the previous chapter while the processing of metals is discussed in this section. In addition, an early school of carvers of materials such as bone, antler and ivory, is recorded at the site from approximately 650 BC on the basis of raw materials, unfinished products and finished artefacts. Over 50 pieces worked on one or more sides, were found along the southern flank of the Piano del Tesoro at Poggio Civitate. Within the trenches at the site, more than 400 fragments of ivory, bone and antler were discovered from 1978 to 1980. One ivory block had rasp marks on all four sides and can be considered to be an unfinished product. Nielsen argues that the artisan who worked at Poggio Civitate was not an itinerant craftsman because otherwise the large number of unworked pieces cannot be explained since a travelling artisan might be expected to take his materials with him. Nielsen furthermore suggests that there was a strong correlation between the manufacture of small, copper alloy artefacts and the documented carving of materials such as bone, antler and ivory. A similar relationship between metalworking and carving hard substances was noticed at other sites such as *Pithekoussai*, *Satricum* and *Caere*. This sustains the opinion that at several settlements various materials were processed near to each other, possibly on one location during the 7th century BC. Thus, the industrial debris from Poggio Civitate supports the claim that from about 650 BC various materials were worked at the site. As such, it can be described as an early centre for craft specialisation. A concentration of refuse is located in and near the monumental stoa-workshop. Other primary evidence for industrial activities is scattered about the site and implies that workshop activities were not restricted to the Piano del Tesoro. However a full assessment of these
activities remains problematical. So far one can deduce that the artisans who worked on the *Piano del Tesoro* were primarily involved in the manufacture of status markers though the local pottery production included cooking wares and other ordinary wares. The processing of ores at the site requires further verification but would change the meaning of the site significantly. The excavators have until recently focussed their attention on the monumental structures of the *Piano del Tesoro* but if the processing of local ores at the site can be substantiated than it would be interesting to examine the settlement features around this plateau as well as potential traces prior to 650 BC.

3.6.9 *Marzabotto*

The metallurgical evidence from Marzabotto is as important as the evidence for the pottery workshops presented in the previous chapter. There were several metal workshops which probably functioned simultaneously. This means nucleation of workshops for metalworking within the urban centre from the late 6th century BC. A similar account was given for the pottery workshops in section 2.6.7. Figure 38 shows five locations which are associated with metalworking debris. I will present the primary industrial evidence discovered at these locations individually, in order to support the argument for metalworking activity at the site.

The first workshop to be introduced is located in *Regio V, Insula 5* (Fig. 61).

The earliest traces of this workshop are dated to the second half of the 6th century BC. Therefore the metallurgical activities at this location predate the rectangular layout of the town. The 5th century BC workshop is incompletely preserved. It can be entered from the main street A. Immediately to the right there are two rooms with irregular pits. Room 3 to the east, contained a circular furnace with a combustion and firing chamber. Both chambers were separated by a raised oven floor with ventilation holes.

The remains of this metal workshop consist of various rooms, a casting room on account of the debris that is presented next, and basins and canals for water supply and drainage. The pottery associated with the 5th century BC workshop, incorporates local wares and some imported vessels. One local *bucchero* bowl is inscribed in Etruscan with *I am of Venel*, a name which is common in Etruria and the Padana. The workshop finds include copper alloys droplets, sawn bones, tap slags with copper alloy flecks, moulds, tools and copper alloy artefacts. The debris demonstrates that copper alloys were processed and cast in this workshop. The artefacts include statuettes, large nails and fibulae of which one still required finishing. The sawn bones affirm once more the close relation between metallurgy and bone-working. One of the tools is a small black serpentine slab with a series of holes with different diameters ranging from 6 to 16 mm. It is probably an instrument for making metal wires. This tool is marked and inscribed in Etruscan with various lines, one of which is interpreted as *I am of Sualu*.

The most interesting feature are the moulds which demonstrate the range of artefacts manufactured in this

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341 The interpretation of this furnace varies since it mirrors the design of a pottery kiln while the industrial debris is related to metalworking: Sassatelli 1990, 69-74; Zimmer 1990, 72. The exact function of this furnace within a metalworking context remains unclear. Sassatelli suggests that the furnace might have been employed for roasting ores or for refining the copper bars by extracting the possible excess of iron in the bars: Sassatelli 1990, 70; 1994, 179. Roasting ores implies that copper ores were smelted in the town which would be remarkable because ores are preferably processed nearby mines.


