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THE ROLE AND STATUS
OF
THE BRONZE AGE SMITH AND THE ORGANISATION
OF
METALLURGY

by

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ABSTRACT

THE ROLE AND STATUS OF THE BRONZE AGE SMITH AND THE ORGANISATION OF METALLURGY

by Diane Williamson

The aim of this study is to explore the role and social standing of the smith in Bronze Age communities and consider the possible forms of organisation of the craft during this period. The approach employed seeks to illuminate the findings of archaeology with the results of anthropological theory and research. It has been to draw on examples of metalworking in the ethnographic record and, from these descriptions and accounts, including in addition, reference to literary and mythological evidence, to formulate hypotheses about the smith which can be checked against archaeological data.

The study is organised into an introduction, six chapters and a conclusion. The separate chapters examine: mining and smelting, ore supply, manufacturing technology, the status of the smith, trade and exchange and bronze metalwork.

The process of metal production is broken down into its essential technical stages - from ore extraction and smelting through to the fabrication of objects, their trade and exchange and social meaning. Each of these stages is examined as a social, political and ritual process. The results of this underline the need for and importance of a typology of Bronze Age craftsmen and of the different forms of society of which they were a part.



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INTRODUCTION

This study concerns the role and status of the Bronze Age smith and the organisation of metallurgy in the Bronze Age. The aim is to recover from the evidence of archaeology the social arrangements of bronze production, to see more clearly the work of craftsmen themselves, and to understand their place within the communities in which they lived.

The archaeological record on this topic is a varied one. One of the main categories of evidence is the bronze metalwork itself. It exists in a spectrum of forms ranging from tools to weapons and more ornamental prestige objects. In some areas we have examples of a developed mining and extractive technology. There is evidence of metallurgical technology in the form of furnaces, fragments of tuyères, crucibles and moulds. There are many indications of exchange systems, of inter-regional trade with evidence of the transport and shipment of copper ingots. Some of this evidence exists in the form of written texts or tablets.

An examination of this material, even using the most sophisticated techniques of modern archaeology, can only take us so far. In order to move the discussion forward to understand the different types of metal industry that could have existed and the various forms of craft organisation within which the smiths worked, concepts and models derived from anthropology will be used. This study illustrates the ways in which the ethnographic record of metal production can illuminate the evidence of archaeology extending powerfully the analytical resources of the subject.

Archaeology owes a lot to anthropology! The use of the present as a guide to the past is not a recent area of study, however. Père Lafitau wrote in his 'Moeurs des

Sauvages Amériquains Comparee aux Moeurs des Premier Temps', published in 1742, that:

I was not content with knowing the nature of the savages and with learning their customs and practices, I sought to find in these practices and customs vestiges of the most remote antiquity (cited Daniel, 1981:38).

In the 19th century variability in the contemporary world was seen as representing different stages in the development of human society. Concern at this time with ideas of evolution and progress led to the belief that some societies were more advanced than others. Evolutionists held that societies passed through different stages and contemporary 'primitive' cultures closely resembled the early stages through which their own culture had evolved. The dramatic advances in the theory of evolution in the biological sciences associated with Darwin lent weight to the argument that the same evolutionary approach could be applied to the history of human society. This way of thinking influenced a great deal of social and political theory and is inseparable from the development of European societies in the period of colonial expansion, especially during the industrial period from the end of the eighteenth century (Burrow, 1966).

It was a way of thinking which inspired much anthropological work in the nineteenth century where too often ethnographic observations were interpreted in the light of evolutionary assumptions. The tradition is still evident in the work of Emile Durkheim who, in his analysis of the religious life of the Australian aborigines, pointed out that since they were the simplest society technologically speaking, they must have the simplest form of religion and gave us evidence of what our own past may have been like (1954). It was not brought to an end until the late inter-war period of the twentieth century, when ethnographic research found a surer scientific footing with Malinowski, Radcliffe-Brown and

Evans Pritchard (Beattie, 1964). Stripped of evolutionary assumptions the ethnographic record is a rich source of data, not only for anthropologists but also for archaeologists, especially prehistorians.

Archaeologists have frequently turned to the ethnographic record because it supplies reasons why things happened which the archaeological record does not. Also the archaeological record is incomplete, it reflects only a small sub-sample of the total populations; only a limited number of sites and artefacts are preserved. The evidence from anthropological sources can broaden out the range of materials, contexts and social processes against which archaeologists can assess the data from their excavations. However, there are problems with the ethnographic record too, some of which will be outlined in Chapter 4.

One basic rule that should be applied though is that in turning to the ethnographic record we should be using it to frame questions not answers; and the archaeological record then acts as a test to these questions. This is the approach taken in this study and it has its roots in the deductive method of scientific study in the social sciences. It is an approach used by Gellner in an attempt to outline a view of human history. He defines the method as follows:

Conclusions are extracted from clearly stated *assumptions*; various possible conclusions are then checked against available facts. Assumptions are revised if the implications fail to tally with the available facts (Gellner, 1988:13).

He then goes on:

The painting of a historical backcloth cannot possibly be a matter of mere description: reality is so rich and diverse that no unselective description could ever be begun, let alone completed. Instead one chooses the crucial and elementary factors operative in human history, selected to the best of one's judgement,

and then works out their joint implications. If the resulting picture fits the available record and highlights the relevant questions, well and good. If not, further tinkering with the premisses is evidently required. The method is in principle very simple; its implementation is not.

The difficulties in following this approach are compounded in this present case because the available archaeological and ethnographic record is so incomplete. This will always be a problem for archaeologists. If, on the other hand, they acknowledge that the best they can do is build up plausible descriptions of the phenomena they seek to explain then the methodological problem appears in a slightly different light. Since, as Gellner notes, 'unselective description' is impossible, the real challenge is to construct the analytical framework to provide for appropriate description and to help in the formulation of explanatory hypotheses.

The focus of this study is the Bronze Age smith and much of the argument will be in terms of the sorts of concepts of the smith and the organisation of the craft that are possible and appropriate in the various social conditions and formations with which we are dealing in the Bronze Age. The main claim is that the archaeological record must be seen in the light of an understanding of the knowledge and skills of smiths. To achieve this the smith has to be seen a) in the context of the whole technological process from ore-extraction and mining to manufacture and consumption, bearing in mind that these are social processes that involve exchange and trade; and b) in the light of ethnographic parallels where information from non-industrial societies is taken to illuminate these operations.

Throughout this study the knowledge and skill of the smith and the social organisation of metal-working are discussed as being central to our conception of Bronze Age society.

The archaeological artefacts are human products fashioned by men - and perhaps women.

A number of scholars have been concerned to locate the smith within Bronze Age society. Childe, Hawkes and others saw the smith as a privileged specialist holding a high status position in the community. Childe, for example, says:

.... metallurgists are always specialists. Probably from the first metallurgy was a craft as well as a technique. Smiths and miners not only possess peculiar skills, they have also been initiated into mysteries. Presumably their craft lore was transmitted by the same concrete methods of precept and example as hunting law or textile skill. But it was not divulged to all members of the community as these would be; not every clansman was trained as a smith. The operations of mining and smelting and casting are too elaborate and demand too continuous attention to be normally conducted in the intervals of tilling fields or minding cattle. Metallurgy is a full-time job (1965:85).

Textual references to Homer are cited referring to the status of the craftsman god, Hephaestus, son of Zeus and Hera, who makes the weapons for Achilles and other heroes and this image of the divine master smith has been used to substantiate arguments about the privileged position of the smith in prehistoric times. A close inspection of the ethnographic record, however, shows a great deal of variety in the social standing of this craftsman and also helps to define archaeological possibilities.

It is apparent both from ethnography and our own society that the status of the smith is ambiguous. On the one hand he is admired for his accomplishments while on the other hand he is undervalued as a common worker. Finley has drawn attention to this ambiguity surrounding the status of the smith even in Homer. He states:

Much of the psychology of labour, with its ambivalence between admiration of skill and craft and its rejection of the labourer as essentially

and irretrievably an inferior being, found its expression on Olympus. Having humanized the gods the bard was consistent enough to include labour among the heavenly pursuits. But that entailed a certain difficulty; Zeus the insatiable philanderer, Apollo the archer who was also a minstrel, Ares the god of battle - these were all embodiments of noble attributes and activities, easily re-created in man's image. But how could the artisan who built their palaces and made their weapons and their plate and their ornaments be placed on an equal footing with them, without casting a shadow over the hierarchy of values and status on which society rested? Only a god could make swords for gods yet somehow he must be apart from other gods.

The solution was neatly turned, very neatly indeed. The divine craftsman was Hephaestus, son of Hera. His skill was truly fabulous, and the poet never tired of it, lingering over his forge and his productions as he never sang of the smith in Ithaca. That was the positive side of the ambivalence. The other was this: of all the gods Hephaestus alone was 'a huge limping monster' with a sturdy neck and hairy chest' (XVIII. 410-5). Hephaestus was born lame, and he carried the mark of his shame on his whole personality (1979:72).

There are difficulties in testing these hypotheses about the status of craftsmen in the archaeological record. The Bronze Age is defined by material artefacts and their distribution, typical settlement and burial patterns, traces of craft activity sites etc. The aim is to generate a paradigm for the analysis of the bronze smith and craft organisation and the interpretation of this archaeological data i.e. to correlate activities and patterns of organisation with the material evidence which survives. The paradigm must identify a number of concepts with which we must approach the past such as the notion of skill and how it is acquired, maintained and passed on from one generation to the next; the question of the monopoly of knowledge and whether it is the property of a closed or an open group; the whole spectrum of organisation from part-time, seasonal occupation to craft guilds and how this is correlated to the social organisation

of the society as a whole ; the division of labour within the craft ; the relationship between craftsman and consumer and the social recognition of the smith. The task then is to relate archaeological data to ethnographic and literary evidence in order to examine hypotheses about the organisation of production. In this way the discussion, within archaeology, of the Bronze Age smith can be extended.

There has been a long history in the use of the ethnographic parallel. Similarities and analogues have been used to swell out the patchy nature of the archaeological record. But their application has not always been rigorous and systematic and there have been a number of criticisms of the use of analogy. Ucko (1969) has demonstrated the substantial number of pitfalls for the unwary archaeologist who interprets prehistoric burial practices and ritual using this comparative method. He illustrates, with the aid of ethnographic data, the wide variety of beliefs associated with a number of burial rites. Taking, for example, the presence of grave goods he shows that societies who share this practice do not always share the same religious ideas and the objects do not always signify a belief in the soul and an afterworld. Other archaeologists such as Bonnicksen (1973) have examined the remains of recently abandoned Indian camps and then discussed their interpretations with the previous occupants, to demonstrate the wide discrepancy between the two reconstructions.

These criticisms are mainly concerned with the problems associated with a lack of discipline and control in the use of analogy. A number of scholars challenge the rationale behind the use of analogy and suggest ways in which the present might act as a straight-jacket on the past and may limit our understanding in various ways. Dalton (1981) has argued that the use of analogy actually imposes restrictions on our understanding of past social, political, and economic

forms. The range of these forms must be poorly represented among contemporary small-scale societies since they have all, to a greater or lesser degree, been transformed as a result of colonization which has brought them within the framework of the much wider economic system of the industrialised nations. The ethnographic record is therefore as biased and incomplete as the archaeological record. Add to this the biases of anthropologists who, Wobst (1978:306) argues, have created artificial social boundaries around the subjects of their study and we have even less reason for assuming that the ethnographic record represents the totality of human behaviour.

Another limit to studying the present as a guide to the past is that a lot of models of ethnographic variability are based on correlations and very often jump from there to causality. However, correlation does not equal causality and the whole relationship may just be coincidental. Other problems include the lack of correspondence between the data sets, ethnographic data being based on social facts i.e. direct observations of people, while archaeological data is static being the end result of patterns of human behaviour. There is also the point made by Popper (1961) to consider, that it is impossible to predict what is going to happen in the future. Logically, it should be equally impossible to know past processes with any degree of certainty.

Archaeological data on the other hand do not convey self-evident meanings, they do not speak for themselves. They are made up of material things and arrangements of features such as pits and post-holes etc. According to Binford (1980) the aim should be to translate this static data into hypotheses about the dynamics of past ways of life. Other proponents of the use of ethnographic analogy such as Gould and Hodder also maintain that the ethnographic analogy can be useful but only if employed in a systematic and disciplined way. It

has often just been assumed that because societies and cultures have shown similarities in some aspects then they must necessarily be similar in other respects. This uniformitarian view is rejected by Hodder who sums up his position as follows:

Interpretation with the aid of analogies is unreliable and non-rigorous when the similarities between the things being compared are few in number and when the relevance of the comparison cannot be adequately demonstrated. The proper use of analogy in archaeology must pay special attention to context; that is the functional and ideological framework within which material items are used within everyday life It is necessary to examine not only the existence and strength of covariation but also its nature and cause. (1982:27)

The approach sketched out above provides one such disciplined framework within which ethnographic analogies can be used in the interpretation of the archaeological record. The essence of it is this: ethnographic data help the archaeologist frame questions and hypotheses and in doing so help test and interpret archaeological data. In this study the questions being asked refer to aspects of the functional organisation of metal-working practices which any society in which metal is used must solve. These include the extraction and smelting of ores, the fashioning of objects and trade and exchange. There are a number of sub themes which have to be examined. Among the most important of these is the question of skill and knowledge and how they are transmitted. In relation to each issue the findings of anthropologists guide and enrich the work of archaeologists. It is one of the main aims of this study to justify this claim and to show how the approaches of both subjects can be used in a disciplined way.

The study is divided into six chapters and a short conclusion. In the first two chapters the possible sources of ore are located, the processes of prospecting, mining and smelting are examined as well as the types of exchange mechanisms that would be feasible in the transfer of the extracted metal to the smiths' workshops. Chapter 3 is concerned with the stages in the manufacture of objects and technological development. There is a discussion of how knowledge is acquired and transmitted and this element is elaborated in Chapter 4 where the point is made that technical knowledge does not exist except within a particular cultural context. Technology does not stand on its own but it is through various networks of social relationships that knowledge and skill are transmitted by providing the essential conditions for cooperation and exchange of ideas. With the aid of ethnographic analogy and literary sources the smith is located in a number of social settings and his social standing within the society is explored together with the organisation of metalworking.

Chapter 5 discusses the relationship between the craftsman and the consumer and the way different types of transaction could be picked up in the archaeological record. The idea that objects have more than a functional value is explored. In Chapter 6 the relationship between the smith and the products of his skill is examined. The objects have a value which is reflected in their usefulness, or in the scarcity of the raw materials used in their manufacture. They also have a value represented in the masterly craftsmanship employed in their making and the aesthetic pleasure they can give. But what is also significant is their value as objects of prestige or political status and what this implies for the control and organisation of the manufacturing process.

CHAPTER 1

EXTRACTION, MINING TECHNOLOGY AND SMELTING

The aim of this chapter is to examine the process of extraction of metal ores and their refinement prior to the manufacture of metal objects by craftsmen. The two processes with which it is concerned, i.e. mining and smelting, are both complex within themselves. The aim is to examine some of the principal findings of archaeological research in this area and to outline some hypotheses about the social organisation of mining and ore processing. The central idea is that when the technology of extraction is examined as a series of processes which must be carried out through a number of distinct phases of work, a number of suggestive hypotheses can be framed which prompt both new questions and an informed searching of the archaeological record.

This chapter will show that an understanding of the technical processes of extraction and smelting has to be informed by an awareness of the social and cultural formations of Bronze Age societies. These shape and presuppose the knowledge, skills, division of labour and organisation of the various crafts involved.

The chapter will also provide a summary of some key points which archaeologists have made about Bronze Age extraction. First, perhaps, a distinction ought to be made between extraction and mining. Mining implies a much deeper extraction which involves the process of driving tunnels into the ground, as in drift mines or adits, or exploitation by shafts and a system of gallery networks. The prehistoric miner's first attempts at exploiting sources of copper were probably by simply collecting ore nodules from the surface, or open cast extraction by shallow digging or deeper pits;

methods where there were no special technical problems to solve.

Mining and extraction

The type of mining technology would have been governed by geological conditions, so that in the case of vein type deposits this may have developed into the adoption of a tunneling technique as described by Pittioni, as miner's followed steeply inclined seams of copper ore underground (Pittioni, 1951). Shaft mining, on the other hand, involves digging vertically to exploit a mineral outcrop at or just below the surface. In some cases galleries were dug out of the rock as miners followed horizontal seams from the vertical shaft. Neolithic flint miners often used this method of exploitation. However, in all cases the actual techniques employed would have depended both on the nature of the deposit and the technology available to the miner as well as a knowledge of the skills involved.

It appears that the types of skills and knowledge required to mine ores were already present in Late Neolithic communities throughout Europe and the Middle East. Miners had quarried and mined for a number of minerals including salt, lapis lazuli, turquoise and flint. Hermann (1968-69), for instance, has reported on mining for lapis lazuli in the province of Badakhshan in Afghanistan. Here she examined the ancient workings in the Sar-i-Sang mines. These consist of a series of huge caverns connected by narrow passages which have been tunneled into the mountainside. The walls were covered with a thick deposit of soot which, Hermann suggests, attests to the ancient method of extracting stone, i.e. fire-setting. Their position in the mountains means that they can only be reached for 3 months of the year during the summer season which would argue for a seasonal

exploitation of the mines. Unfortunately, there are no dates given for these workings.

The chronological and technical relationship between flint and copper mining techniques has been tested more successfully by Weisgerber (1987). He demonstrates that although mining and processing of copper have been proved to exist in Europe in the 4th millenium BC, the early copper mines do not have the complex system of shafts and galleries present in some flint mines of the same age such as the mines at Krzemionki in eastern Europe, dated between 3500 and 2000 bc, and the Belgian mine of Jandrin-Jandrenouille dated 3495 + 260 bc. Copper mines like those reported at Aibunar, Bulgaria (Cernych, 1978) and also near Huelva in southern Spain (Rothenberg and Blanco-Freiheiro, 1980) were not so systematically developed and the steeply inclined seams were simply quarried from the surface. Further, in the 3rd millenium BC the use of shaft mining techniques in flint extraction shows an increase. Examples include Harrow Hill, Sussex, dated 2980+150 bc, Grimes Graves, Norfolk, dated 2340 - 1750 bc and Spiennes, Belgium, dated from 3000 bc (Weisgerber, 1987:134). A comparative level of technology for copper mining does not seem to have been achieved until much later. For instance, at Timna a system of shafts and galleries was developed around 1200 BC.