343 Sassatelli 1994, 180-5.
These moulds were employed for casting small tools, fibulae, decorative copper alloy artefacts such as attachments for vessels and possibly components of helmets. Some mould fragments establish that in addition to small artefacts, monumental statues were also cast in this workshop. The fragments are from a mould of a head and possibly a limb. Around 500 BC they were used to cast a statue of approximately 90 to 100 cm height. This is important since it establishes that monumental copper alloy statues were made in central Italy by 500 BC. Moreover, it provides evidence of casting of large statues which could be achieved in a local workshop primarily involved in the manufacture of smaller copper alloy artefacts.

Fig. 61. Marzabotto, Regio V, Insula 5, remains of metalworkshop.

Another mould fragment that is associated with this workshop is interpreted as a negative from a ramo secco bar which was employed for casting and marking copper alloy bars. These bars are identified as currency bars, are well known in the Padana region and represent a pre-monetary exchange system in a rudimentary market.

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The moulds were made from a refractory clay. At least one was described as composed of two fabrics. The outer layer consisted of a red fabric while the interior of the mould was made from a fine grey clay. It could preserve surface detail of the wax model though the grey colour is typical for the cire perdue method: Zimmer 1990, 72, 201.

Sassatelli 1990, 72-4; 1994, 179.
The presence at Marzabotto of a mould for casting currency bars is remarkable for various reasons. First it marks the prominent role of this site within the regional economy. Metals were essential for exchange activities and the casting of the pre-monetary bars points to the market function of Marzabotto. Therefore it supports the notion that the site functioned as a centre where transfer trade in commodities was organised. Moreover, the presence of this mould within a workshop context verifies the primary role of workshops within an elementary market system.

Fig. 62. Marzabotto, Regio IV, Insula 1, living quarters and metalworkshops.

\(^{346}\) cf. Burnett et alii 1986; Rasenna 1986, 141-3. See also chapter IV.
The excavated finds from the workshops in Regio V, Insula 5 are exceptional. For example, Zimmer who studied the remains of foundries in Greece, includes this workshop because it is the only example where casting monumental statues could be associated with a permanent workshop. In Greece, the casting of these statues is related to temporary arrangements. The range of artefacts produced in this workshop at Marzabotto is significant. It was involved in the manufacture of ordinary metal artefacts such as tools and in high quality production. This could reflect a division in tasks between a master and his assistants.

The second location at Marzabotto where metalworking has been reported is situated in Regio III, Insula 4. The architectural remains are slight but metallurgical debris records industrial activities during the 6th century BC. De Maria describes some walls, canals, and a pit which was filled with carbon and numerous slags. He implies that there was a metal workshop in this section of the town prior to the rectangular layout of Marzabotto. Some metres to the west of the pit, traces were excavated which were interpreted as a hut of 3.5 by 2.8 m. The account does not give details of the slags and, therefore, it is uncertain if iron, copper alloys or both metals were processed here.

The third metalworking site is located in Regio IV, Insula 1 and is dated to the 5th century BC (Fig. 62). The excavated area of Insula 1 is about 145 m long and 35 m wide and revealed 7 or 8 houses some of which contained metallurgical debris. The buildings are spacious but of various dimensions and at least four have an open courtyard that is generally cruciform. The courtyard is entered by a corridor that opens to the street. The workshop activities were located along the street and are identified with buildings 4, 5 and 6. This is established by the significant amounts of slags, copper alloy ingots, carbon and other residues that were discovered in these complexes. In building 4, a large stone with a width of 1.2 m had been shaped into a rectangular block and was interpreted as an anvil. Many iron slags were found during the excavation of this house and it is probable that the front part of this building was used as a smithy. Building 6 produced a pair of iron tongs which is a typical tool for smithing as well as copper alloy scrap metal probably intended for resmelting. Furthermore, traces of intense heat in specific parts on the floor of building 6 demonstrate pyrotechnological activities. Clay vessels described as thick, shallow and with a nozzle may have been employed for smelting copper alloys.