This study does appear to support the hypothesis that copper mining techniques were influenced by a technology that had been developed much earlier for flint mining. Smolla (1987), suggests that there is also a technical similarity between the sinking of mine shafts and water wells and notes reports of wells as early as Linearbandkeramik in Eastern Europe, in Moravia and Bulgaria, as well as in Neolithic China. These technological achievements in flint mining and digging wells suggest that the level of expertise required to procure copper developed from a much earlier technical, and

knowledge base and the origins of copper mining are best seen as developing within this tradition.

The earliest flint mining was carried out in secondary deposits and involved open cast workings such as pits and irregular diggings. Later the technology developed for deep shaft working of primary deposits such as those found at Grimes Graves, Spiennes or Kremionki, where the flint layers lie horizontally in beds of rock (Weisgerber, 1987). As a rule flint was selected from levels with the highest quality flint. Miners sunk vertical shafts and then followed horizontal galleries. The technique of fire-setting was used to loosen rock from the work face and antler picks were used to prize flint out of the seam. All of these elements indicate developed mining techniques and a high level of experience in prospecting for materials, as well as a degree of knowledge of the properties of the material they were working with.

Turning to copper mining, there appears to have been a similar sequence of development. As surface deposits of copper and copper ores grew rare and prospecting skills developed this led to the discovery of deeper strata. The more sophisticated techniques required for their exploitation must have brought along specialization. It would no longer have been possible to procure ore, produce the metal and the finished object from it. A division of labour would have arisen with the prospector and miner on the one hand and the metallurgist on the other. Further specialization among the metallurgists is also conceivable with the smelter whose job it was to produce the crude metal, the smith who manufactured utilitarian objects and tools and the fine metal-workers who created art objects and decorated metal objects.

Pittioni (1951), in his study of Early Bronze Age mines in the Austrian Alps, notes separate sites for extraction, preparation and smelting. He also draws attention to the fact that although oxidised ores are found in the same area these were never mined by Bronze Age miners who concentrated exclusively on the pyrites ore. This demonstrates the fact that miners had an intimate knowledge of the area they were working and were seeking to maximise their output by selecting more extensive seams with the objective of sustaining extraction over a long period.

A number of interesting problems are raised at this point in the discussion. How is this knowledge and the skills, experience and techniques associated with it transmitted from generation to generation? The types of relationships involved here could range from those of master and apprentice to hereditary relationships. Also, in view of the strenuous nature of the task, was this an occupation that was reserved for the young adults within the community? Deep mining is essentially a hazardous occupation. A number of problems have to be solved, for instance ventilation, drainage, timbering, the separation of the waste products from the useful part of the rock and their removal from the work face. These problems would seem to require the presence of a large back-up team of ore-transporters, timbermen etc. in addition to the actual miners and this in turn suggests some form of overall coordination.

Another question which arises in discussions of specialist occupation groups is whether or not the specialist is self-sufficient and fits his trade into a calendar of agricultural tasks, perhaps mining on a seasonal basis, or whether he is supported by a surplus produced by other members of the community. None of these questions can be answered by the archaeological record alone, but the latter does suggest a number of points about the organisation of

mining and the status of the miner and locates him perhaps within a more complex network than has previously been assumed. There is a danger, as always, in applying our own modern concept of a specialist occupational group too rigidly. An ability to mine may well have been just one aspect of a range of skills which were possessed and used. What is clear from the archaeological record is that mining skills were highly developed.

Coghlan (1951) and Forbes (1964), among others, have traced stages in the development of mining and metallurgical techniques. After some use of native copper it is suggested that the most plausible hypothesis is that smelted copper would have been obtained from the oxide group of ores. These ores are found on the earth's surface, weathered and oxidised. They argue, in the case of malachite, the green carbonate, and azurite, the blue carbonate, their bright colours would have attracted attention and they would have been readily available by simple collection or open-cast working. Exploitation of the sulphide ores which generally occur in deeper strata in the same areas, required more sophisticated technical skills and equipment with a change to the technique of tunneling and shaft mining.

Distribution of mines and mining activity

Turning to the archaeological record, it is difficult to know how to recognise sites of prehistoric mining activity analytically. In the case of small oxide deposits there is little chance of reconstruction as the ore has been completely worked out and in some cases the whole area has been disturbed by later Roman workings. Some ore sources have been re-worked in recent times by modern mining operations revealing archaeological traces which have not been excavated and recorded e.g. in Cyprus (Weisgerber, 1981) and South East Europe. But prehistoric mines have been

traced in some areas, for instance, in Spain, Austria, Cyprus, the Balkans, the Timna valley and the British Isles.

The remains of copper mining activity in the British Isles are few. One of the sites with the best evidence of early exploitation is at Mount Gabriel, County Cork, reported by Jackson (1968). The main case for Bronze Age activity at the site rested on the presence of stone hammers or mauls with a characteristic groove or waist pecked around the middle. These implements seem to be diagnostic of Early Bronze Age mining sites according to Craddock (1986). Excavations at the Chiflon mine in Spain produced hundreds of these, although they are noticeably absent in late Bronze Age levels in the Rio Tinto mines a few kilometres to the north. They also appear in the mines of south east Europe and Timna, Israel. Marks left on rock by these mining tools are very distinctive. At Timna surface markings on the walls of the galleries give some idea of the chronology of tool use. The grooving or chisel marks produced by early metal tools and given a Late Bronze Age date of 1400-1200 BC overlie and cut through the pecking marks of stone tools (Craddock and Gale, 1988).

In addition to the mauls at Mount Gabriel some radiocarbon dates have been obtained from the site. Since an earlier and disputed radiocarbon date (see Briggs, 1983), two further determinations have been carried out. The first was on a sample of charcoal taken from the bottom of a layer of peat which was overlying a mine dump. This gave a date of 1250 + 110 bc. Another date of 1180 + 80 bc has been obtained from wooden tools found within the mines (Craddock, 1986).

Traces of an ancient mine have also been reported at Orme's Head, Llandudno, Wales. Any remains of activity on the surface have been erased by modern mining or buried under later waste heaps, but careful examination of underground

workings has revealed two ancient galleries with evidence of bone and stone tools and fire-setting. A radiocarbon date was obtained from a deposit in one of these galleries which gave a result of about 1470 to 975 cal. BC. And the indications are that early mining here was on the sort of scale of the prehistoric mines in Austria (James, 1988).

Mines that have received a great deal of attention are those in the Austrian Alps investigated by Pittioni (1951) and the workings in south east Europe. At Rudna Glava in north east Serbia it was discovered that mining works had been exploited during the main Middle Chalcolithic phase, the Vinca culture. The method of exploitation had been to dig irregular shafts following the veins of ore. Lower reaches of the deposits were worked by means of access platforms. On many of these there have been finds of pottery including figurines and other items of a votive nature. Stone, bone and wooden tools were excavated including the characteristic massive stone hammers or mauls which may have been used for crushing and grinding the ore, as wear traces on their surfaces suggests.

Similarly, at Aibunar in Bulgaria traces of early mining activity were revealed (Cernych, 1978). These consisted of narrow, wedge-shaped open-casts. Fragments of antler implements were found, in addition to the waisted stone hammers just described, and two copper tools - a hammer axe and a cast axe-adze. Another interesting discovery was that of extensive traces of settlement left in the areas of mining activity which suggests the possibility that mining was separated from the processes of smelting and metalworking. The hypothesis is supported by two facts. First of all, no traces of slag or smelting furnaces have been found within a substantial radius of the site. Secondly, copper implements and objects found in surrounding settlement sites have not shown any correspondence in

chemical composition to ores from the Aibunar mines, although ore samples found at these same settlements were found to originate exclusively from Aibunar. On the basis of this evidence, Cernych has proposed a model for the organisation of metallurgy in the Balkans during the Chalcolithic. He suggests that the ore may have been transported some distance from the site of the mines to 'metallurgical centres' where it would have been smelted together with deposits from other areas in the Balkans.

In terms of the logistics of transporting loads of ore, the balance of probability would seem to be in favour of primary smelting taking place close to the source of extraction unless the ores were rich in copper, in which case relatively small amounts of slag would result. The results of chemical analysis, such as those used by Cernych (1978), are of great importance in relation to this sort of problem and in any discussion of mining and metallurgy and the technical and social systems involved. However, the analytical approach to the identification of metal objects from a particular source has not been very successful on the whole. It has proved difficult to identify characteristics of particular ore sources in copper objects. Some trace elements used in the analysis have been shown to vary in quantity depending on the smelting conditions. For example, the elements bismuth, lead and nickel cluster together during heating so are not found to be uniformly distributed throughout an artefact.

A recent advance in this area of research has been made with lead isotope analysis which relies on the fact that ratios of lead isotopes always reflect the ratios in the ore supply. Some recent work in this area has focussed on objects of bronze from Crete and the Cyclades, and the implications are that Cretan objects derived their copper from the Laurion mines in Attica (Gale and Stos-Gale, 1982).

Clearly this type of analysis will be significant in considering questions of technological organisation such as the separation of mining and smelting areas, as well as the mechanisms of distribution and exchange which will be discussed later.

Mining technology and organisation

Turning back to the archaeological evidence of mining activity, Bronze Age copper mines discovered by Pittioni in the Austrian Alps suggests a complexity of organisation and a relatively large scale operation (Pittioni, 1951). It has been demonstrated that the mines were first worked in the Early Bronze Age. The miners followed veins of ore down into the earth using the technique of fire setting, i.e. building a fire against the rock face and then dousing with cold water to cause contraction and cracking of the rock. Bronze picks and wooden implements were then driven into the cracks in the rock and large pieces of material were eased out and later broken up further to remove the gangue. As miners tunneled deeper into the mountainside, it appears that galleries were timbered for protection from falling rock and waste material was stored on top of the timbering on wooden platforms. These structures also helped to regulate the air supply. As smoke from the fires was drawn upwards and out of the tunnel along the space between the platform construction and the roof, fresh air was drawn into the mine.

A range of implements have been preserved in the shafts including ladders, troughs for water, shovels, picks and hammer stones for crushing and dressing the ore. The remains of this operation are seen in the form of waste dumps which were deposited close to the mines.

Pittioni has estimated the labour requirement for three tunneling operations at 180 people (Pittioni, 1951). This

figure includes those employed in activities other than the actual process of mining, such as timbering, ore-dressing and transporting ore. It implies a system a dramatic leap away from the craftsman who collects his own ore, smelts it and then shapes the resulting metal into implements. On the other hand, we do not know over what length of time these mines were exploited. Extraction of ores could have been carried out on a much more ad hoc basis, although the development of a specialised technology suggests a preoccupation with the efficient use of time. Also, the investment of time and labour implies a commitment to the task.

It is possible to see a development in mining technology at Timna, although the exploitation of ores there was not continuous and each period of activity is separated by many generations (Rothenberg, 1972). Chalcolithic copper extraction involved simple collection of the ore nodules from the surface. In the Late Bronze Age - Early Iron Age the technique used was open-casting, and there is evidence that the miners recognised greater concentrations of ore in some rock formations and focussed their activity on these areas. Hammer stones, as well as various types of grinding and crushing equipment, were discovered at the rock face and at the ore dressing sites situated just below the mines. Further developments took place during the Roman period. Shaft mining was introduced at this time and again there is evidence that the strategy was selective and areas of greater ore concentrations were exploited.

However, it would not be valid to superimpose this pattern of development on all prehistoric mining systems. The development of mining technology and organisation would not have been uniform in each of the different metaliferous areas, but should be seen as a function of the nature of local ore deposits and internal mining traditions, as well

as the social organisation of communities and such things as the availability of manpower.

Smelting of ores

Turning now to the refining process, the smelting of metal ores has to be considered in the light of observations concerning 1) the technical process of smelting 2) the knowledge and skill required by the smelter 3) the technical changes in smelting technology and 4) the relationship between the smelter and his suppliers and clients. The discussion develops to examine the hypothesis that smelting was, for most of the Bronze Age, a much more specialised task than mining, the likelihood being that it was performed again by a distinctive occupational group.

One has to distinguish the treatment of two types of ore. The oxide cuprite and the carbonates malachite and azurite can be refined by heating and reduction of the ore with charcoal or wood. In the case of the sulphide ores, however, a preliminary stage is involved. This consists of roasting the ore to drive off sulphur. Once the sulphur has been driven off the ore is ready for smelting. The development and refining of this technique, which requires more controlled conditions than the simple reduction of oxides, permitted the exploitation of the more inexhaustible supplies of sulphide ores.

The first stage in the process, prior to the actual smelting of ores, is concerned with the concentration of ores and the elimination of unwanted minerals. Traces of early ore-dressing sites have been excavated at Timna, consisting of large stone-crushing mortars and anvils. In addition, a number of stone hammers, flint tools and nodules of copper ore were found scattered around these crushing instruments. The ore nodules, mainly malachite and chalcocite,

corresponded to those at a nearby mining site. All of these sites have been dated to the Chalcolithic. One of the ore-dressing sites was located on the slope below a hilltop on which excavation revealed the remains of a bowl-type copper smelting furnace. The distance between the two sites was about 100 metres and Rothenberg concluded that the ore-dressing site supplied the smelt material to the smelters, who worked at the top of the hill (1972).

Many attempts have been made to explain how it was discovered that copper could be obtained by the process of smelting of the ores. Most of the literature assumes, however, that smelting was discovered by chance. The campfire theory was popular for a long time. Adherents to this theory e.g. Childe (1966:95), supposed that malachite and other ores may have been accidentally reduced to the metallic state in a campfire. Experimental work, however, indicated that it would have been highly unlikely that the process of smelting could have been discovered in this way. Coghlan founded his explanation within the existing level of pyrotechnological skill and knowledge, (1951). He suggested that the firing of pottery in kilns must have influenced the development of smelting. The high temperatures required could have been obtained in the pottery kiln and potters must have had the knowledge of the control of atmospheric conditions within the kiln. He then went on to speculate on the accidental reduction of a copper mineral such as malachite which was being used as a pigment to decorate pottery. Other authors such as Tylecote and Boydell (1978), favour the hypothesis that smelting of ores developed out of the process of melting down native copper.

The social organisation of smelting

Although chance must play an important part in the process of discovery and innovation, knowledge and purpose are also

important elements, because without them the value of the new information would not be clear and understood and would in that case go unrecognised. As we have seen, the smelting of ores has been described as accidental by many authorities, but it must have been more than accident. There must surely have been a foundation of acquired knowledge which enabled the importance of the discovery to be recognised and appreciated. But there must also have been an element of purpose, of actually seeking out new information.

On the whole, it seems that many scholars have been constrained and handicapped by their own ethnocentricity and cultural biases and have taken the view that prehistoric man's mental capacity was inferior as well as his ability to think logically. De Jesus takes up this point (1980). He puts metallurgy on the same level as the domestication of animals and the development of agriculture, i.e. innovations which developed with strategies to solve particular needs within communities. One can speculate as to how these new needs arose. Communities extracting native copper were exposed to metal objects, albeit in a simple form. Their use as social and political assets, increasing the social standing and prestige of individuals and creating alliances between groups, may have led to a shift in the traditional economy and social structure of the group. As a result, new needs would be generated which may only have been satisfied by the production of more metal forms. The technology to carry out the process was already present as was the knowledge of the change in the physical state of the materials which could be effected through heat treatment. De Jesus says of man in pre-metal societies:

.. he made wood into charcoal, clay into pottery and he saw substances, such as beeswax, turn into liquid when heated and back into a solid state when left to cool..... These and many other phenomena must have been studied for their potential usefulness, but to make them useful he

had to translate them into human terms. And this meant experimentation. (1980:37)

He sees the discovery of copper smelting as the result of such experiments and inquiry.

It is interesting to note at this point in the discussion that the psychologist Kelly proposed that every human being in their own particular way is a scientist (1963). The aim of the scientist is to predict and control through the testing of hypotheses and this is what each individual does, he argues, as he tries to make sense of the world and seeks to predict and control the course of events which concern him. We formulate hypotheses about events which we then test and modify in the light of the outcome and as we learn by the mistakes that we make. Earlier theories concerning the discovery of smelting underestimate the rational, experimental character of all human behaviour and rest on an inadequate model of human beings. Recent psychological theories stressing the idea that humans are always testing the environment support the hypothesis that metallurgy, like agriculture, is best understood as a calculated response to changing needs.

Another important point is that most models of metallurgical development are quasi-evolutionary in character and are concerned with a unilineal sequence of events starting from the hammering of native copper and continuing on to the smelting of sulphide ores and finally the smelting and carburization of iron. Lechtman argues that this pattern of development is too simplistic and takes no account of the various cultural frameworks within which metallurgy developed (1980).

Fuels and furnaces

It has been established that the technology required to perform the process of smelting was already present and that pre-metal societies were already familiar with high temperature kilns and were probably aware of the characteristic properties of charcoal, such as its higher burning temperature. Charcoal also produces a reducing atmosphere because of its high carbon content, although it has been pointed out that copper oxides require only a slightly reducing atmosphere to smelt and it would have been possible to use wood (Horne, 1982). For a successful smelt, however, the temperature achieved should be high enough to melt the slag so that droplets of copper can collect in the bottom of the furnace rather than becoming trapped inside the slag. In the latter case the cold slag has to be broken up and the copper removed as droplets or prills.

Fuel for smelting was therefore a critical resource and the quantities required were very high as estimates have revealed. According to Horne (1982), the charcoal to copper ratio for smelted oxide ores is 20 to 1, based on historic records in Europe. Using this estimate and various reports on charcoal production in Iran, she has calculated that in order to produce 5 kg. of copper, 'enough for perhaps 20 shaft-hole axes', 100 kg. of charcoal would be needed at a conservative estimate and this would require about 3.3 man days of labour to produce. Also this yield of charcoal would utilise 700 kg. of wood. In Shiraz it was observed that it took one day to dig a pit and line it with stones to prevent soil mixing with the charcoal, one day to carbonize the wood and two days to put out the fire. Apart from these tasks, trees had to be felled, cut into appropriate sizes and stacked neatly into the pit in such a way that there was a minimum of space between each length of timber.