The findings demonstrate that iron and copper alloys were worked in this section of the town. This means that by the 5th century BC both metals could still be processed in one workshop. An interesting feature of buildings 4, 5 and 6 is that they combine metalworking activities with living quarters. An internal division between these functions is convenient because the manufactured goods were exchanged along the street while the nuisance caused by fire and smoke could be limited to some extent. An interpretation of this arrangement could be that there was a formal division between those who owned this complex and lived in it and their dependants who had to work and live in the front side. Such a separation is known from later centuries and the individual buildings are large

348 De Maria et alii 1978, 72-5.
349 Sassatelli 1994, 71-89; 1989, 62; Mansuelli 1963; Bouloumié 1976. Figure 62 is based on: Sassatelli 1994, 72, Fig. 7 and Mansuelli 1963. Building 3 is not well defined and could belong to either building 4 or 2. The entrances of building 1 and 4 are uncertain as well as the identification of an anvil in building 4.
350 Bouloumié who examined the pottery from building 3, Regio IV, Insula 1, reports numerous slags and ceramic fragments that could derive from furnaces or ovens. The slags accompanied the pottery that derived from this context: Bouloumié 1976, 137-40. Building 3 might actually be part of complex 4.
351 Mansuelli 1963, 62; Bouloumié 1976, 97, n. 4.
352 Sassatelli 1989, 62.
enough to house more than one family. However when I consider the evidence from the various workshops at Marzabotto in general, it seems to me more likely that within each complex a family lived and worked while some assistants may have helped out. The layout of these buildings could reflect conditions that combine characteristics of both a family concern and a master-assistant workshop.354

Fig. 63. Marzabotto, Regio V, Insula 3, living quarters and metalworkshop.

354 The distinctions between types of workshops are discussed in section 2.1. A general assessment of the workshops at Marzabotto is presented further down.
The fourth site with a concentration of metalworking debris at Marzabotto is located in Regio V, Insula 3 (Fig. 63). Copper alloys were worked in building complex VI where moulds, carbon, slags and casting refuse were found in the courtyard, in area VI E. A hearth was identified in the middle of this yard by an accumulation of ash, carbon and industrial debris. Some of the moulds were probably used to cast decorative artefacts. Furthermore, rooms VI A and A' contained metalworking refuse such as slags and copper alloy droplets. These rooms were also used for household activities such as weaving and carving bone. The pottery found in this complex dates from the first quarter of the 5th century BC.

The metal workshop in Regio V, Insula 3 measures 20.6 by 16.8 m and is not well preserved at the south end. It is not located along a major road as are most of the other metal workshops and, therefore, its position is less convenient for the direct exchange of manufactured goods. The activities in complex VI involve metalworking, weaving and carving bone and may indicate a family workshop. On the other hand Pairault Massa implies a master workshop because she mentions a bronze caster and his assistants. It is also significant that the artisans who worked in this building could probably read and write. Furthermore, the workshop contained quite a lot of imported Attic vessels and the conditions in which these craftsmen lived and worked can be described as comfortable.

Pairault Massa compares the buildings shown in Figure 63 with those in Regio IV (Fig. 62) and suggests that a functional division between living quarters and workshop activities can be detected in Regio IV, Insula 1 as well as in Regio V, Insula 3. The difference is that in Regio V the functions appear to be formally separated by a dividing wall in the middle of the insula. This hypothesis is interesting but hard to substantiate. A detailed account of the associated finds per room and complex is required in order to distinguish use and function of sections of buildings and these accounts are scarcely available for Marzabotto. In addition, it is not certain whether or not there were passages between the various buildings that were excavated in this insula. Moreover, the workshop in complex VI is not accompanied by other workshops as were the workshops in Regio IV, Insula 1. In my opinion, the excavations at Marzabotto show that in the majority of the building complexes, working and living quarters were combined. The industrial debris is in most cases accompanied by household ceramics. A strict separation of functions seems to me too rigid until more details on context and associated finds prove otherwise.

The fifth metalworking site is located in Regio V, Insula 4 (Fig. 38). So far I have been unable to find detailed information for this workshop except that the earliest traces of metalworking are dated to the middle of the 6th century BC. During this period the settlement consisted mainly of huts. The casting of copper alloys continued into the 5th century BC and a metal workshop was incorporated into the rectangular layout of Marzabotto.