The charcoal burner requires great skill and experience it seems and it is possible that the prehistoric smelter, in some contexts, obtained his supply from a specialist occupational group. In the archaeological record it would be difficult to distinguish charcoal which had been specially prepared and that which results from fire burning in a hearth. However, charcoal burning traditions lasted well into the present century and evidence of the process on later sites, such as medieval ones, gives insights into the structure of the kilns and the kinds of traces a charcoal clamp would leave, which might assist with their recognition on prehistoric sites. Rothenberg discovered an accumulation of charcoal dust beneath a slag heap at the site of the Roman copper works at Timna which he attributes to charcoal manufacture (1972). In view of the large amount of charcoal consumed in the smelting process and the practical skill and knowledge required of the charcoal maker in order to convert wood into charcoal efficiently, it seems likely that charcoal burning was a specialist activity in any metallurgical industry of some scale.

Because charcoal was so crucial to copper smelting, its supply could have had an influence on the improvement of smelting techniques and smelting furnaces as the need to conserve fuel became an important consideration in some environments. Rothenberg has pointed out that there was never any continuity in mining and smelting enterprises at Timna and periods of activity were separated by several generations, (1972). This has been accounted for in terms of the destruction of the environment and a diminishing supply of acacia wood with which to make charcoal (Bachmann and Rothenberg, (1980) cited by Horne, 1982). On the other hand, excavations at Timna have furnished evidence of a continuous tradition of metallurgy and the development and improvement of smelting furnaces and techniques is well-documented.

Starting at the simplest end of the spectrum, the Late Chalcolithic smelting furnace referred to earlier is very primitive in construction and consists basically of a bowl shape dug into the ground without any lining. There is no evidence of bellows or tuyères to indicate the use of a forced draught, although Rothenberg argues that some sort of forced ventilation must have been provided to account for the temperatures reached (1972). Also, there was no arrangement for tapping off the slag. After the smelting operation the upper part of the furnace would have been dismantled. Some metallic copper would have sunk to the bottom of the furnace and the remainder would have been found within the slag and would have been separated from it by breaking open the slag and removing the copper as prills or drops.

Following on from this period of metallurgical activity, the Raeside or Late Bronze Age/ Early Iron Age smelting furnace was also of a simple bowl form, but it was lined and had been built into a hollow in the ground which included a pit for tapping off the slag. Fragments of clay tubing have been interpreted as tuyères for bellows. It is assumed that on completion of the smelting operation a hole would have been drilled through the front wall of the furnace and the slag run off into the pit.

Evidence of prehistoric smelting activity has also been found in Spain. Traces of crushed slag, reflecting the simplest smelting technology, were found close to Chalcolithic/Early Bronze Age mines at Chiflon in S.W. Spain, for example. Also, Late Bronze Age workings at Corte Lago in Rio Tinto show evidence of a more developed smelting technology, including furnace linings and slag tapping facilities (Rothenberg and Freijero, 1980). In Cyprus evidence of the extent of metallurgical activity is reflected in the extensive occurrence of slag heaps, over 40

having been recorded so far with a total tonnage of slag estimated at 4 million tons (Constantinou, 1982). Remnants of furnaces, on the other hand, are rare.

On the whole, there is relatively little documentation of prehistoric smelting furnaces. The problem here may be that primary smelting activity was probably located close to the ore deposits and mines and modern reworking may have destroyed evidence of on-site smelting. The availability of wood to convert to charcoal would also have been a factor influencing the siting of smelting furnaces. Excavation of prehistoric settlements is therefore unlikely to reveal traces of primary smelting technology. The site of copper smelting at Enkomi, Cyprus, which Tylecote (1971) reconstructed as a simple non-tapping furnace has been re-interpreted as a site where refinement of primary smelting products took place (Steinberg and Kouchy, (1974) cited by Stech, 1982). A model is proposed for Late Bronze Age Cyprus of primary smelting taking place near the mines with the enriched slags being produced transported to the cities around the coast where further refinement took place.

There are exceptions. In the Timna valley smelting sites are located close to habitation sites in both the Chalcolithic and Ramesside periods (Rothenberg, 1972). A uniform pattern concerning the relationships between mining zones, organisation of smelting and the siting of settlements would not be feasible, on the other hand. The environment and geological setting will inevitably be a strong influence. Deposits of ore are often located in regions where human habitation would not have been possible all the year around. Miners and smelters, therefore, may have carried out their tasks on a seasonal basis and there would have been less need for permanent dwellings.

Cultural factors may also have some bearing on the organisation and location of smelting. According to the ethnographic literature, smelting furnaces are rarely found within settlements. Wagner reports that among the Vugusu clan of the Bantu tribe of North Kavirondo the iron smelters never set up their furnaces within the villages but out in the bush (Wagner, 1956). He was told that 'the people do not like to have "the dirty things" near their houses'. And among the Baganda, during the time that they are involved with smelting, men may not have any contact with or eat with anyone apart from fellow workers and live in temporary huts (Roscoe, 1965). It is also clear from both accounts that smelting is a restricted activity. In North Kavirondo smelting furnaces were found only in the northern and north western parts of the district. Here the smiths of other tribes exchanged iron for livestock and grain. The actual art of smelting was confined to certain clans who were anxious to keep their skills and knowledge within the group and reluctant to instruct outsiders in the traditional techniques. The Baganda smelters also exchanged iron either with the other villagers who would then commission smiths to make implements for them, or with smiths who were not able to smelt.

Conclusion

Speculation on the status of prehistoric smelters and their relationship with suppliers and clients is difficult at this stage of investigation in the field of archaeo-metallurgy. It seems reasonable to suppose, however, that in some cases they would have operated as a distinct group and the raw material was exchanged with secondary producers, who then manufactured the tools and other metal objects. The argument put forward here is that with small scale mining and metallurgical operations the division of labour would be limited. Specialised miners, smelters and smiths emerged

with larger, more organised systems which were a product of socio-economic and political changes in the society stimulating the development of new techniques in mining, ore preparation, smelting technology and metal working. Further study on the location of mining zones, smelting sites, their distribution and their correspondence to the siting of settlements together with trade in minerals and finished objects is important to the understanding of the relationships between these different elements in the production of metal. These will be discussed in the following chapters.

CHAPTER 2

SUPPLY ROUTES

The aim of this chapter is to examine the processes involved in the transport of metals from their point of origin, as mined and smelted ores, to the point where they are acquired by the craftsmen ready for manufacture into implements. The first set of problems to be discussed concerns the spatial distribution of metal deposits. Following on from this, there is a need to analyse the archaeological record to discover the forms in which metals were transported, and the directions in which they travelled. This leads necessarily to a large number of further questions. These include questions such as the quantity of ores being mined, the method of transportation and the organization of transport and also the nature of the exchange.

Distribution of ores

Turning first to the question of distribution. The problem is this: the grouping of copper and tin ores does not correspond to the distribution of tin bronze artefacts. Some parts of Northern Europe, e.g. Denmark, are well outside the spread of both of these minerals, although there is a substantial record of bronze finds in this area, and this leads to questions of the nature of trade mechanisms over long distances during the Bronze Age and how the smith obtained the raw materials of his craft.

The sources of copper were fairly widespread. In the British Isles they were confined to Ireland, Scotland and the west of England, particularly Devon and Cornwall, and Wales. In Europe deposits occur in the south east, in the Balkans and Carpathians, in the Bohemian Ore mountains, the Harz

mountains, the Austrian Alps, Tuscany in Italy, Sardinia, Iberia and Brittany. The Laurion mines in Attica are also thought to have been an early source of copper according to Gale & Gale, (1982).

Near Eastern deposits which were mined during the Bronze Age or earlier include those on Cyprus, Timna in the Arabah of Israel, Iran and Anatolia. And it has been noted that the presence of copper in the Eastern Desert, Egypt has been confirmed by geological survey, including evidence of ancient workings in the form of stone hammers and grinders and remnants of slag (Muhly, 1973:218).

Although it seems likely that copper deposits in Cornwall and Devon were being exploited in the Bronze Age, there is no archaeological proof of prehistoric working. This lack of evidence might be explained by the later, deeper mining of deposits which has resulted in the destruction of traces of earlier activity. This has been a problem in other areas of investigation too e.g. Cyprus, where Roman mining operations may have disturbed the original traces of the first miners, although finds of grooved pebble hammers from Mathiati are typical for Chalcolithic copper mines (Weisgerber, 1981). Cyprus was one of the major sources of copper in the Eastern Mediterranean perhaps only during the Late Bronze Age. All the evidence for copper smelting here comes after about 1500 BC and this late appearance may have been due to the nature of the copper deposits on Cyprus which consist mainly of low grade sulphide ores such as chalcopyrite which present certain difficulties in smelting (Muhly, 1980). In other areas e.g. Spain, Turkey etc. the detailed mapping and recording of ore sources and possible traces of prehistoric exploitation is being carried out as well as the characterisation of ore bodies in order to measure the extent of exchange in copper ores.

Turning now to the question of tin we have an even more problematical issue. Tin ores show a much more restricted distribution than copper ores raising the question of a long distance trade in this particular metal. Cornwall and Devon are among the few places where tin deposits occur in the British Isles and European sources are limited to Brittany, Iberia, Etruria, Sardinia and the Erzgebirge mountains, which lie on the border between what is now East Germany and Czechoslovakia.

Whether the Erzgebirge deposits were ever mined during the Bronze Age has been the subject of some dispute. There are two schools of thought. One view is that the mountains were never an ancient source of tin because 1) the deposits are located in veins of granitic rock which would have been beyond the techniques and technology of Bronze Age miners (Muhly, 1978:44) and 2) there are no references to Erzgebirge tin by the classical authors, and had these been important in the Bronze Age it is unlikely that they would have escaped later attention (Muhly, 1985:289).

Others have argued that tin mining must have been important in the Erzgebirge during the Bronze Age, otherwise it would be difficult to explain the achievements of Central European metallurgy. Recent research and examination of the geology of the area, reported by Taylor (1983:296), has revealed that primary lodes of cassiterite are limited to the upper part of the granite and this zone has been subject to considerable erosion due to the harsh climate. The result of this has been the production of placer deposits of stream tin which occur in the area of almost all the primary tin ore deposits. They are easily mined and have been among the most important sources of tin ore in the Erzgebirge for centuries. Taylor suggests that these abundant supplies may have been contributory factors in explaining the apparent wealth of the local Unetice culture.

New archaeological evidence supporting this claim for the early exploitation of Erzgebirge tin has recently been presented (Bouzek et al., 1989). A number of Bronze Age settlements have now been located close to copper and tin deposits in the Erzgebirge where many small sources of ore would have been accessible to the prehistoric prospector whose techniques would have included collecting samples on the slopes below ore outcrops and in rivers.

The archaeological record for the development of a Bronze Age tin industry in S.W. England is again incomplete. It seems likely that the first deposits worked were in the form of the stream tin just discussed, the result of the weathering of cassiterite-bearing lodes. The resulting ore-bearing rocks are then carried by water into the beds of streams where the stream tin can then be panned out. Unfortunately, the method leaves no trace of the former contents and therefore complicates the search for ancient sources of tin. Recent archaeological evidence for tin in Cornwall is noted by Tylecote (1986), who points out that in an area of Bronze Age barrows at Caerloggas, near St. Austell excavation has revealed seven small pieces of tin smelting slag containing entrapped globules of metallic tin which have been dated to the early Bronze Age. At another later Bronze Age settlement site, Trevisker, in North Cornwall, a collection of alluvial cassiterite pebbles has been found (Shell, 1978). There have also been finds of tin ingots although very few have been found in stratified contexts. And no tin smelting sites have been discovered so far.

The fragmentary archaeological evidence outlined above for the ancient working of tin in Cornwall has been supplemented by documentary data from later periods in discussions of whether such tin found its way to Late Bronze Age Greece. The assumption appears to be that, since the

exploitation of this source is well documented throughout the historical period, then its reputation must have extended back to the Bronze Age. Diodorus, probably using a 4th century BC source, reported a pre-Roman trading post for the trading of tin from the S.W. of Britain with the name of Ictis. He says that ore was found in Belerium or Cornwall and after smelting was cast into ingots like 'ostragali' and transported to Ictis before it was finally shipped to Gaul (Hawkes, 1984).

There are also textual references to rumours that tin was found on a group of islands called the Cassiterides. Muhly (1985:276) notes that Herodotus, writing in the 5th century BC and pondering the source of tin in Classical Athens, admitted 'nor do I know anything of the existence of islands called the tin islands, whence we get our tin', although he was aware that both tin and amber came from 'the ends of the earth' (Book 3:115) Later writers, anxious to resolve this puzzle, have suggested a number of locations among which has been the coast of Cornwall. But the idea of a Cornish tin trade with Mycenaean Greece in the Bronze Age is questionable and has been based mainly on negative evidence from Europe and the apparent lack of more accessible sources there.

The source of early tin in the Near East is even more problematic. Tin bronze occurs in 3rd millenium contexts in Mesopotamia, Central Anatolia, N.W. Anatolia and the Cyclades and is very rarely found elsewhere until the end of the millenium, according to Stech and Piggot (1986). Explanations of this supposed that this distribution was related to the location of tin sources in each of these areas. However, geological research has failed to detect any tin in the places concerned, with the exception of the very recently discovered find in Anatolia (Yener & Ozbal, 1987), and suggests that we have to look elsewhere for tin

supplies. Egypt seemed a suitable location but although tin is found in the central area of the Western Desert, and the Eastern Desert has significant deposits of alluvial tin, it is not known whether tin was recovered from this area in the third millenium. Tin bronze does not occur in Egypt itself until the second millenium so it appears unlikely that this was a source of tin for the 3rd millenium contexts referred to above (Muhly, 1985:283).

Thailand has also been quoted as a possible source as metalsmiths here were producing bronze with about 10% tin by 3,000 B.C. and the tin of India has been noted. However, the Old Assyrian texts indicate that the trade was not so farflung although they suggest that it did have an eastern origin beyond the Zagros mountains. For example, documents dating to the second millenium indicate that merchants from Assur brought tin to Anatolia although there is no reference as to how the tin got to Assur. Also Gudea of Lagash (c.2,200 B.C.) states that he used tin from Meluhha and, although it is not precisely known where Meluhha is located, the consensus seems to be to place it in Afganistan or Pakistan (Cleuziou & Berthoud, 1982).

Traces of tin reported in the ores of Misgaran, Afghanistan and recent investigations of mineral deposits in the Sarkar Valley, Afghanistan by Cleuziou and Berthoud seem to support this claim. A survey of ancient mining sites in the area south of Herat was carried out. Here in the Sarkar Valley tin is found in alluvial deposits downstream from the granite hills which encircle the plain. Flakes and several lumps of cassiterite were recovered from the alluvial sand by the research team. They also report that Soviet prospectors have come across tin deposits in Uzbekistan in Central Asia which were exploited from the mid second millenium. The proposition that Afghanistan is a good

potential source for the tin used in S.W. Asia in the 3rd millenium is therefore gaining support.

Although there is as yet no conclusive proof, another factor important to this discussion is that tin deposits extend into the province of Badakhashan where mining for lapis lazuli has been reported. Herrmann (1968) claims that the mines at Badakhashan were the probable source of the vast quantities of the stone that were imported into Mesopotamia from as early as 3,500 B.C. And it was Muhly (1973) who first pointed out the possible connection between the trade in tin and that in lapis lazuli. His argument went as follows: since there was already a well-developed trade in the semi-precious stone with the starting point focussed in Badakhashan and considering the evidence for the use of tin bronze in Afghanistan it seems reasonable to suppose that tin also was being traded from the same area.

Stech and Pigott (1986:56) sustain this view and believe that the focus of the tin trade in Mesopotamia, bound up as it was with markets in exotic materials like lapis lazuli and gold, had less to do with a recognition of the technical improvements which tin bronze represented than the fact that it was valued because of its rarity. The fact that it had to be transported over a vast distance would have had an influence on estimations of its worth. There would be no other reason to import tin from a distant land if arsenical bronze was available and this alloy seems to have been present throughout S.W. Asia. Furthermore, in his study of the development of metallurgy in Anatolia, de Jesus (1980) argues that the necessity for tin has been over-emphasised in the literature and reports the surprisingly common use of unalloyed copper in this area throughout the Early Bronze Age, a situation that was also prominent in the European Early Bronze Age. He makes the point that there would have been little reason for these bronze-producing communities to

import tin over long distances when it is obviously the case that metal-workers could manage well without it (1980:59).

Yet early Anatolian tin bronzes are known and a number of scholars have been attempting to locate sources of tin there. A very recent development has been the discovery of significant amounts of tin in the form of stannite in samples of argentiferous galena ores taken from the Bolkardag Taurus mining area in Turkey (Yener & Ozbal, , 1987). A survey of this area also revealed the presence of archaeological settlement, furnaces for smelting, slag and other occupational evidence dating from the Neolithic (Yener, 1986); and the current research programme is concerned with examining these ancient mining sources and the sites associated with them, in order to locate the development of metallurgy within the framework of a changing social system.

Transport of ores

The subject of the distribution of metal ores and supply routes prompts the questions of how and in what form they were transported. Once again tin remains an enigma and the questions cannot be fully answered in view of the lack of documentation on the metallurgy of early tin. Since very few artefacts of metallic tin occur, it seems likely that tin was shipped and used as an ore rather than as a metal. On the other hand, a long distance trade in tin, although it is hypothetical at the moment, would seem to suggest transportation in the form of metal rather than ore since this would reduce the weight and bulk of the load considerably.

The occurrence of tin in its metallic form would confirm the latter, but it has already been pointed out that finds of pure tin are rare. The earliest include a bracelet from

Thermi, on the island of Lesbos off the west coast of Turkey, which dates to the middle of the third millennium B.C. and two objects from Egypt which have been dated to around 1400 B.C. More recently, there has been the discovery of more than forty tin ingots and many fragments of ingots on the Ulu Burun wreck off the South West coast of Turkey (Pulak, 1988:8). Other tin finds on the wreck included a mug, a pilgrims flask and a bent plate. Further, five tin ingots, three marked with syllabic signs, have come from an undated context off the coast of Israel (Galili et al. 1986, cited Pulak, 1988; Penhallurick, 1986). And tin ingots have also been reported from the harbour at Haifa, two of which survive, and have been tentatively dated to 1500-1100 B.C. on the basis of the Cypro-Minoan inscriptions which they bear (Maddin et al, 1977). Although these are the earliest tin ingots known to date, there seems to be good reason to speculate that they were in existence a lot earlier. The Akkadian word 'riksu' which has been translated as a chain, a knot, a link and a torque does suggest that tin was transported in its metal form (Garelli, 1963 cited in de Jesus, 1980).