The primary evidence on metallurgical activities at Marzabotto confirms the relationship between the processing of iron and copper alloys as well as the association of metal-working and carving hard substances such as bone and

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355 Sassatelli 1994, 137-54; Pairault Massa and Vallet 1978. Figure 62 is based on both publications.

356 Pairault Massa suggests that zone II was also used for industrial activities: Pairault Massa and Vallet 1978, 139. The presented data are, however, not convincing.

357 Pairault Massa 1994, 139.

358 Pairault Massa 1994, 140.

359 Pairault Massa 1994, 137.

360 Brizio 1889; Sassatelli 1994, 155-67. Mansuelli denotes that Regio V, Insula 4 was marked by Brizio as Insulae VII and VIII: Mansuelli 1963, 45-6, n.2.
horn. These relations were encountered at other sites in previous centuries but the evidence from Marzabotto demonstrates that various materials could still be manipulated in one complex during the 5th century BC.

The findings also imply that the various workshops at Marzabotto were directly involved in trade. This suggestion is supported by the mould for casting Ramo Secco bars in the metal workshop of Regio V, Insula 5 which shows the role of workshops in the marketing of commodities. Coins of small denominations were not available at the site, nor anywhere else in central Italy during this period. I think that this implies that a mature market mechanism did not yet exist. Moreover, a public area or forum has, so far, not been definitely identified for Marzabotto. I, therefore, suggest that market exchange at Marzabotto was rudimentary though the existence of various metal workshops in the urban centre implies that market conditions were known. The mechanisms of market exchange seem to be accepted but the transfer of commodities by coins was not established. This indicates that within the sequence of commoditisation introduced in section 1.7, goods were transferred by quantitative evaluation. In the next chapter I will try to establish how quantitative exchange proceeded at Marzabotto.

The evidence for the metal industry at Marzabotto demonstrates that there were several locations where metals were worked during the second half of the 6th century BC. This establishes that prior to the rectangular layout of the town, some families were involved in industrial activities. These activities persisted on the same site when huts were replaced by buildings and this feature affirms continuity in family activities. Thus the original functions of various quarters were incorporated in the new design of the town. During the urban reorganisation of the late 6th, early 5th centuries BC, the workshop facilities increased in size and this could mark a transition from family to master workshops but the distinction may not have been as rigid. The metal workshop in Regio V, Insula 3 for example, contained evidence for additional pursuits such as weaving and carving bone. This implies communal activities of a family within specific areas of building VI. On the other hand, the metal workshop in Regio V, Insula 5 produced a range of metal artefacts including common items as well as monumental statues which could indicate a master-assistant arrangement. Furthermore, the association of industrial debris with household ceramics makes it hard to separate habitation from industrial areas. However the distribution of finds as well as the layout of buildings 4, 5 and 6 in Regio IV, Insula 1 suggests that the main habitation area is located at the rear of these buildings. This division could be interpreted in terms of social differentiation but this aspect remains difficult to assess for Marzabotto. The artisan families may have belonged to a middle class but the status of their assistants as unfree or free dependants is open for debate.

### 3.7 Conclusion

The most basic mechanism for dividing labour is assigning specific tasks to either males or females. Examination of ethnographic information established that mining, smelting and metalworking were activities chiefly assigned to men. These pursuits were difficult to combine with household tasks as is hunting. As such metalworking can be compared to pottery production that is characterised by a reallocation to males with increasing craft specialisation. Metallurgical activities are from the start, primarily male tasks. Smelting and smithing were in all circumstances acknowledged as technologically complex. Open air mining and the pretreatment of ores may be a communal pursuit involving both men and women but smelting and smithing were male activities. For example, Clark records