There is also pictorial and textual evidence for metallic tin from the Near East. The Tomb of the Two Sculptors at Thebes shows a metal processing scene which depicts two ingots - a red copper ingot and a blue/grey rectangular tin ingot. And exact proportions of tin and copper are referred to in recipes for bronze making contained in many Bronze Age cuneiform texts (Muhly, 1980:46).

The find of the Haifa ingots not only helps towards resolving the problem of what form the alloying agent took but also constitutes a significant step as far as resolving the question of the direction of the tin trade in the Eastern Mediterranean is concerned. Maddin et al. discuss the implications of the script on the ingots (1977). These

markings are also found on copper ingots of Late Bronze Age date and Maddin suggests that both metals were distributed together by an administrative centre focussed on Cyprus. Whether or not the tin was in ingot form when it arrived in Cyprus, or whether the imported ores were smelted on the island, are questions which remain unanswered.

Other evidence for the long distance trade in tin and copper comes from two LBA shipwrecks off the coast of Turkey. Excavations off Cape Gelidonya revealed the cargo of a Bronze Age ship, the bulk of which consisted of copper and bronze ingots and fragments of ingots. Some white material has been tentatively identified as tin (Bass, 1967). The Bronze Age cargo also included copper ingots and the Cypro-Minoan script on these clearly indicates the Cypriot connections of the vessel. It seems likely that the ship was sailing in an east-west direction and had called in at Cyprus. It has been estimated that there was one ton of metal on board.

Another LBA shipwreck has been recorded at Ulu Burun (Kas), again off the coast of Turkey (Bass et al, 1984, Bass 1986, Pulak 1988). An initial count of the copper ox-hide ingots on board estimated a number of 150, but there may be many more. In addition there are more than 40 tin ingots and several fragments, 17 of which appear to be of the ox-hide form.

Again there has been speculation concerning the focus and direction of trade routes. Bass et al (1984) conclude that the Cape Gelidonya ship was a Syrian or Cypriot merchantman, although other scholars argue that it was probably Mycenaean and propose a Mycenaean monopoly of Bronze Age merchant fleets. It seems that the Ulu Burun wreck was evidently sailing west of Cyprus too, but its ultimate destination can only be a matter of conjecture

based on matching the types of objects found on board with their corresponding distribution on land. Pulak (1988:36) proposes that, since the wreck demonstrates that Syrian and Cypriot wares did reach the Aegean, then their absence in this area could be explained by the fact that this particular part of the cargo was destined for elsewhere and that, after unloading the main cargo of copper, tin, resin etc. on the Greek mainland, the voyage continued to Egypt. Excavations on a small island close to the natural harbour at Mersa Matruh have recovered quantities of Cypriot, Minoan and Mycenaean wares.

This level of 'international' trade in metals presupposes an organised system of transportation. According to Heltzer (1977), for journeys overland we are dealing with the caravans of donkeys, which are mentioned in ancient texts. And Muhly (1973:262) notes that the transport of knuckle-bone shaped tin ingots across Gaul to the mouth of the Rhone by pack animals is described by Diodorus Siculus. But the recovery of the shipwrecks, together with the fact that copper oxide ingots exhibit an essentially coastal distribution, lends weight to the argument that the trade in copper throughout the Mediterranean was mainly a seaborne one. Ingots have been found in the Levant, Sardinia, Sicily, Crete, Bulgaria and Cyprus. However, although ingots have been identified with a trade in Cypriot copper for a long time, few ingots have been found in Cyprus itself. Apart from a number of miniature ingots with Cypro-Minoan script the only other known ingots from Cyprus are one found at Enkomi and a fragment of an ingot found with the Mathiati Hoard (Muhly, 1980:42).

Only one mould for these oxide copper ingots has come to light so far, at the palace of Ras Ibn Hani, Syria (Bass, 1986:294). Bass has suggested, given the paucity of mould finds, that this example, which is made out of stone,

probably had some special symbolic purpose and copper oxide ingots would normally have been cast in individual perishable moulds. Some recent experimental work has demonstrated that they can be cast in sand with convincing results (Merkel and Tylecote, 1982).

With the recovery of more material and further analysis of ingots and artefacts, in addition to the characterization of ore deposits of the sort typified by Gale and Gale, it may be possible to demonstrate the direction of these trade links with more certainty. Pottery evidence too indicates an extensive trade link between Greece and the Levant but in one direction only. Mycenaean pottery has been found in the Levant, although Levantine wares are rare in Greece.

In Central Europe too there is evidence that copper was being carried around in ingot form in a period contemporary with mining at the Mitterberg. Two forms of ingot have been identified and there is a pattern to the distribution in that ring ingots show a density around Austria and Bulgaria whereas rib ingots show a more western grouping. Junghans, Sangmeister et al. (1968), cited in Harding (1983), analysed a large number of ring ingots and were able to classify them into a number of metal groups. One type was predominant, although another occurred quite frequently, and accounted for 20% of the ingots. The results give good reason to suppose, therefore, that there was one major source of metal and another ancillary supply, as well as those sources which provided only a minor input. It is suggested that the major contribution came from the Austrian mines.

Using techniques of analysis like this it is possible to make direct correlations between the source of ore and the smelted product and trace the direction and distance from the point of origin. The aim could be, perhaps, to provide a classification of trade links into long, medium and short

distances while at the same time examining the nature of the links for evidence of interlocking networks which may have existed, distributing other exchange commodities apart from copper and tin. Other critical variables include the direction of the exchange, whether it is in one or both directions and whether the flow of goods is symmetrical, i.e. is it substantially greater in one direction than the other?

The long distance trade in metals has usually been defined as a specialist one in the literature, involving an organization of specialist occupational groups such as miners, smelters and smiths together with the personnel involved in the transport of the raw materials. While this scale of organization might be envisaged for some areas in the Bronze Age, particularly those with urban centres, e.g. the cities of Sumer and the palace centres of the Mycenaean civilization, for the most part settlement in this period is characterized by small, self-sufficient communities. Clearly the needs would vary enormously and, whereas metal may have become a necessity in one context, in another it would have remained in the luxury sphere. In addition, there is evidence for increasing social stratification in the Bronze Age and therefore differential access to metal is also a variable which has to be taken into consideration in the discussion of trade networks and the procurement of metals.

To project onto Bronze Age society a model involving direct or indirect contact between specialist groups connected in a wide network over sometimes vast distances would seem to represent, therefore, a gross simplification and only one end of a whole spectrum of exchange mechanisms and spheres of exchange and which will be discussed now in the light of some ethnographic parallels.

Exchange mechanisms

The notion of exchange is an extremely complex one and has become an important area of study in archaeological research. Briefly, there are two main theoretical frameworks which are used to explain economic formations in societies - the formalist school and the substantivist school.

Formal economics developed in the context of a Western industrial market economy, the basic assumption being that human material wants are unlimited but the means of achieving these wants are not. People, therefore have to make choices between the different uses of these means i.e. how to use time, capital etc., in order to achieve the ends. Another assumption is that people economise, they will make choices between different courses of action, or means, in a rational way, i.e. in a way that will maximize the individuals profit. But this definition of economics only makes sense in the context of the society in which it developed.

Anthropological data shows that in all societies individuals make choices in terms of means and ends, but the choices that they make are governed by very different values and principles from those of Western industrial societies. The choices that they make may seem irrational and uneconomic to us, e.g. the investment of time and energy in ceremonial occasions or in leisure activities which do not seem to bring any material benefit to the individual, but this is only because we are judging them in terms of our own value system and assume that individuals have unlimited wants for material possessions. Again, in all societies individuals make choices based on increasing their prestige and social status, but this is not always associated with personal

display but may involve appearing generous and giving goods away to other members of the community.

Gellner explains these differences succinctly in a discussion of the discontinuity which exists between primitive and modern mentality and cognition systems. What we have to understand, he says, is the difference between 'single strand activities' on the one hand and 'multi-strand activities' on the other. In our own society with its complex division of labour activities are neatly separated, an aspect of our own particular and distinctive course of historical development. The effectiveness of the outcome of these activities can be objectively measured. But this is not the case in simpler societies where there is no single, clear aim involved, as he goes on to illustrate:

A man making a purchase is simply interested in buying the best commodity at the least price. Not so in a many stranded context: a man buying something from a village neighbour in a tribal community is dealing not only with a seller, but also with a kinsman, collaborator, ally or rival, potential supplier of a bride to a son, fellow juryman, ritual participant, fellow defender of the village, fellow council member. All these multiple relations will enter into the economic operation, and restrain either party from looking only to the gain and loss involved in that operation, taken in isolation. In such a many-stranded context, there can be no question of 'rational' economic conduct, governed by the single-minded pursuit of maximum gain. Such behaviour would disastrously ignore all the other multiple considerations and relationships which are also involved in the deal, and which constrain it (Gellner, 1988:44).

Formal economics, therefore, has limited application in the economic systems of non-industrial societies, both past and present, and we therefore have to turn to the substantive meaning of the term economic. According to some scholars, this implies not trying to separate out any behaviour which can be defined as purely economic, but to examine the way

that all material needs are satisfied in the society. Also, economic activity may not only be concerned with maximization of material interest, but also has social and political ends. Polanyi (1957) and others have pointed out that a particular form of economic exchange is embedded in a particular social formation and therefore has to be interpreted against a background of the total cultural system. The anthropologist, in his study of economic relations within a society, has to examine a variety of institutions other than markets in which economic activities are embedded.

Polanyi (1957) identified three main ways in which exchange of goods and services takes place: reciprocity, redistribution and market. Each type is predominantly associated with a particular form of social and political organization although more than one system usually exists in any society. Industrial societies, for example, are distinguished by the large extent of a single sphere of exchange governed by market principles, although the market does not intrude in gift exchange which has different rules and principles governing it. Where there is more than one system then, each will normally be used for the exchange of different types of goods and services.

In this discussion of conceptual issues it might also be appropriate to introduce the notion of spheres of exchange. These are the different categories or contexts in which specific types of exchange take place with interchangeable goods. For example, Salisbury, in his study of the Siane of Papua New Guinea, noted three spheres of exchange (1962). The first was concerned with subsistence goods, the second with luxuries such as tobacco, palm oil etc. and the third with valuables, e.g. ornamental stone axes, rare shells, bird of paradise plumes etc. The exchange between clans of women in marriage also belong to this category. The last

group are used only in ceremonial exchange between groups led by 'Big Men' and it would be impossible to think of exchanging an item in this category for one in another such as food. The individual who tried to do so would be regarded as either mad or the victim of sorcery. However, although these categories may remain watertight within the boundaries of the community, there are examples in the ethnographic record where a commodity, exchanged in a particular context internally, is used in external trade for impersonal 'one-off' transactions between individuals who have no kinship links.

Returning to the archaeological record, ethnographic studies of exchange have been useful to the debate about trade in that they have illustrated a whole range of mechanisms. Given that the ethnographic record is fragmentary anyway, even these do not represent the totality of cultural possibilities. In the light of this evidence, a model of long distance trade in the Bronze Age, involving specialized trade contacts, would be difficult to support in most cases. Distance would have been an important factor in influencing people's behaviour. Political and social interaction stops at community boundaries beyond which the individual assumes the dangerous status of stranger.

In a study of ceremonial exchange and trade among the Wola people of the southern highlands of Papua New Guinea Sillitoe notes that, where a commodity occurs in the territory of a neighbour or unoccupied country separates them from the source, then individuals will travel considerably long distances to gain access to them (1978). On the other hand, where the source is a vast distance away or the intervening territory is inhabited people do not move to the goods but wait for them to filter through to them, as they change hands in a diffuse network of trade links. Wola tribesmen, on the periphery of the distribution area for

stone axes travelling from the eastern highlands, have no idea of the distance or direction of the source.

Another interesting point concerns the widely held assumption that materials flow from their point of origin to areas where they are not found. This type of movement would seem to conform to an economic logic in that people close to the source of a particular raw material, for example, would keep back enough to satisfy their own needs before exchanging any surplus for goods from elsewhere. However, this type of economic reasoning does not explain the flow of material back in the direction of the source. In the highlands of Papua New Guinea objects such as stone axes travel back in the direction of their source and even return to their point of origin, according to Sillitoe (1978). He explains this movement in terms of the social value of some materials as opposed to their functional value. Objects which are used in ceremonial exchanges are continually handed on, so the fact that an individual may receive something of which he has enough to meet his needs is of no consequence since he will pass it on again in another ceremonial exchange. This example illustrates a point also made earlier, that objects and raw materials have a value as social and political assets, as well as economic ones, and social and political forces will affect the movement of goods.

Studies such as these may be useful in interpreting anomalies in the distribution of materials in the archaeological record, as well as illustrating the kinds of patterns of exchange that arise and the outcome of such exchanges. In the example just given and in Melanesia generally wealth, both in the economic and symbolic sense, circulates throughout the society as do the socio-political positions which it legitimizes. Goods are not withdrawn but continually change hands within the system giving temporary

access to prestige and status. In contrast, in other systems, access to strategic goods is limited to individuals or groups within the society and invested in such things as lavish burials, which reinforce and legitimize the authority of the elite.

Exchange mechanisms, then, vary as a function of social and political organisation, and the means by which smiths and smelters received the raw materials of their craft could have differed enormously. At one end of the spectrum would be the example of specific allocations of metal to skilled craftsmen attached to high status groups, such as seems to have been the case in L.B.A. Greece, for example, (Chadwick, 1987:140). Palace officials may have supervised commercial networks which followed well-defined routes as in the case of the Benin kingdom, where long distance trade was controlled by various trading associations, each operating on different routes. Bradbury (1973) points out that it was in the interests of traders to support the Benin polity in that they then secured a state of security in which to carry out their transactions.

This type of level of organization, however, is unlikely to be found outside of a formally centralized political organization. The standardisation in the form of ingots, documented in Central Europe, the Mediterranean area and the Near East, implies an increasing efficiency and centralization in the production of metal. At the other end of the scale, the smith concerned with production for a small general population, perhaps supplying a small settlement or a group of neighbouring settlements, would be involved in different kinds of mechanisms. Rowlands (1971) describes how smiths in many societies are supplied with the raw materials by their customers, who obtained it from a smelter or by exchange. There are also cases to be found in the ethnographic literature of iron-smiths collecting their

own raw materials, as is the case with some Baganda smiths (Roscoe, 1965).

The problem of ethnographic analogy, in the case of an actual trade in metals and metal ores, is that, in contemporary societies, the metal in question is usually iron and this shows quite a different distribution pattern to copper and tin. Iron ore is probably the most widespread and abundant ore and, therefore, questions of supply routes and the means by which the raw material was procured by the smith are bound to be different, especially when compared with the situation of a Bronze Age smith operating in an area where workable deposits of copper ore were not so freely available. Indeed, it has been suggested that a breakdown in copper supply routes and patterns of exchange may have been one of the most decisive factors in the transition to the predominant use of iron by prehistoric societies (Snodgrass, 1971:258).

Conclusion

The relevance of this discussion to the main theme of this study is this: the production of bronze artefacts is something to be seen in the context of a complex series of processes concerned with the extraction and processing of metal ores and their transportation to the places where craftsmen could work the metal. While it is plausible to interpret these processes in terms of the logic of economic exchange, it has also to be acknowledged that exchange is culturally prescribed, and that this is only one of the possible forms of exchange within which metal and metal ores came to be distributed.

CHAPTER 3

MANUFACTURING TECHNOLOGY

This chapter is concerned with the processes involved in the manufacture of bronze objects. The individual techniques have been well-documented by Hodges (1971) and Tylecote (1986) and need not be repeated in great detail here. However, the critical questions which this chapter will focus on will be levels of skill and technical change as seen within the context of a particular socio-economic setting. Technology does not stand by itself, it is always embedded in specific social arrangements, and skills reflect as much on social organisation as on technological knowledge. So, although on the one hand the aim is to examine the development of increasingly complex techniques and processes, the underlying assumption is that it is somewhat artificial to separate these off from social organisation.

Practical skill and knowledge

There are many aspects of social structure that have to be understood in the light of the skills required to manipulate the materials used in metalworking. In the case of the inlaid daggers described by Vermeule (1964), from the Shaft Graves at Mycenae, for example, these are obviously the work of skilled specialists operating within the framework of a society which was highly differentiated with a complex division of labour. This is an instance too when craft skills border on or are combined with artistic skill. The daggers are intricately decorated with figured scenes in which different materials have been used for their contrasting colour and texture. It seems we are dealing here

with a society where certain individuals are recognised as having exceptional artistic skills and may have been full-time artists. In many Bronze Age societies , on the other hand, even if the artistic qualities of an individual were acknowledged his speciality would have been combined with other types of activity and applied to the manufacture of objects of everyday use.

Artistic skill too cannot be seen outside of cultural context. Art is a symbolic way of communicating. It conveys and reinforces cultural values which are important to the society. In our society our conception of the artist is someone who is separate and perhaps at odds with society and this is in keeping with cultural values which place an emphasis on individualism. The product is seen as unique in contrast to other societies where it appears to conform much more to the cultural traditions. The artist too, then, is a product of a particular culture. And this point is further emphasised by the fact that, although individuals with artistic skills could be found within all groups, most societies restrict this role to certain individuals and in some cases it may be inherited within families, clans or castes just as in the case of the craftsman.

The societies with which we are dealing in the Bronze Age are ones in which there is much evidence of a complex practical knowledge of metallurgy without there being any information on the level of theoretical, scientific understanding of all the separate processes involved. What we are concerned with, therefore, is accumulated empirical knowledge or experience built up over centuries. For example, the Early Bronze Age smith had control of a material which could be moulded, hammered or cast into a tool, an ornament or a vessel. The finished objects could be melted down and re-shaped. But for all that he was faced with a problem, which is that copper will not take an edge.

As we understand it in modern terms this is because of the crystalline structure of the metal. Its crystals have parallel planes which slide over one another making the metal soft and ductile. In alloying some of the copper atoms in the crystals are replaced by a different kind making the overall crystalline structure more rigid. This is something which we have come to understand very recently as a result of developments in the field of atomic structure. Yet, by experiment and experience ancient metallurgists found the solution too, that when you add tin to copper the result is an alloy which is much harder than either metal.

Shils (1981:80) has some important comments to make about empirical knowledge and how it is acquired and transmitted from one generation to the other. In the case of empirical technology, he says, the model of the object or artefact always remains concrete and real rather than abstract, i.e. it exists in material form from which a pattern is taken for the reproduction of a similar object, and it also exists as an image in the mind of the craftsman. This image is concerned with the model of the artefact, the uses to which it will be put, the craftsman's knowledge of the tools required to make it and the patterns of physical movements that his body traces in the various stages of the production process. Bodily skills have to be acquired before a tool can be used properly and efficiently. And although tools can be of an extremely simple form they can require a long learning process in an appropriate setting before they can be used to good effect. There are a number of elements involved in such a highly technical process as metallurgy including skills and the rules governing each separate and distinct step in a complex sequence of steps before the final product is achieved. This knowledge was acquired orally and practically by watching a skilled craftsman perform and also making an object under his guidance.

According to Shils, however, the tradition of empirical knowledge does not result in endless repetitions of identical tools and other objects. Craftsmen learn by a process of oral and practical transmission of skills but there is also room for innovation and refinement:

Their innovations were guided by the imagination and sensitivity which arose in the course of their own experience of long-performed operations, itself first acquired by seeing and being orally guided by their elders. This mastery of empirical knowledge is not only capable, through persistent reproduction of transmitting to others what was done before but, to some extent, of becoming detached from tradition through efforts to see how work could be done more effectively (1981:84).

Innovation, therefore, has to be seen as an aspect of human creativity.

An interesting point has been made by Bronowski, which is relevant at this stage in the discussion, and this concerns the process by which ancient metallurgists ordered their experience. He argues that this ordering of the procedure is one of the functions of ritual:

The making of a sword, like all ancient metallurgy is surrounded with ritual and that is for a clear reason. When you have no written language, when you have nothing that can be called a chemical formula, then you must have a precise ceremonial which fixes the sequence of operations so that they are exact and memorable (1979:131).

So it is not just oral and practical tradition which transmit knowledge, but also ritual.

That we are dealing with a range of complex skills is not a new idea. Childe (1930:4) believed that the art of the smith was so complicated that a prolonged apprenticeship would

have been necessary. And Hawkes compares the body of knowledge possessed by the smith to a proto-science:

In the first place, the original implicit recognition that shapeless ore, liquid molten metal moulded in any shape desired, were all forms of the same substance, had been an intellectual feat which deserved to rank among the foundations of scientific thought. In the second, the elaboration of the smiths technique, by constant experiment and invention, turned the product of thought into a skilled craft - a 'mystery' into which the layman could not penetrate, but which made its masters indispensable to him and his whole society. Maintained therefore.....out of society's surplus of subsistence production, the smiths became privileged specialists, passing on their knowledge only within a limited circle of apprenticeship (1940:285).

This chapter then aims to describe the skills involved in Bronze Age metallurgy, to assess their level and complexity and variations in the extent to which these skills were possessed. Some aspects of technological change will be discussed and the means by which changes in technique became known to other craftsmen and were developed further. To provide a framework for the discussion, each distinct manufacturing phase will be separated out and the archaeological data considered. The smelting of copper ores has already been considered in a previous chapter, the focus will now be on casting and mould technology, hammering and beating, the various methods of joining such as rivetting, soldering and 'casting on' and the techniques of decoration and finishing. Other important elements in this debate include the identification of workshops with melting furnaces and the metal-workers tools, e.g. tuyères or blowing pipes, tongs and bellows. An additional aspect is the whole question of design as a process. The craftsmen we are dealing with had to match up the objects they made with the function they were intended to perform. They had to know, therefore, a great deal about the structural

properties of their materials and about what form their products should have to be to fit the uses to which they would be put. Such design skills are a vital part of the overall skills needed to work metal successfully.

Casting

In order to produce a casting the metal has first to be melted in a crucible in a fire or furnace in which a sufficiently high temperature has been achieved. According to Tylecote (1986:81) the earliest crucibles have been dated to the beginning of the 3rd millenium. The archaeological evidence, however, is still not clear on the question of which process was invented first, smelting or melting? The point has often been made that, because of the relatively high temperature required to melt copper (1083°C), smelting must have been discovered first, but there is no conclusive proof either way. Native copper could have been melted and cast into artefacts, but it has as yet proved impossible to isolate and distinguish these objects from those of worked and recrystallised smelted copper of high purity (Maddin et al, 1980). What is clear, 'according to Coles and Harding (1979:10), is that a remarkable degree of uniformity can be seen in the development of manufacturing techniques throughout the European Bronze Age and this is reflected in the similarities in assemblages of bronze weapons, tools and other objects found in different parts of Europe.

The molten metal was cast into moulds which may be of stone, clay or metal. Four basic types of mould can be recognised: open moulds and piece moulds for solid castings, and false-cored and lost-wax or *cire perdue* moulds for hollow castings. The first moulds were simply shallow depressions made on stone, which was specially selected for its properties, which prevented shattering on contact with the hot, molten metal. Sandstone is an example. A number of

stone moulds for flat axes have survived from the Early Bronze Age some of which have two cavities or more. Although they are described as 'open', both Tylecote (1986:84) and Hodges (1964:70) agree that the use of a flat stone cover was plausible in view of the significant amount of metal that would be otherwise lost through oxidation. Their main disadvantage was that they constrained the metalworker to work with the very simplest forms and shapes. However, they continued to be used for objects such as ingots where, perhaps, there was less stimulus to generate design innovation, no further refinements being necessary. They are also mainly limited in distribution to those areas where local supplies of suitable stone can be found. In Britain this was Ireland Scotland, Northern England, Wales and Devon and Cornwall.

The later development of piece moulds and false-cored moulds of stone and clay overcame these restrictions and seem to show more care taken in their construction. Tylecote, (1986:84) notes that the steatite socketed spearhead moulds of the British Middle Bronze Age are carefully faced and greater attention has been paid to the finish of the mould cavity. At Knighton, Devon, for example, two sets of two-piece stone moulds were found, which had been carved to take a matrix for casting rapiers and strips of metal, which tapered to a point perhaps for manufacturing bracelets and rings. They are both made of mica schist which is found locally in Devon and Cornwall (Rowlands, 1976:11). Rowlands also records the remains of cores seen within damaged spearheads dating to the late Middle Bronze Age (1976:12). It may be worth noting at this point that mistakes in casting were obviously made and miscast pieces are known from excavations, but many 'rejects' must have been remelted and recycled so that no assessment can be made of a failure rate in casting. In the early use of the two-piece mould the two parts seem to have been tied together and put

in position by means of deep scratches incised on the outside surface across the join. Tylecote (1986:85) notes an example of this seen in a rapier mould from Killymaddy, Antrim. In a later development the two halves were located using dowel pegs which fitted into opposing holes in each part.

Other refinements included the sprue cup to top up the quantity of metal in the mould as it cools and slowly contracts, and false cores to produce hollow castings as, for example, in the case of socketed tools and weapons. The cores were generally made of clay and held in position inside the mould by means of chaplets. Occasionally moulds are provided with air vents to allow the escape of gases given off during the casting process. But in most cases the porosity of the mould material, as well as the difficulty in achieving a really accurate fitting of the two parts, precluded the addition of these improvements.

Another type of mould that appears in the archaeological record is the clay piece mould, the frequency of its occurrence increasing in the Late Bronze Age. Tylecote (1986:89) explains this shift from stone in terms of the development of increasingly complex moulds in the Middle and Late Bronze Age, which would have been more difficult to fashion in this material. Further, although the stone mould has the advantage that it can be used many times unlike a clay mould which only survives one casting, great care has to be taken to heat the mould up to avoid thermal shock and the resultant cracking on contact with the hot, molten metal. Again, the uniformity in clay moulding technique is noted for the Late Bronze Age. Two-piece moulds seem to be the norm. These were frequently fitted together by means of dowels or an outer casing of clay, which kept the inner mould pieces in position and were accompanied by a core when required.

In many cases it is evident that the craftsman was fully aware of the refractory properties of the clay and there are examples of two types of clay being used in the manufacture of moulds. For the inner pieces the clay had been carefully prepared and a filler had been added to prevent serious shrinkage, while the clay making up the outer casing had not been modified at all and was quite coarse. At Dainton, Devon, Needham (1980:181) points out that the mould debris indicates double-layered mould units, the two inner mould pieces being covered by an outer casing of clay. Further, these are distinguishable not only on the basis of structure, but there are differences in the composition of the clay fabric which are clearly identifiable. These variations, he says, do not result from the use of different clay sources. They arise from distinct differences in the preparation of the clay. This apparent careful selection and preparation of material for the moulds to produce the objects required clearly suggests that a great range of skills and expertise were available. It is interesting to note that it has been estimated that this mould evidence from Dainton reflects the best part of a years work for a small group of smiths who concentrated on the production of weapons (Northover, 1988).

The Irish cast bronze horn is an object which reflects the more extraordinary metallurgical accomplishments of the Late Bronze Age smith, and is a useful illustration of the evolution of a complex mould technology. Holmes (1978) has investigated the manufacturing technology of this instrument. All the Irish horns appear to have been cast in two-piece clay moulds consisting of a cope, a drag and a core. With a curved core, however, the problem is how to support it within the mould during the casting process. Held at both ends by the provision of 'prints' in the mould, nevertheless the centre of the core is subject to various forces which can cause it to twist and move in the mould.

When the mould is filled with molten metal, for example, the core is forced vertically upwards which results in a thin section in the cope or upper part of the mould. According to Holmes (1978), this is one of the most common casting faults to be seen in these instruments and he has studied developments in the design and placing of chaplets, which were obviously intended to overcome this imperfection.

Small clay supports placed above and below the core could have been one simple solution. Left in place during casting, the result would have been holes in the walls of the tube, and evidence for the use of this technique is seen in some instruments, where openings left by the core supports have been filled with cast-on bronze plugs. That this device may have proved inadequate, however, is suggested by the specimen examined by Holmes (1978), which shows traces of additional core-supporting features in the form of metal chaplets, which become integrated into the body of the casting. Even these did not prove to be entirely effective. Held in a grip between the cope, drag and core, this pressure has to be quite precise if they were to remain in position during the casting process. A number have obviously slipped at some stage and this particular problem was solved by manufacturing chaplets which were keyed into the core. This was no easy solution, however, and presented a number of challenges among which was the design of a chaplet that would pierce the core easily. This was achieved on a well-defined group of instruments by the development of a hollow, tanged chaplet. Other problems included the need for the core to be wet for the chaplet to penetrate it, and a solution had to be found to overcome the change produced by the shrinkage of the clay on drying out.

The Irish bronze horns, therefore, show how mould technology developed step by step from the relatively simple Class 1 forms to highly complex Class 2 types. And Holmes (1978),

makes some points which are useful in the debate about empirical tradition and innovation. He says that Class 1 horns utilize the simpler processes, but at some stage the manufacture and use of horns spread to the south west of Ireland, where a more complex technology was used. So it seems to have been in this area, free from the tradition that had grown up around Class 1 horns, that technological development really seems to have taken off.

Another type of mould, the bronze mould, can be identified from the Middle Bronze Age onwards. It is possible that bronze was cast direct into them and Tylecote (1986:92) cites Coghlan who has carried out such casting experiments successfully. The question remains, however, as to whether they were actually used for direct casting of bronze axes and other objects or possibly creating models in materials of a lower melting point such as lead. A number of moulds have been identified with traces of lead adhering to them. And another point to be made in any assessment of the problem is the fact that, as the bronze mould could have been re-used for a number of castings, the expectation would be that products from the same mould would be identifiable. The absence of many examples of identical objects would imply that they were not used very frequently for direct casting or else they were comparatively short-lived.

An alternative method which was used to produce complex mouldings was the lost-wax or *cire perdue* technique. In this process a core model was built up of clay to conform very roughly with the lines of the finished object. This was coated with several layers of wax until the desired thickness of metal was achieved. The exact details of the object were cut in the wax and the whole was then encased in an outer mould of clay. After it had hardened, the mould was then heated and the molten wax was run-off leaving a space into which the metal would be cast. There is no

evidence so far for the use of this technique in Bronze Age Britain but it is well-attested in Europe and the Near East in the later Bronze Age. For example, the huge array of bronze figures which have come to light in Sardinia appear to have been cast by this process (Guido, 1963).

Finishing

Once the objects had been cast, there were the various stages of finishing and fine decoration to be performed. With those objects which had been cast in two-piece moulds, the ridges of metal that remained where the moulds had joined were sometimes removed. This treatment was not always carried out and the 'flashes' or joinlines that remain on some objects are almost certain proof that they were manufactured in a piece mould. Final shaping, in the case of axes and daggers, involved reheating, annealing, hammering and polishing to produce a sharp and smooth edge and also to create flanges. Hodges (1971) points out that, besides being a means of shaping, if the metal is left unannealed after the final hammering treatment it remains very hard and produces a good cutting edge.

A number of other finishing details are worth noting. Bronze objects were often coated with another metal, a process called flushing or flashing. For example, Clarke et al. (1985:181) note two axes from Sluie, Moray which have tin enriched surfaces and they cite a number of scholars who have also reported the apparent tinning of bronze axes, e.g. Kinnes et al. (1979). Presumably this was to give the impression of silver objects and single them out from the general run of bronze axes.

Joining

A number of techniques were used to join two pieces of metal together. The process of running-on or casting-on was commonly used in the manufacture of swords, where the blade and tang were cast first and the handle cast-on later. It relies on the principle that molten bronze, when cast against a bronze object, will fuse with it on condition that the original bronze surface is perfectly clean. Casting-on was also frequently used to repair broken castings or in the addition of a handle to a beaten bronze object. The new piece is cast and attached to the earlier stage in one operation.

Other joining processes were known. Tylecote (1986:110) notes the use of a welding technique known as 'burning' in the repair of an Irish Late Bronze Age sword hilt. Molten metal had been poured between the heated surfaces of the broken weapon to fuse them together. And he points out that the principle of soldering using a different alloy to join two pieces of metal appears to have been understood by the Late Bronze Age in Britain. Bronze with a higher tin content, for example, has a lower melting point than a less alloyed bronze. The advantage to the craftsman in using such a solder is that he can then work at temperatures well below the melting point of the metal being joined.

Bronze Age smiths were also familiar with riveting. In the first instance these consisted of short lengths of metal rod simply hammered down at both ends. But at a later stage rivet heads were specially made by casting or by shaping with a punch type of instrument into a variety of forms. Besides resulting in a stronger join, there was also the advantage of the decorative effect that could be achieved through their use.

Sheet metalworking

Sheet metalworking was also undertaken and Bronze Age smiths were capable of producing quite large pieces of sheet bronze beginning with the initial flat ingot which was then hammered out, probably with the use of smooth stone pebbles. The improvement of this technique made it possible to create objects such as bowls, cups, buckets, cauldrons and items of armour - a great technical achievement when one considers examples of earlier hammer-work which were limited to small ornaments such as sheet metal pendants. Copper, as cast, is soft and malleable but with the addition of tin the physical characteristics of the metal are altered so that it becomes harder. Cold-hammering also alters the elastic properties of bronze so that the harder it becomes, the less malleable it is, until it will eventually crack. This can be reversed by annealing or heating the metal to a temperature of about 400°-500°C and cooling it, a process which returns the metal to a soft and workable condition again. This procedure would have to be repeated a number of times in the production of large pieces of bronze sheet. Examples of sheetmetalwork of a monumental scale, seen in the decorated bronze overlays for palace and temple doors in Assyria in the late second millenium, illustrate the smiths' total control of the technique (Moorey, 1985:50).

Tylecote (1986:107) notes one of the largest pieces of British Late Bronze Age bronze sheet which forms the upper part of the Colchester cauldron and measures 0.28 m by 2.13 m (weight approximately 2.27 kg). In Central Europe smiths seem to have had even more control of the technique and produced cauldrons which have been formed out of a single sheet of beaten metal. These and smaller vessels, such as cups and bowls, were produced by either of two techniques or a combination of both. In a process called sinking sheet metal is hammered from the inside on the surface of a wooden

anvil, which can be either flat or have a depression cut into the surface. The alternative method, referred to as raising, involves repeated hammering on the outside of the sheet using an anvil with a small dome-shaped head (Hodges, 1971:74). On average, the thickness of the sheet metal used for these vessels is usually of the order of 0.5 mm. They must have been extremely difficult to make requiring a high standard of workmanship.

Although the malleability of gold makes it an easier metal to work by hammering and beating than bronze, the quality of sheetworking in this metal even in the Early Bronze Age and the production of very thin leaf or foil again argues for considerable skill. Like bronze the metal is worked cold, but requires annealing, otherwise it becomes brittle. When working with sheet gold a stage is reached when it is no longer possible to hammer the metal surface directly, and in the final stages of production it seems that the metal was held between two sheets of leather to reduce the extent of the impressions made by the hammer. Some of the finishing effects that have been perfected are positively awe-inspiring. According to Taylor, the final highly burnished surface that has been achieved on some gold leaf objects among the grave goods of Wessex, such as on the Bush Barrow belt hook and lozenge plate or the Upton Lovell button cover, have proved a puzzle to modern goldsmiths, who cannot find a satisfactory explanation of the processes entailed (Clarke et al., 1985:184).