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361 See chapter IV.
363 Brizzolara 1980, 108. It is reported that the social structure of the town does not reflect an oligarchy. See also section 2.6.7.
364 Murdock and Provost conclude that in about 98% of the societies that were recorded, the activities mining (for 93.7% of the societies), smelting (for 100%) and metalworking (for 99.8%), were allocated to men: Murdock and Provost 1973, 207.
that mining and the pretreatment of ores was a family task in Central Africa during the early stages of mining copper ores. The last process in which women were involved was the roasting of ores. Subsequent stages, smelting and smithing, were male tasks. Nevertheless, in most cases the mining and processing of minerals would have been a male enterprise especially when the exploitation of the ore deposits intensified. For central Italy I think that this intensification was a slow process that varied from site to site. This opinion deviates slightly from a hypothesis that was formulated by Warden. He suggests a division in stages for the increase in mining activities. According to his hypothesis, mining was characterised by incipient, possibly seasonal exploitation prior to 750 BC. Specialised mineral production increased from 750 to 550 BC while after 550 BC it became an intensive, industrial activity. I consider his hypothesis in essence valid particularly for the most important mining regions. Nevertheless, the primary evidence on metalworking in central Italy present a more miscellaneous development. The industrial debris from the huts at Acquarossa shows that various families were involved in part time metallurgical activities during the late 8th and early 7th centuries BC. This is also observed at the 6th century BC settlement at Lago dell'Accesa. For Acquarossa one can deduce from the building activities from about 640 BC, that exploitation of the nearby resources increased and thus supported the economic prosperity of the site. It remains, however, impossible to assess the nature of this progress because workshops or industrial quarters were not excavated. To me, it seems likely that the former part-time occupation was intensified though full-time involvement is doubtful. The establishment of an industrial quarter for the processing of ores outside the original urban centre of Populonia during the 6th century BC, demonstrates how metalworking advanced to a full-time occupation in the most important mining region of central Italy. The above assessment of the economic activities at Acquarossa, the settlement at Lago dell'Accesa and the industrial quarter at Populonia, presents variations in social-economic conditions that prevailed in central Italy during the 7th and 6th centuries BC. There were urban centres with developed modes of production as well as settlements with an antiquated production system. This difference is mirrored by varied and distinct social structures. The social-economic conditions in central Italy were more diverse during the Archaic period than is implied by a mere classification in rulers and those who were ruled. The variety may be related to the degree to which individual appropriation of resources was feasible. In section 1.8, I presented information indicating that the transfer of control of resources from community to individual is a slow process during early state formation. I believe that especially at those sites where mineral resources were exploited by a community prior to the social stratification process of the 7th century BC, private ownership may have developed less than at those sites where social differentiation advanced as is recorded by the necropoleis of the primary sites in central Italy. The communal mining of local minerals at Acquarossa is probable from the late 8th century BC. The exploitation continued to increase during the following century but this economic intensification seems to be accompanied by a slow development of distinct social classes. It appears that the economic growth was substantial and could accommodate the material needs of most of the inhabitants. This probably affected the political significance of Acquarossa. In my opinion it is revealing that mining sites as Acquarossa and the settlement at Lago dell'Accesa did not last into the 5th century BC suggesting that the social-economic conditions that emerged at these sites could no longer be maintained. The disappearance may be the result of a relocation of mining activities. An alternative cause could be that the social-economic arrangements at these sites could no longer be tolerated by the primary centres of central Italy.

The account of the development of mining activities in central Italy is reflected in the evolution of the craft of metalworking. Metallurgical debris from Late Bronze Age - early Iron Age sites such Gran Carro, Scariceta, Elceto, Sorgenti della Nova and Luni sul Mignone, indicates that metalworking was a part-time activity of resident smiths.

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366 Warden 1984, 360.