Techniques of decoration

Decoration has obviously been an important aspect of the craft of the metallurgist and again there are considerable variations in the scale or degree of accomplishment. As already indicated, this is sometimes an area where technological skills merge with artistic ability, and some

individuals were obviously more competent in technical skill as well as having a more sharply developed sense of the aesthetic. e

There are a number of techniques. Decoration was cast in or applied either by cold working of the metal itself, or by overlaying or inlaying with other metals and materials. In *repoussé* work, for example, thin bronze was worked by raising decoration from either the front or back, so that it stood out in relief giving a three-dimensional quality. The decoration was impressed with round-ended punches on the surface opposite to that on which the relief design was required. In some cases of exceptional workmanship the height of the relief suggests that it was raised against a material that yielded enough to allow the pattern to be impressed into the surface, but was at the same time firm enough to support it. Traces of such a material have been identified in the fill of the gold Lannion box (Lanting, 1974 cited Clarke et al 1985:184) and analysis has shown that it is an equal mixture of sand and fir resin, similar to modern jeweller's resin. In those examples of *repoussé* work which do not demonstrate the same precision of technique, the decoration may have been raised against a pad of leather.

The application of other metals such as silver and gold was carried out in two ways. The crudest method involves a degree of pressure welding in which decoration is achieved by hammering the overlay metal down onto the roughened surface of the metal to be decorated. In a more refined process, known as inlay work, the metal to be applied is hammered into cavities or recesses in the surface and lies level with it in the finished product. In the finest examples of this technique the edges of the cavities were undercut to ensure that the metal kept in place. The inlaid dagger blades discovered in the Shaft Graves at Mycenae show

the most remarkable mastery of this technique. Vermeule describes them as follows:

For the three Mycenae blades the smith cut a shallow bed into the bronze and laid in a darker sheet of bronze against it, into which cold-hammered cut-outs of figures and landscape elements were set. He polished the surface to remove hammermarks, oxidized the blade to darken the silver parts, engraved the details of tunics, hair, eyes and spotted skins. Finally he filled these incisions with black niello, a copper-lead-sulphur-borax compound, heating the blade to burn it in. Different grades of metal were used for colour contrast: in the Nile scene, pale gold, polished silver, and pale electrum for the fish and papyrus blooms; reddish electrum for drops of blood on a duck's breast; dark silver for the river; and bronze for the fields behind, all framed in the brighter bronze of the cutting edge. This is correctly called Metallmalerei, or painting in metals (1972:98).

The working of bronze reached its finest expression in examples such as this and the possession of such an object undoubtedly enhanced the status of the owner considerably. The craftsman obviously had complete command and control over the material he was working, although the tools that he worked with may have been relatively basic. An inventory of the Bronze Age smith's instruments and equipment has to be surmised both from the finds and an examination of the methods used in this particular period.

The toolkit

The tools and equipment of the smith would have varied with the particular metalworking technique so that for the melting and alloying processes, for example, there is evidence for the use of crucibles and bellows. In the casting process tongs or some equivalent device, such as two pieces of green wood or withies, would have been used to pour the molten metal from the crucible into the mould. The

latter method can be seen in use in many Egyptian tomb drawings such as that in the tomb of Mennah at Luxor, in the Valley of the Kings. Once the objects had been cast there were various stages of finishing and fine work to perform. This stage may have involved cold-working the metal and annealing and hammering to produce a cutting edge, sharpening or grinding the tool edge, or the removal of casting seams where the two pieces of the mould had joined. Some pieces were decorated with punch marks or other tool marks at this point. The tools required would have included hammers, chisels, punches and tracers and a grinding surface provided by a whetstone. In the production of sheet bronze work an anvil and hammer were again a necessary part of the equipment and drills and punches would have been needed to form rivet holes, as well as other instruments which could be used to produce incised decoration. However, although this outline of the tools and equipment as well as the metallurgical techniques of the Bronze Age smith can be determined from the evidence available, taken together the reconstruction of metalworking activity at a particular site often must depend on the most fragmentary evidence. Though it may give some notion of the type of smithing activity involved, many questions are left unanswered.

Turning first to those indicators for alloying and melting, we now have crucibles from a small number of Bronze Age sites in Britain. At Dainton, Devon, for example, a number of crucible fragments have emerged some of which are quite substantial and show the remains of legs and pouring lips (Needham, 1980:186). A vessel reconstructed from these remains shows a unique tripod structure and has been estimated to have had an internal diameter of 135 mm, and bowl depth of about 40 mm. According to Needham, this could have held a mass of 2,970 gms of copper alloy and represents the upper limit of the size range at present, probably reflecting a period when production was involved with fairly

large tools and weapons. At the same site a distinctive form of mould material was recovered consisting of fragments of two-piece clay moulds with an outer clay casing. Crucible fragments have also turned up among the metal-working debris at other Late Bronze Age sites such as Mucking, Essex; Rathgall, Co. Wicklow (Raftery, 1976), and Runnymede Bridge, Berkshire (Needham and Longley, 1980). At Springfield Lyons 'stronghold', again dating to the Late Bronze Age, clay moulds which appear to have been used for casting swords were discovered in the ditch terminals although there was no trace of metal found throughout the enclosure (Buckley, 1988).

Crucible and mould technology also appear at a number of European sites; Hallunda, Sweden; Swiss lakeside sites; Lake Ledro in Northern Italy etc. Other equipment associated with this metallurgical phase includes bellows and tongs. Hodges (1970) notes that bellows were certainly around shortly after the beginning of the second millennium, because there is a reference to them in an inscription on one of the Mesopotamian clay tablets, and at a later date there are depictions on Egyptian tombs showing bellows in use. From them the air is directed straight into the furnace by means of a clay nozzle, or *tuyère* and, although the bellows themselves would have consisted of organic material which has not been preserved, *tuyères* have been found quite often on archaeological sites.

Tongs, on the other hand, turn up infrequently. They are much more common in the Iron Age, when the fact that iron had to be worked while red-hot led to changes in metalworking techniques and the development of a different tool-kit. All hammering processes with copper and bronze could have been carried out in the cold, therefore the use of tongs could be avoided. However, the excavation of an important site in the context of Late Bronze Age

metalworking activity, Heathery Burn Cave, Co. Durham, brought to light a pair of bronze tongs with a fragment of a copper or bronze ingot and one half of a bronze bi-valve mould, as well as bronze tools and weapons and a bucket of riveted sheet bronze (Britton, 1968). Two pairs of smithing tongs have also been recorded in Cyprus (Catling, 1964) and what has been recognised as the blade of a pair of tongs was discovered on the Cape Gelidonya shipwreck off the coast of Turkey (Bass, 1967).

Technology required for the finishing process and for sheet metalwork is also documented. Cushion stones and whetstones are known from burials in Britain and Europe. And, although it seems likely that blocks of stone would have functioned as anvils for tools and weapons, small bronze anvils have been recorded, which were obviously used for more delicate work. A small number of bronze anvils have been found from Bronze Age Europe, which seem to have been produced in the later Middle Bronze Age. Ehrenberg (1981) has examined these finds and concludes from their small size that they were only used for fine and delicate metalwork, such as in the production of ornaments. For the larger items produced by tool and weapon smiths, stone anvils would most likely have served and this point has been borne out by the discovery of some blocks of stone at Swiss lakeside sites which show traces of percussion marks (Chantre, 1875 cited Ehrenberg, 1981). The bronze anvils are variable in shape. Some are simple rectangular blocks of metal, while others are provided with beaks for working metal into a curve or with beaks and swages. The latter consist of grooves into which strips of metal can be beaten to form wire. Such grooves can be seen on the anvil from Kyle of Oykel, Highland (Tylecote, 1986:103) and also on the anvil from Fresne-la-Mere (Eogan, 1967 cited Rowlands, 1976:16). The anvils also showed signs of wear in the form of hammer and other tool marks and in most cases have been found in association with

a socketed hammer. These are indisputably sets of bronzesmiths tools but an obvious problem is the difficulty in allocating some tool assemblages to the smith, since a stone hammer and a whetstone alone could not be said to make up one particular specialists toolkit.

Lowry et al. (1971) have discussed some of the decorating techniques of the Iron Age bronzesmith and the question of tools. They compare this craftsman with the modern day silver smith arguing that the physical characteristics of the metals are quite similar and therefore they respond in the same way to comparative treatment. They maintain that, from the Late Bronze Age and even earlier, the different types of tool marks that can be identified on objects can be so easily reproduced with the basic tools of the modern silversmith that the ancient toolkit must have been remarkably similar. The difficulty arises in distinguishing bronze tool marks from steel ones and, although they accept the fact that very hard bronze may have been made and used, they argue that bronze cutting tools such as gravers or scorpers would have been ineffective on bronze. There is, of course, evidence for the production and use of iron in the Bronze Age. Recently an iron object of awl or punch form was recovered from a Middle Bronze Age trackway in a raised bog in Drenthe, Netherlands, which was proved on metallurgical examination to have been produced by a reduction process and then forged (Charles, 1984). On the other hand, a sharp point of flint or hard stone can be used on bronze to draw a design.

Skills, technological change and society

Having looked at the evidence for the sophisticated range of metal-working techniques that were within the capabilities and experience of Bronze Age smiths, it seems clear that the manufacture of bronze metalwork must have formed a

specialist activity, although not all smiths would have had a monopoly of the more complex skills, and many would have been involved in primary subsistence activities to varying degrees. The organisation of metallurgy and the status of the smith, however, does not only vary with degree of technological complexity so that increasing specialisation can be seen to be a result of greater centralization of production. The issue is much more complicated than this. The smith and his craft are embedded in a particular cultural context with specific socio-economic and political forms and all of these will have some influence on the scale and organisation of metalworking. And all of these things must be seen dynamically in the context of changes. Whether societies are centralised or not is not a matter of historical fact, it is an achieved outcome of social, economic and political processes.

In order to accumulate specialised technological knowledge the society would have to be organised so that some individuals did not have to be engaged in food-producing activity for some or all of the time. In some instances demand for the products may not have been great, with no sufficiently large aggregates of population to require a full time specialist. Increasing specialisation and division of labour, with full-time craftsmen producing goods for which there was a continuous demand, may have been stimulated by a number of factors. One of these would have been the demand for prestige goods by a newly emerging elite, and there is convincing evidence that some members of Bronze Age society were more privileged than others. In most parts of Bronze Age Europe wealthy graves can be contrasted with much poorer ones. Wealth, as an aspect of social stratification, is the accumulation of material resources and/or access to the means of production of these resources. The growth of wealth would have helped to create a further clientele for the products of the bronzesmiths and, as the

techniques demanded of the craftsmen became increasingly complex, so it would have been impossible for one man to master all trades or aspects of the economy.

It seems highly likely, then, that with an increasingly differentiated society the force of politics would have been an important one, with leaders seeking to control the raw material itself, as well as the skills of the craftsmen and the final products. And this would be reflected in a move towards a greater centralisation of metal production. Political control might be otherwise threatened in a society where social rank is seen to be becoming increasingly dependent on economic factors. The smiths had the monopoly of important technological knowledge and, therefore, would have the opportunity to become economically better off than the rest of the population if there was no control over them. Haaland (1985:70), has discussed the question of centralisation of iron production in Darfur, Sudan. He argues that both economic and ecological factors should favour decentralisation of the industry in that more labour would be required to transport charcoal to production sites as the immediate area became deforested. Also, severe deforestation would constitute a problem in itself. However, he goes on, both of these explanations ignore those forces found in the area of politics. Decentralised production would always be a source of weakness as far as total political control of the society is concerned, since the technology could be used to produce weapons which could be a basis for the growth of locally decentralised power. But in the case of iron production, it would be extremely difficult to control the source of ore since it is so ubiquitous in the area. Haaland's hypothesis is that political ideology degraded the occupation and set the blacksmiths apart from the rest of the society as a means of maintaining control over them and increasing their dependence on the central authority.

This is one example of the factors that might operate to favour certain organisational solutions as far as craft specialisation is concerned. In other areas other conditions prevailed and the response was obviously different, as reflected in the higher status position of the smith in some societies. It is difficult to compare the situation in Sudan in the recent past, where the technology was specifically directed towards weapon production, with that in the Bronze Age. The uneven distribution of copper and tin is also an obvious dissimilarity; sources and supply routes perhaps could have been much more easily supervised and controlled. But such an analysis of the structure of an industry does provide us with some understanding of the complexity of the forces involved.

It seems fair to assume that one of the conditions required for the maintenance of full time craftsmen would include a large community with an elite group constantly demanding products. The development of more complex skills and technology would have been encouraged too by such aggregates of craftsmen. As Shils (1981:87) argues, the tendency for human beings to invent is probably quite rare and it is probably more usual to adapt traditional techniques and designs. Invention in technology did not become really widespread until relatively recent times, according to Shils. Before then innovators, because of poor communication, would have been unaware of what was happening elsewhere and this is important since 'the perception of inventiveness arouses invention'. Nevertheless, technological imagination was not lacking in the minds of the Bronze Age smiths and centralisation of production must have represented a step forward in this respect as the exchange of ideas became possible. Conversely, with the weakening or collapse of centralised power, the stimulus to innovate, to improve or invent a new tool, might be lost as there was less requirement on metal-workers to do so.

The problem is how to identify different categories of organisation in the archaeological record. It seems likely that a full time specialist would have a permanent workshop equipped with the tools of his trade. One of the clearest examples of this is found at Phaistos, one of the Minoan palaces, where a massive bronze foundry set within a courtyard on one side of the palace implies the presence of resident full time smiths. And metalworking equipment suggestive of a bronzesmiths workshop has also been found in a Minoan mansion at Knossos. Catling and Catling (1984) have described evidence of the casting process, including several clay crucibles, droplets and spills and pieces of metal, which would appear to have solidified in the headers, the runners and the risers of the moulds and were broken from the castings after their removal from the moulds. Remains of a small furnace were also discovered, a nozzle from bellows as well as the tools appropriate to a smith's workshop, such as heavy chisels, drills, punches, awls and tracers. There was also a stock of scrap metal, perhaps intended for remelting.

The high degree of craft specialism is also apparent in the records from Palaces such as Knossos and Pylos, which point to a high proportion of skilled labour not involved in farming. The clay tablets also show that the palaces kept strict control of production. At Pylos exact quotas of metal distributed to smiths are recorded (Chadwick, 1987:140). And it seems that smiths were concentrated into groups of up to twenty six, although interestingly not all of these were located in the main towns. Others were situated in places rarely mentioned again, a pattern which, he suggests, might reflect the availability of a good fuel supply and favourable sites for furnaces. This type of evidence for craft specialism and centralised production is rather unique though. What we are usually dealing with are small isolated groups of tools and other equipment.

In seeking to identify the permanent workshops of full-time specialists we have to define the type of evidence that would clearly fall into this category, apart from the substantial furnace remains in their palace setting already mentioned. We also have to define the nature of the part-time craft. This could have been carried out by individual smiths occupying isolated settlements on the basis of supplying objects, which would normally require a low level of technology, whenever they were required. On the other hand, individual smiths or groups of smiths could have manufactured items on a seasonal basis, spending the remainder of the year in agricultural production. This may even have been the case sometimes in centralised governing centres like the Mycenaean Palaces with their great variety of productive specializations. Evidence for the possible seasonal nature of work was cited in the last chapter. It seems quite probable that some individuals were involved on a part-time basis, cultivating their land or shepherding flocks in between to a variable degree. On the other hand, it also seems reasonable, having considered the evidence of the complex techniques with which they were familiar, to suppose that certain master craftsmen could have had total exemption from productive labour. It could be argued that complete mastery of the practical knowledge and skills involved in the manufacture of some objects could only have come from the persistent accumulation of experience.

The evidence for both these categories of craftsmen would seem to be indistinguishable at this stage. In order to identify them in the archaeological record several different criteria can be considered. First of all the presence of direct evidence of metal-working in the form of 'work-shop' areas. And since the assumption is that the presence of a high degree of specialism presupposes a sizeable community as well as an elite clientele, the hypothesis would be that any associated settlement evidence would reflect these

conditions too. The Late Bronze Age site at Hallunda in Sweden provides a good test case. Here excavations have revealed a major settlement including the foundations of at least three large houses. The largest of these was about 18m long and 8m wide and contained the foundations of twelve furnaces with diameters ranging from 0.6m to 1.5m. The traces of a possible air vent to provide a forced draught were preserved in one of the furnaces, and remains of baked clay fragments in the foundations of each structure suggest a dome-shaped upper part. An analysis of these fragments indicate that the temperatures achieved may have been as high as 1,200°C. Close to the furnaces there were 40 crucible fragments, the remains of about 70 clay moulds and 11 narrow bronze rods as well as a lump of smelted bronze and two casting taps. Although none of the clay moulds survived intact, it was possible to recognise that swords, spearheads, socketed axes, buttons and rods had been cast. Bronze casting debris was also found in other areas of the settlement (Jaanusson, 1981).

Generally speaking, evidence of bronze objects from settlements is very rare, but Hallunda is exceptional in that a relatively large number have come to light including a razor, buttons, knives, a sickle, and pins. Bronzes have also been recovered from graves found within the settlement, usually small ornaments such as pins and rings. All of this evidence, complemented by the high quality of pottery retrieved from the site, seems to confirm its status as a wealthy community. The workshops seem to have been equipped to produce metalwork which was technologically advanced with a high order of skill requirement and in quantities which must have outstripped local needs. Such direct evidence of a high ranking workshop is rare at present, however, although a survey of bronzes in Europe indicates that they must have existed, and it ought to be possible to distinguish between them and lower ranking sites turning out

simpler material. The question of a low recovery factor has already been discussed in relation to ethnographic parallels, workshops often being located outside of settlement boundaries on account of pollution factors. But siting is also important for technological reasons which include the necessity for a good draught, as well as a supply of wood for fuel for the furnaces. An important point to be made about the Hallunda site in this respect is that it is positioned on top of a hill.

Evidence for a sizeable bronze industry in Late Bronze Age Sardinia is also impressive and foundries are associated with the most important of the sophisticated defensive structures known as *nuraghe*. In addition, there have been finds of both ox-hide and plano-convex ingots and thousands of implements and weapons have appeared in hoards and in many workshops in *nuraghe* and *nuraghic* villages. Another body of evidence is represented by smithing tools such as bronze tongs, hammers and shovels. And open and bivalve stone moulds are known from museums and have been found in the excavation of *nuraghe*. Lo Schiavo (1981:273) notes a mould for a hilted dagger from a *nuraghe* near Fonni, and one which may have been for a bracelet comes from another of these sites. So it seems that every big *nuraghe* had its workshop where tools and weapons could be made as well as mended. Perhaps this reflects increasing control over the activities of the bronzesmiths in unsettled times as production of weapons became more urgent.

In Britain too in the Later Bronze Age, larger, more fortified settlements are now in evidence, as seen at sites such as Springfield and Mucking in Essex and Thwing in Humberside. And the first defensive phase of hilltop settlements dates to this time e.g. Rams Hill, Berkshire. The size of the bronze industry was obviously considerable, judging by the evidence of the products which have survived,

although evidence of smithing sites in the archaeological record is still relatively meagre. At Thwing a timber framed round house of vast proportions was set within a double ditched enclosure. Not the dwelling of a mere subsistence farmer, it is argued, but more likely that of emergent chieftain perhaps. Small bronze objects such as pins, rings and awls have been found and bronzeworking is represented by beads of metal, clinker and scrap, but there is no evidence of foundry equipment as yet (Manby, 1980:322). A similar settlement pattern is repeated at Mucking, with mould fragments from bronze casting turning up among the finds as well as fragments of copper ingot, a bronze pin and part of a socketed axe (Jones & Bond, 1980). And at Runnymede Bridge, Berkshire, excavation revealed a riverside settlement, strategically placed to control river traffic, with metalworking evidence which included casting debris, a clay mould and a crucible with traces of bronze. In addition there were bronze tools, a socketed spearhead and a number of ornaments (Needham & Longley, 1980).

In Southern Britain during this period there was a conspicuous increase in the range of weaponry and prestige objects and ornaments. This body of evidence suggests the emergence of a ruling class or elite who controlled the supply of raw material, as well as the output of bronzesmiths and the distribution of their products. The metalworking debris found at Dainton in Devon lends some support to this view perhaps, in that all of the moulds were for the production of spearheads, swords and ferrules (Needham, 1980). And the Springfield Lyons moulds seem to have been only for casting swords (Buckley, 1988:8). This focus on weaponry is also seen at the defended site of Rathgall, Ireland where a timber building located just outside of the ditch contained hundreds of mould fragments. From the matrices it can be seen that weapons and blade instruments were the predominant form. Four gold objects

were also revealed including a composite bead of gold and glass obviously requiring a degree of skill and expertise appropriate to an accomplished craftsman (Raftery, 1976).

The case for centralized control of a weapon industry is supported by Northover (1988). Given the fact that the manufacture of a sword would have been vastly different to the manufacture of routine tools, in terms of both the technology and economics of the process, he argues that in some cases the industries would have been quite separate and controlled in different ways. Weapon production would have been more centralised and directed by an elite while tool production could have been organised in a number of ways, a division which is reflected in Late Bronze Age metal hoards. He points out that there is an emphasis on either tools or weapons and that hoards which contain a balanced proportion of tools and weapons are generally small.

Conclusion

The examples above suggest a model of a period when wealth and power, as reflected in larger settlements and a huge quantity of bronzework, become more closely associated in the archaeological record with control over the activities of bronzesmiths. The position of the smith clearly did not remain static, therefore, but must have changed dramatically over time as the organisational needs of the society changed and became more centralised and also during times when the centralised system itself became unstable and weak. In order to understand the importance of the smith in a society then he has to be seen in the light of its techno-economic components as well as in its social and political context.

CHAPTER 4

THE STATUS OF THE SMITH

In this chapter the aim is to look at a number of issues concerned with the status of the smith in the Bronze Age and the organisation of metal working. Drawing on both literary and ethnographic evidence, an attempt is made to interpret appropriate aspects of the archaeological record to throw light on the position of the smith and the relationship between the producer of bronze objects and the consumers.

Some of the constraints surrounding the use of ethnographic analogy have already been mentioned. A number of general observations are worth noting here about more antiquated ethnological accounts of smelting and metal-working in non-industrial societies. These are invaluable, on the one hand, in that many provide the only written record of an industry before any great changes came about as it adapted to a Western money economy, but there are problems; they are often superficial and incomplete. Sutton, for example, has pointed out that a common and implicit assumption has been that each particular tribe had its own metal-working tradition with a characteristic style of furnace and distinctive way of treating ores (1985:164). He argues that if there is only one record of the iron-making industry in that defined area, then there is no way of telling whether these methods were specific to that particular tribe.

Another drawback has been that the literature pays more attention to the description of material aspects of the industry, rather than recording elements of the technological process including technical skills, rules of procedure, methods of recruitment and training, patterns of

relationships among blacksmiths, their socio-economic roles within the community and the place of magic and ritual in the technical performance. Direct observations of the craftsman at work could have presented difficulties. In many societies blacksmiths have a special role and the secrets of the craft are strongly guarded. Participant observation of smelting and smithing by the anthropologist may have required special permission and arrangements and would have demanded a great deal of patience.

Other biases can get in the way of objectivity too. Among these are the anthropologist's own cultural values and attitudes, and the perception of the labourer as being a social inferior is important in this respect. Ethnographers have traditionally studied more exotic aspects of other cultures. The more mundane elements of the material culture have often been avoided or, at best, given a more cursory description. Of course, archaeologists are increasingly making their own ethnographic observations rather than relying on the accounts of anthropologists, but changes in the smith's profession must have been dramatic and in many cases it may not be possible to study iron-working in its completely traditional form. The subject has to be approached, in part, through the study of these literary accounts as the only historical documentation of an earlier period.

In what follows we will be exploring, first of all, the conditions of apprenticeship and arrangements for teaching metal-working skills. We will then consider access to technical knowledge and how this is controlled, the organisation of technical production and, finally, the social standing of the smith in Bronze Age society.

Transmission of skill

Turning to this notion of skill and the question of how expertise is conveyed to another person, direct observation of contemporary non-industrial societies reveals that, in the majority of cases, the smith's profession is a family affair and a man's son will learn the craft from him. There are exceptions, where recruitment to the profession is not solely related to kinship. In an archaeological survey of Liberia information on recruitment and training of apprentices was obtained from smiths from several different tribal groups (White, 1974:21). Among all of these groups a son was expected to follow his father, his paternal uncle or his grandfather into the profession, but other reasons were given for becoming a blacksmith, including the advice of a diviner or simply the aspiration to do the job.

In each case no distinctions in the training were made. The period of training occupied up to 18-20 years during which time the teacher, who was never the father in the case of the Loma tribe, had to maintain the apprentices. The arrangement was reciprocal, however, and the apprentices were expected to show respect towards the master, to assist him and return a substantial 'gift of appreciation'. This is described in the study as a type of professional 'social security' system which had little to do with the actual time required to learn the skills of iron-working.

In the case of the Southern Kikuyu of Kenya, there was no custom which prevented any man from apprenticing himself to a smith (Leakey, 1977). The only requisite was that the appropriate fees were paid, in the form of sheep and goats, and this was not even waived for the son of a smith, although the amount was not so high, a fact which perhaps indicates a preference for the parent-child link. Apprentices had the opportunity to acquire livestock with

which to pay, since they were entitled to a proportion of pig iron from the smelting process. This could either be exchanged in the ingot form for animals and other commodities, or made up into swords and spears and then sold to cover the cost of fees.

In those societies where the craft is a descent group organised activity, there is still considerable variation in organisation. In some cases, for example, smiths belong to a caste or endogamous group. According to Tobert, among the Zaghawa of the Sudan the term itself does not necessarily indicate occupation, 'but if born a blacksmith one will always be a blacksmith' (1985:279). The son of a blacksmith may actually work in iron, aluminium, wood or leather and skills are hereditary, being handed on from father to son. Because they and their craft activities are considered polluting, moreover, other members of the society will avoid eating and drinking with them, and marriage is forbidden with any group other than the potters.

There are other groups where principles of craft organisation are based on descent. But differences exist; there are cases in which the smiths are confined to particular clans, such as the Chagga of Kenya, noted by Rowlands (1971). In contrast, the smiths of the Kikuyu mentioned earlier (Leakey, 1977), are confined to certain families but not to specialist clans, and the smiths of the AGiryama, also of Kenya, may be of any clan (Champion, 1967). Among the Nilotic Luo of East Africa the art of smithing and smelting is restricted to certain clans within each tribe, who by tradition are not allowed to pass on their knowledge of the craft to anyone, other than their sons or other close relatives (Ocholla- Ayayo, 1980). The education of the Luo apprentice is a long process. In the beginning, he will work the bellows for the elder smith and learn how to make simple implements. Later, he is introduced

to the more complex techniques of smithing, but it is not until after marriage and the birth of children that he is allowed to set up in a workshop of his own. This workshop is given over to the ancestral spirit of his clan in a dedication ceremony, stressing the inheritance nature of the craft.

Even with greater centralisation of production and the formation of guilds of metalsmiths, the descent group principle prevails. Rattray (1923) points out that the art of goldsmithing was retained in certain Ashanti families and if the son did not follow his father's trade then the nephew was compelled to do so. Craftsmen are always united by kinship ties in Yoruba towns too (Lloyd, 1953), with members of a lineage sharing the same craft and a common workplace. In the smaller villages the blacksmith sets up his son in life providing him with land, tools and the first wife, but he will teach only this one son to succeed him.

To demonstrate a number of similarities in the way that arrangements are made for passing on craft skills over a range of social formations in the ethnographic record, does not in itself prove similarities between past and present situations. However, looking at the different groups that are found in society of the sort traditionally studied by anthropologists, kinship relations are the basis of any group formation, in contrast to our own society in which other principles of social organisation operate and act as a basis on which groups are formed. Since the importance of kinship is paramount in all kinds of relationships in small-scale societies, it seems reasonable, and not too ambitious to suppose, that it served an important function in the transmission of skills from one generation to the next in prehistoric societies.

A further reason refers to the logic of the process by which skills are conveyed. This is a prolonged process involving a number of aspects, such as experimentation, practice and the opportunity to observe as well as the maintenance of the standard or quality of work. There must also be a strong personal commitment to learn and carry on the tradition, plus the recognition of duties and obligations over time and kinship affords a powerful mode for organizing this. Also, if membership of the group is restricted to close kin then this increases their monopolistic position in the society, a facet of organisation which we will turn to next.

Monopoly of knowledge

The core of the craftsman's skill is knowledge and his detailed understanding of the tools and materials and processes with which he has to work. In societies without an advanced division of labour, and in which most competent adults possess a wide range of skills needed for survival, the claims of one group to have distinctive skills and to retain a monopoly of their use in practice, is something which needs to be specially legitimated. The control of the body of knowledge, which is at the heart of the craft, is central to this process.

Several aspects of that control can be identified. Of great significance is the control of access to knowledge, to ensure that the secrets of the craft are not widely diffused. Secondly, there is the question of organising the transmission of that knowledge to initiates and of ensuring that those learning skills do so effectively. The development of technique and the improvement of tools or materials is something which also has to be managed. Finally, although by no means exhaustively, the claims of the group to a distinctive competence in an area of work

have to be made legitimate in the eyes of those who draw upon the skills of the craftsman.

Monopoly of knowledge may be maintained by defining boundaries around the group whose property it is. In the words of Max Weber, the aim of the group would be to secure a 'closed relationship'. Weber distinguishes between open and closed relationships, defining an open one as a relationship which is 'open to outsiders' and does not deny participation to anyone who wishes to join. A closed relationship, on the other hand, is one which is 'closed against outsiders so far as, according to its subjective meaning and its binding rules, participation of certain persons is excluded, limited or subject to certain conditions'. He goes on to conclude that if 'their (the participants) expectations are of improving their position by monopolistic tactics, their interest is in a closed relationship' (1978:43). Other motives behind a closed group include the maintenance of quality and this can be associated with prestige.

There are various ways of excluding groups. Berger and Luckmann, for example, have defined craft specialisations as sub-universes of meaning. These result from the process of increasing role specialisation and division of labour in a society, so that knowledge specific to a particular role specialization, is intelligible to the initiated only. They argue that:

the increasing autonomy of sub-universes makes for special problems of legitimation vis-a-vis both insiders and outsiders. The outsiders have to be kept out, sometimes even kept ignorant of the existence of the sub-universe. If, however, they are not so ignorant, and if the sub-universe requires various special privileges and recognitions from the larger society, there is the problem of keeping out the outsiders and at the same time having them acknowledge the legitimacy of this procedure. This is done through various

techniques of intimidation, rational and irrational propaganda (appealing to the outsiders' interests and to their emotions), mystification and, generally, the manipulation of prestige symbols. the insiders on the other hand have to be kept in (1966:102).

Turning to the ethnographic record, it has already been shown that membership of the craft group in most cases is determined by family relationship, the skill usually being passed on to the male offspring of the smith. Exclusiveness may be reinforced by ritual practice and taboos, which have the effect of intimidating the rest of the population while at the same time legitimating the craft specialisation itself in the eyes of the initiates. In addition, Weber (1968) has noted a tendency for status groups to protect their position of monopoly by developing a secret language, or maintaining some linguistic peculiarities to distinguish them from the rest of the population. Hollis (1905) has documented this tendency among the Masai. In Masai society, every clan has its smiths, although there is one clan, the Kipuyoni, to which most of these craftsmen belong. They practice endogamy or marriage within the group, and social boundaries are further maintained by the fact that they have their own language which, although it is a corruption of Masai, is not understood by ordinary Masai.

A survey of the ethnographic literature reveals a widespread occurrence of various rites and taboos surrounding both the smelting and smithing processes, in which 'medicines' and 'spirits' may play a part. A principle figure in the iron industry associated with the Bambala (Zimbabwe), for example, is the 'iron doctor' who jealously preserves the secrets of his craft (Smith & Dale, 1920). He performs ritual acts at certain stages during the construction and preparation of the smelt furnace. The packing of the furnace is done almost entirely by the "doctor", who builds it up

with alternate layers of ore and charcoal, adding the "medicines" at the same time. This ceremonial activity heightens the mystery surrounding the profession and therefore maintains the closure of the group, although the people themselves do not see it in these terms. According to Smith and Dale, the people believe that it would be impossible to extract iron from the ore without medicines. They say: 'The medicines transform the ore into iron'.

In the same way, the Dogon smiths (Western Sudan) are isolated from the rest of the society by the special place they occupy in the origin myths of the society and also by the ritual functions that they continue to perform (Griaule, 1965). These iron-workers are an endogamous group in relation to the rest of the Dogon. In theory they neither own land, nor do they receive direct payment for the agricultural implements that they manufacture or repair. They receive a portion of the crops at the harvest. Their exclusive status stems from the fact that they are, according to Dogon belief, the culture heroes of agriculture. When the first smith fell down to earth his collision with the primal field broke his limbs, providing him with joints with which to do his work. His anvil was buried in the soil, cleansing it and therefore providing men with grain. In this primal field, the granary was erected on the north side, which is the reason why all smithies occupy a position on the north side of a village square. The smith therefore is seen as the source of many benefits and this underlines his distinctive place in the society, a position which is legitimated further by the many rituals he performs.

Within the craft itself there appear to be mechanisms for keeping one group of practitioners in control over production and exchange. In Liberia, for example, it has been noted that there was a religious aspect to the

relationship between elder smiths and apprentices (White, 1974:22). The elders were the sole repositories of ritual knowledge, which was essential both to the physical well-being of the apprentices and also their prospects within the craft. In this way they had control over the statuses to which the younger men aspired, and at the same time secured their own positions in the hierarchy as the group in control.

In addition to the ritual activity performed by initiates, there are many taboos associated with metalworking which amplify the mystification and keep 'outsiders' out and ignorant of the techniques and skills of the smith. Among the Kikuyu, there are special taboos against touching an unfinished object that the smith is working on (Leakey, 1977). The smithy and smelting furnace are open and built fairly near to the smith's house in the Kikuyu village, but the smith never takes anything home at night because no-one would ever steal from the smithy. The reason for this is fear of the evil which, it is believed, would automatically result. This analysis of taboos could be extended much further. It could, for example include a discussion of sexual taboos. Among the Baganda (Uganda) the smiths stayed away from their wives and had no intercourse with them (Roscoe, 1965). They were not allowed to eat with anyone or come into contact with anyone beyond those they were working with. Food was brought to them by their wives and children and placed near the temporary huts. Smith and Dale (1920) also note this type of strict sexual taboo within Bambala metalworking tradition and this practice is well-documented elsewhere.

Such practices establish boundaries around the metal-working group. However, the social and ritual separateness just described would be difficult to identify in the archaeological record. Spatial separateness would be more

easily translated and there is a lot of evidence, ethnographically, that metal-working sites are distinct from settlements and often built well away from them. Spatial distinctiveness would leave its traces in the way of hearths, furnaces and other kinds of debris at or beyond the boundaries of settlement. Tobert (1985) has drawn attention to this fact and points out that archaeologists usually focus on the centre of a site for information on craft technology, whereas, in view of the ethnographic data, a survey of the area on and outside of settlement limits may prove to be more profitable.

The Organisation of Metalworking

Childe (1965) believed that metallurgists were full-time specialists supported by the rest of the population, a point that has already been mentioned. He also argued that, because of an altered division of labour and occupational independence, the craftsmen would have been less constrained by the cultural norms and values of the society, since he was freed from the need to produce food and he could exchange his products anywhere on a contractual basis. These impersonal, 'one-off' transactions differ from the type of traditional exchange found within small-scale societies, which are not just a matter of economics but bind people together in a network of mutual indebtedness. As Durkheim had argued in 'The Division of Labour in Society' (1933), all individuals in small scale societies perform the same kind of work and produce similar goods and submit to certain universally acknowledged rules of behaviour. He went on to explain that, as a society gets more complex and specialists emerge, the individual can no longer provide for his own needs and enters into contracts with other producers. In such circumstances relationships are determined by the exchange of goods and not by the

universal code of law of the society. According to this theoretical position the smith would, therefore, have more freedom to travel outside of the boundaries of his society wherever he could find a market for his skills. According to Childe:

The rare metal objects that we have encountered in the Copper Age villages were very likely made by itinerant smiths travelling about the country with ingots of metal and producing implements on the spot 'to order'. This was demonstrably the case in the European Bronze Age (1965:86).

However, the assumption that individuals or groups are ever unrestrained by social duties and obligations is a questionable one. As members of a society each individual is obliged to conform to the norms and values of the culture. The sort of situation where specialist craftsmen moved around the country negotiating and bargaining with employers and offering their skills and services on a purely commercial basis is a difficult view to sustain in the light of the evidence. Even in the later stages of ancient Near Eastern history, although the independence of craftsmen had increased compared with conditions in the Late Bronze Age palaces, there is still no basis for presuming a free labour market according to Zaccagnini, (1983:264).