These smiths operated within a regional or interregional network for the exchange of raw metals which were locally exploited. During the 8th century BC the production at local metal workshops was transformed significantly. An increase in output is recorded by the metallurgical examination of 8th century BC fibulae which began to be produced in series. However the major change in the craft of metalworking is recorded by a general shift from copper alloy to iron tools and weapons. An intermediate stage in this transition is reflected by an increase in the number of iron knives. Snodgrass reports that it was in knife blades that iron may have found its earliest acceptance for functional use in the Aegean. This could also apply to central Italy during the late 9th - early 8th centuries BC. Gualtieri notes that iron knives are the first objects to be made and that they appear to be numerous at the major sites during the early Iron Age. In central Italy this stage is illustrated by Osteria dell'Osa where from 770 BC all knives were made of iron while during the preceding period, iron knives had been rare and appear to have been part of exceptional tombs. This means that the transitional period towards a fully fledged Iron Age in Latium Vetus corresponds to the 8th century BC. Early production sites in central Italy where iron was worked are rarely recorded and this leads to speculation about the transmission of the necessary technology. It is possible that the processing of iron took place at certain sites in central Italy prior to the 8th century BC but it did not become widely adopted during this period. Local manufacture of iron in central Italy is indicated by its rapid adoption during the 8th and 7th centuries BC. The development of iron technology in central Italy can be compared with similar events elsewhere in the Mediterranean. Pleiner, for example, distinguishes two periods in Greece: the proto-'Iron Age' from the 12th to 8th centuries BC and the early 'Iron Age' from the 8th to the beginning of the 5th centuries BC. The proto-'Iron Age' is characterised by a gradual increase in the number of iron objects. Individual tombs steadily became equipped more extensively with iron swords, knives and tools. The 8th century BC represents a critical period which brought many improvements. Iron working intensified and local blacksmiths produced increasing numbers of iron artefacts. Smithies were equipped with specialist tools while metal smiths mastered quenching techniques and the use of steel for manufacturing implements. This is reflected in a well known passage in the Odysse when Homer comments on the blinding of Polyphememos:

'Even so, we took the fiery-pointed stake and whirled it around in his eye, and the blood flowed around the heated thing. And his eyelids wholly and his brows round about did the flames singe as the eyeball burned, and its root crackled in the fire. And as when the smith dips a great axe or an adze in cold water amid loud hissing to temper it - for therefrom comes the strength of iron - even so did his eye hiss round the stake of olive wood.'

According to Pleiner, crafts without iron tools, agriculture without iron harvesting implements and woodwork without iron axes were no longer imaginable in Greece from the 8th and 7th centuries BC. The stage of specialised blacksmith work starts in the 5th century BC. There were several branches that produced different metal artefacts,
such as armourers, swordsmiths, cutlers and hoe-makers.\textsuperscript{375} 

When this account of the development of iron production in Greece is compared with the situation in Italy, than it is remarkable that in both areas the 8th century BC is crucial in quantitative terms. Moreover, the evidence from \textit{Satricum} corresponds favourably with Pleiners' description of the 8th to 6th centuries BC because at \textit{Satricum} a large variety of iron objects is recorded for this period (Figs. 50 to 56). As such, these artefacts represent a range of iron objects which were available in central Italy during these centuries. The initial stages in the use of iron in central Italy can be examined by the archaeological evidence of the Quattro Fontanili cemetery at Veii. The iron artefacts excavated in this necropolis indicates that there was a gradual increase in iron artefacts from 800 BC with a marked development from 760 to 720 BC. The number of iron objects as well as the variety of types increased sharply.\textsuperscript{376} Hartmann reports that at Vulci this intensification occurred slightly later, between 720 and 690 BC.\textsuperscript{377} In \textit{Latium Vetus}, the use of iron increased gradually during the 8th century BC while the 7th century BC displays a marked upsurge in its adoption. I, therefore, conclude that in Etruria as well as in \textit{Latium Vetus}, iron had become the most important metal for tools and weapons by the 7th century BC. This stage may have occurred somewhat earlier in Etruria but the evidence from Osteria dell'Osa indicates that in this respect the difference between both regions is minimal.

The metallographic analyses presented in this chapter, record the control of characteristic physical properties of iron by the smith. These examinations correspond with results from similar studies executed elsewhere in Europe. During the early stages of iron technology, different types of iron were used as was reported for the 7th century BC iron tools from \textit{Satricum}.\textsuperscript{378} The metallographic studies from other sites in central Italy confirm this differentiated use of iron while evidence for quenching is still scarce.\textsuperscript{379} Sofar only an axe from Vetulonia was quenched and thus intentionally hardened.\textsuperscript{380} 

The late 8th and early 7th centuries BC record the growth of other metalworking techniques besides ironworking, such as the repoussé and granulation technique. These decorative techniques are associated with the manufacture of status markers. Immigrant craftsmen from the Levant were probably responsible for the transfer of technological knowledge.\textsuperscript{381} The local adoption of these metalworking techniques helped in the spread of craft specialisation and was encouraged by the demands of aspiring members of the local communities. This corresponds with the account of the specialisation process of the ceramic craft which was reinforced by a growing demand for highly crafted artefacts. Nevertheless, the metal craft was basically transformed by iron which was originally a precious metal but in time, gradually became a base metal. The almost complete replacement of copper alloy tools and weapons by iron items within about 100 to 150 years signifies a major industrial event. During this period, the resmthing of scrap iron could not fulfil the increased demand because there was no stock in the form of iron hoards. Therefore the smelting of iron ores had to be intensified. In section 3.4, I have specified that smelting was a labour intensive enterprise and thus, the transition from copper alloy to iron will have stimulated the economic evolution of this region that possessed so many ore deposits. The increase in mining and smelting activities was not presented as an arranged, preconceived commercial pursuit but rather as an inherent process which materialised in settlements.

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\textsuperscript{375} Pleiner 1969, 30-1. 
\textsuperscript{376} Hartmann 1982, 59-61. 
\textsuperscript{377} Hartmann 1982, 102. 
\textsuperscript{378} cf. Pleiner 1980, 388. See section 3.6.2 for an account of the metallurgical examination of tools from \textit{Satricum}. 
\textsuperscript{379} Follo \textit{et alii} 1988; Panseri and Leoni 1960; 1961. 
\textsuperscript{380} Panseri and Leoni 1960. The axe from Vetulonia is typologically comparable with an axe from \textit{Satricum} (fig. 52, no. 52). 
\textsuperscript{381} See sections 3.1 and 3.2. In Addition, I refer to: Strøm 1971, 201-16, 212 and Markoe 1992, 78-81.
located near mineral deposits such as Acquarossa, Populonia and the settlement at Lago dell’Accesa. Once there was a reservoir of iron tools and weapons which could be reused, the devaluation of iron became inevitable. Nevertheless, this account is subject to other considerations such as the additional demand generated by an increasing population. From the presence of iron artefacts in rich tombs, it is deduced that iron was still highly regarded in central Italy during the first half of the 7th century BC. A decrease in value must have occurred during the late 7th and 6th centuries BC. A similar devaluation of iron from precious to base metal was recorded for other regions of the Mediterranean. Decrease in value is also suggested for other categories of artefacts such as certain pottery wares and copper alloy bowls and basins. It appears that the intensification of production resulted in circumstances which led to the standardisation of whole categories of artefacts. The most explicit condition which caused an increase in output and standardisation is the workshop which employed a number of people. Expanding output would have promoted devaluation which was aggravated once the initial extra demand due to a general economic progress, started to decline. The advance of the workshop mode of production in central Italy is demonstrated in this chapter though specific conditions varied from site to site. Nucleation of workshops is recorded at Marzabotto and Populonia. The existence of several metalworking shops is probable for Ceare during the 7th and 6th centuries BC while at other sites, such as Satricum and Poggio Civitate the reconstruction of more than one workshop is not possible.

The development of the iron industry in central Italy cannot be separated from the production of artefacts made from copper alloys. It is generally accepted that a separation of copper/bronze-workers and iron-smiths had not yet occurred during the Orientalising Period. The combined processing of copper alloys and iron in the local metal workshop which may occupy various smiths, accounts for the close typological parallels between objects made from either metals. Moreover, there are several sites such as Pithekoussai, Poggio Civitate and Acquarossa, where working of both copper alloys and iron is recorded simultaneously. Even on Elba and at Populonia copper and iron slags are found side by side. This implies that for an assessment of the output of a metal workshop, it is necessary to incorporate the copper alloy artefacts. At the Archaic industrial quarter of Populonia and at Marzabotto it is possible to perceive a separation between both metals. Iron and copper alloys may have been worked in different workshops at the major sites though detailed metallurgical analyses of the debris found in the metal workshops, is absent. An examination of the slags in the various workshops at Marzabotto could verify this separation in the processing of both metals. For example, the workshop in Regio V, Insula 5 appears to be merely involved in the working of copper alloys though debris from the workshops in Regio IV, Insula 1 records a combined processing of iron and copper alloys. At smaller settlements it is probable that copper and iron were still manipulated in one establishment during the 6th and 5th centuries BC.

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383 Crew 1991 a, 113-4; Fedeli 1983, 177; Sperl 1985, 49.