The notion of the free-wheeling smith is also a difficult concept in view of comments made in Chapter 2 about the boundaries of social and political interaction of societies and personal security beyond those. Certainly, the concept of an itinerant specialist is not supported by the ethnographic literature. As Rowlands says:

the existence of a 'free travelling', itinerant smith divorced from any social context is rarely found in ethnographic contexts. One example that resembles Childe's concept is the mongol silversmith who travelled from tribe to tribe staying to work for as long as he was needed. Boyer mentions that such smiths were

often of different ethnic origin and tended to form unstable communities within a population, and their itinerant work often levelled differences in typology and technology between particular tribes (Boyer, 1952: 165-8). But in the majority of ethnographic examples the smith is embedded in a particular social and cultural context, and, even if to some extent 'itinerant', does not necessarily belong to a subgroup of distinct origin and cultural identity (1971:214).

However, although the itinerant smith type of organisation is neither confirmed by ethnographic data nor supported by the archaeological evidence, which is available for prehistoric Europe, this is not to say that mobile smiths did not exist in some contexts. The evidence, for instance, discovered in the Cape Gelidonya shipwreck, which included an anvil, the broken blade of a pair of tongs and a number of tools and weapons, which were perhaps being transported as scrap, is perhaps suggestive of a craftsman on board the vessel (Bass, 1967). He could have been concerned with the production of valuable luxury goods which only a select group demanded. We know from the Old Testament that arrangements of this sort existed in the Near East in the Early Iron Age. 1 Kings VII states:

And King Solomon sent and fetched Hiram out of Tyre. He was a widow's son of the tribe of Naphtali, and his father was a man of Tyre, a worker in brass: and he was filled with wisdom, and understanding, and cunning to work all works in brass. And he came to King Solomon, and wrought all his work.

And in the period with which this study is concerned, the mobility of craftsmen in the Near East has been documented by Zaccagnini (1983:248). Evidence gleaned from the Mari archive about the administration of this Middle Bronze Age Palace economy makes it clear that there were shortages of artisans required for particular tasks, and the palace administration had to have them sent from other areas of the

kingdom. In one letter, for instance, a coppersmith is requested.

Further, documents from Late Bronze Age archives attest to the sending of specialised workers from one court to another by the kings of Egypt, Babylonia, Hatti and Cyprus (Zaccagnini, 1983:250). But we are not dealing here with independent professionals, moving freely from one place to another, but with palace dependants. These were a class of specialists who worked full-time in palace workshops and who relied on the administration to provide them with food, clothing, somewhere to live, raw materials and the tools of their trade - a far cry from arrangements for most of Bronze Age Europe.

Turning now to patterns of specialization, a survey of the ethnographic record reveals that there are different degrees of specialization. At one end of the spectrum are the highly skilled bronze casters of Benin, who were organised into guilds, and at the opposite end are the part-time craftsmen for whom metalworking is an occasional occupation, often seasonal in nature and mainly concerned with making and repairing weapons and agricultural tools rather than objects of artistic merit. For the latter group the major part of their livelihood comes from the subsistence economy. Between these two extremes a variety of different levels of organisation exist. This variability can clearly be related to factors such as patterns of subsistence, the level of socio-political organisation of the society, a more complex division of labour and the pattern of settlement; and there are distinctions within societies as well as between them.

The structure of the craft in Yoruba towns is described by Lloyd (1953). The Yoruba live in south-west Nigeria, predominantly in urban centres, which are basically communities of farmers. Their political organisation

consists of powerful state governments, each with its own chief or king. The traditional crafts for men are smithing, carving and weaving and among the smiths there is a further division of labour, so that there is a distinction between those men who work in iron and the individuals who work in silver or brass. Both of these are differentiated from the work of tinker. Each occupational group is always united by kinship ties, so that members of the same lineage follow the same crafts and share a common workplace. The number of craftsmen in any one town is variable. For example, in Iwo there are almost 40 blacksmiths in 6 different compounds. Most of these men have farms on which they grow a considerable portion of their own food, and Lloyd points out that within any one lineage there are craftsmen who work at their craft full-time while others prefer to farm. In the small villages, on the other hand, there is rarely any craft worker except a blacksmith who can perform emergency work, presumably mending agricultural tools, and he instructs only one of his sons in this skill.

The organisation of the craft has some interesting features. In each compound the eldest man of the lineage, who is known as the *Bale*, has authority over all matters concerning the craft as well as the social life of the lineage. At the same meeting the agenda can include decisions about marriage, disputes between members, the maintenance of high standards of work and the repair of the common workshop. When members of the profession come from a number of different lineages, the *Bale* of one lineage is head of all the craftsmen throughout the town. Smiths from all other lineages come to the craft compound of this man for a meeting held every 16 days to discuss the affairs of the craft and new techniques, among other things. The regularity of these inter-lineage meetings, among the blacksmiths particularly, is significant according to Lloyd (1953:35). The blacksmiths make weapons and therefore it is necessary

to coordinate their activities and maintain some link between them and the king during a century of protracted warfare. This type of organisation has the effect of binding together the separate units of production and achieving greater control.

Not all of the tribes to be found in Nigeria have their own blacksmiths, however, or use their own sources of ore. In northern Nigeria live the pastoral Fulani whose political organisation is basically egalitarian. According to Riesman (1977) the tools that are necessary for enclosing fields and other tasks, i.e. the hoe and the axe, are made only by men belonging to a 'caste' of blacksmiths that does not intermarry with the Fulani and does not have the same social organisation.. An important aspect of these castes or guilds is that they have no geographical boundaries and members move from chiefdom to chiefdom. Marriage is possible between guild members living in different societies, so that while it would be rare for a Fulani to marry a Mossi woman, it is acceptable for a blacksmith living among the Fulani to marry a woman of the blacksmith caste who lives with the Mossi. Meek (1969) reports of tribes who leave the work of smelting and smithing to neighbouring groups e.g. the Magazawa who set up temporary shelters and work through the night smelting ores and making hoes for the local Hausa. In another area of Africa, the Sudan, Tobert (1985:278) has studied a group of migrating craftsmen including blacksmiths and aluminium casters. They spend half of the year cultivating crops on their own land and the other half at market centres throughout the region making and selling their wares, returning to their villages at the beginning of the rains.

Tobert studied the spatial organisation in their temporary camps. All craftwork was carried out in a well-defined area away from the households and there appeared to be no

division of labour. Each specialist worked independently, each blacksmith collected his own fuel for his own hearth. Contrast this with the situation in Bassar, which is located in Togo (near Benin). De Barros (1986) has examined two early German accounts of this traditional iron production centre in West Africa (Hupfeld, V.F., 1899 & Fisch, R., 1911). When the German colonialists first made contact in the 1890's intra-industry specialisation was a characteristic feature of Bassar metallurgy. Smelting was carried out by villages around the rich iron deposits of Bandjeli. In those areas where quartzite stone for anvils and hammers was abundant, villages specialised in smithing, and charcoal making was a speciality of villages which were located near areas of forest. This degree of organisation was closely associated with the appearance of nineteenth century chiefdoms in Bassar. In addition to these inter-village divisions there was, within most villages, a sexual division of labour associated with the industry. For example, in the Bandjeli area the women generally did the mining and transporting of ore, while smithing was limited to the men. Meek (1969) reports that the work of obtaining ore is also the work of women in the Mbarawa tribe (North Nigeria).

This brief examination of ethnographic parallels illustrates the range of possibilities concerning the organisation of metal production, and helps in providing a framework for hypotheses about the prehistoric past. The central hypothesis must be that in those societies where political power and authority are more concentrated, the greater is the degree of specialisation and the more clearly defined the divisions of labour. It is in such societies that specialist knowledge can increase. As Berger and Luckmann (1966:95) have said, in a society that is organised so that certain individuals can focus on their particular specialities, the technical knowledge which is specific to their craft will grow at a faster rate than the general

stock of knowledge of the society. Of course, not all specialists might be entirely exempt from productive labour; it may only be those who are employed in the service of a chief. This point will be dealt with in more detail when the discussion turns to a typology of craftsmen.

So, within some broadly defined categories of metalworking organisation, there are a number of possibilities and, in order to test their likelihood against archaeological evidence, we need more data on the location of workshops, the recovery of crucibles, moulds and other material relating to different stages in the production cycle. A clearer picture of settlement patterns in a particular region would also be relevant, as well as other information which might throw some light on social structure, for example, evidence from graves, since the way a society is organised has important consequences for the growth of specialised knowledge and whether there is provision for individuals to concentrate on and develop their skills. Analysis of finished objects only is of limited potential in a discussion of the organisation of production. We do not know what proportion of metalwork in circulation during the Bronze Age is represented by the material recovered. Different societies may have had different strategies concerning the deposition of hoards, and the recovery potential of metal objects will vary in different areas. A broader approach is therefore needed, and one which relates metal finds to settlement patterns and ties in both to theoretical models of social organisation, built up conceptually from the ethnographic record.

In parts of the Mediterranean and the Ancient Near East archaeological evidence of metallurgy can be supplemented by literary sources to cast some light on the organisation of the craft in the Middle Bronze Age and Late Bronze Age, but only in the areas concerned. The absence of indicators of a

strong central political authority presiding over densely populated settlement areas with economically diversified populations precludes this level of organisation for the European Bronze Age. In the early cities of Mesopotamia a large number of the inhabitants were skilled craftsmen. Contemporary public records reveal that there was a variety of skilled workers. For example, documents from Ugarit list the craftsmen and artisans and provide insights into their organisation (Heltzer, 1982:80-102). Among them were millers, leather-workers, bakers, woodcutters, cartwrights, fullers and potters. Metalworkers are differentiated into coppersmiths, silversmiths, arrowsmiths and smiths whose precise expertise is not given. Clearly, there was a high degree of economic diversity.

The groups of metalsmiths appear to have been in royal service. They received their raw materials of production and also their pay in silver from the palace store. Heltzer suggests that there is some evidence that the smiths, as well as other groups of artisans, had elders who supervised their work to a certain extent and were responsible for the allocations of raw material which they received, although it is not known whether they were self-elected by the particular specialist group or by the administration. That the group was often dealt with as a whole, is understood from the demands for military service and other duties. Tablet KTU.4.68, for example, records that the silversmiths provided the archers with one man. The smiths, however, do not seem to have been concentrated in permanent workshops in the palace but appear to have lived and worked in certain villages. This contrasts with the situation in powerful West African Kingdoms, for example, Benin where, according to Roth(1968), the manufacturing technology, including melting crucibles and the clay and beeswax used for moulding, were all arranged in a compound next to the palace. The nineteenth century Ashanti goldsmiths were also under royal

control and some of their descendants claim that they lived in a special part of the capital, Kumase, to which entry was forbidden to outsiders (McLeod, 1981).

The Old Babylonian palace was also a focus for the organisation of production of goods. At Mari and Karana, kingdoms in N.W. Mesopotamia, the large archives of clay tablets discovered contain details of the system during this period, with lists of professional groups and their allocations of materials as well as letters giving orders, accepting deliveries and recording complaints (Dalley, 1984:50-77). Here again we have a high degree of occupational diversity, and the person who worked gold and silver is distinguished from the coppersmith and the bronzesmith. With increasing diversification of labour and specialisation like this must have come the expertise that led to invention and innovation of new techniques. One character to emerge in the organizational structure is a workshop director whose duties included inspecting the gold stores and advising on supplies. The names of smiths are recorded too and they seem to have carried out their work at the palace, probably in a workshop outside of the walls.

There are striking similarities to be found in the organization of metallurgy and its personnel in Mycenaean Greece, especially in comparison with the system at Ugarit. Our understanding of the bronze industry comes entirely from Pylos, where a set of clay tablets was discovered listing the names of smiths from various locations and recording details such as place names, the amounts of bronze allocated to each of them and the total weight of bronze distributed. The tablets also document those smiths from each location who do not receive a quota of the metal. Lejeune (1961:422-23) records that, besides the smiths, two other types of individuals emerge from the texts. These are the slaves allotted to smiths and the person whom he describes as



'probably a provincial dignitary of secondary importance', who in some way presides over the distribution of bronze between those smiths who have an allocation of the metal.

The smiths do not appear to have performed their tasks in workshops attached to the palace, but were located in a number of villages. There are fourteen different place names mentioned in the set of tablets which document the smiths and out of these nine are not found on any other tablets in the series listing different personnel, which suggests that some smiths may have lived in small self-contained communities. Another fact to emerge is that these craftsmen were not located in every single village, but were concentrated in groups ranging in size between two and three individuals and twenty seven. Individual allocations, which can be either uniform or variable within the same community, lie between 1 kg. and perhaps 12 kg. The most common are 1½ kg. (41 smiths), 3 kg. (17 smiths), 4 kg. (19 smiths) and 5 kg. (43 smiths) according to Chadwick (1973:256). He calculated that 1½ kg. of bronze would be sufficient to make 1,000 arrowheads while 5kg. would be enough for 14 swords or spears.

While the estimated number of smiths - a figure which has been placed somewhere in the region of 400 (Chadwick (1987:141) - suggests the type of economic organisation which was not based on domestic consumption of goods but on the production of a surplus, the evidence from the documents themselves contradicts this hypothesis. Some smiths do not seem to be employed and do not receive a portion of bronze, while those that do are dealing with relatively small quantities. Both of these factors might be said to indicate a shortage of the raw material, a line of argument which gains support from the evidence of one tablet, which is concerned with the collection of bronze objects from religious buildings by local officials, to provide raw

materials for spears and javelins. Chadwick (1973:512-14) suggests that this information from the tablets reflects the crisis conditions at Pylos at the time, and indicates a breakdown in supply routes of raw materials as well as the procedures involved in increasing the output of weapons. The issue of bronze to only a proportion of smiths, on the other hand, may be a reflection of the hierarchical nature of the internal organization of the craft, the allocations of metal going directly to the master craftsmen. Alternatively, smiths without allocations could have been carrying out some service duties in connection with the palace.

The written records then only take us so far. Rather than answering any of our questions definitively, they merely open up a further set of issues and indicate a further range of possible types of craft organization. It must be remembered, too, that it is most unlikely that Bronze Age craft organisation elsewhere in Europe resembled the centralised palace civilizations from which written records survive.

The social standing of the smith

The regard in which the smith is held socially does not emerge clearly from the archaeological data which we have. This is not to say, of course, that material remains cannot help us clarify this problem. There are, in fact, many clues in the archaeological record which suggest how craftsmen might have been regarded by fellow members of their societies. These clues are found in such evidence as grave goods, or the spatial distribution of work places in a community. Appropriately interpreted against other sorts of data from archaeological sites, such material is suggestive of many hypotheses about patterns of social organisation. These hypotheses can be framed also in the light of textual

evidence and, as will be indicated in this section, of evidence drawn from ethnographic research into pre-industrial societies of many different types.

A survey of ethnographic material reveals that the smith is not uniformly accorded the same status in each society. According to Forbes (1964) his place in the social sphere usually, however, falls between two extremes. He is either a respected and well-integrated member of the community, or else he is despised and remains on the fringes of society, both socially and spatially.

The work carried out in the smithy has ugly and frightening associations. With the soot, smoke and sparks, as well as the noise of the bellows and the hammering of the annealed metal, the smithy in some contexts arouses a lot of suspicion and fear. Both his labour and the products of his labour are considered polluting. In many instances the smithy is located outside of the settlement. For example, the migrating group of craftsmen who are the subject of Tobert's study (1985) set up their work place well outside of the settlement limits, and the smithy of the AGiryama of Kenya (Champion, 1967) is generally outside of the limits of the village. Products too might be thought of as impure. Among the Masai they must be purified with grease before use (Hollis, 1905).

Often alienation from the rest of society is further emphasised by the presence of a completely tabooed class of craftsmen, who form an endogamous group with their own social codes. Again, an example of this is found in Masai society. However, not all of those smiths whose social standing is low are not well integrated into the wider society. Although the AGiryama smith does not command respect in the community, he can belong to any clan and is

free to marry any other member of the tribe (Champion, 1967).

Great care is needed, however, in interpreting exclusionary behaviour as suggesting defilement. Such behaviour can in fact, as Douglas has argued, be one way of symbolically underlining the respect in which a particular group is held. As she says:

the universe is divided between things and actions which are subject to restrictions and others which are not; among the restrictions some are intended to protect divinity from profanation, and others to protect the profane from the dangerous intrusion of divinity. Sacred rules are thus merely rules hedging divinity off, and uncleanness is the two-way danger of contact with divinity (1966:8).

It has already been emphasised that, the association of the blacksmiths occupation with a separate caste and other exclusionary behaviour, can be seen as mechanisms for the transmission of skills and the continuity of the craft, as well as preventing competition from those outside of the group. Haaland (1985:60) has noted that the concept of setting aside occupational groups is quite common all over Africa and the Middle East, but the degree of exclusion is variable among the different cultures. He records the most extreme behaviour towards iron specialists among the tribes of Ethiopia. For example, among the Gurage in Central Ethiopia, specialists such as blacksmiths, tanners and hunters are prohibited from cultivating the land or keeping herds, because it is believed that any connection with plant and animal husbandry will reduce fertility.

His own fieldwork among a group of tanners from the Wollamo Tribe in Central Ethiopia showed an extreme case of stigmatization. Here craftsmen are ranked according to a strict hierarchy, with the smiths at the top, and clear

boundaries are maintained between occupational groups, individuals only being able to marry within the group. Again, participation in agricultural activities is forbidden and social rules forbid them to eat out of the same dish as a farmer. In the Sudan, on the other hand, blacksmiths take part in subsistence activities with the rest of the population, and there is no distinction in social rank based on occupation. It is only in a few cases, however, that smiths form a high ranking and high status occupational group, for example, the Kpelle of Liberia and the Suku of South West Zaire.

Magic, knowledge and skill

One fairly consistent characteristic that emerges from the ethnographic literature is the element of magic attached to the position of the smith. His work is such that he is seen as being in possession of supernatural powers. Frazer (1978) noted the association of magical function with the position of chief in many African societies. He cites the case of the Fans of West Africa, where the chief is also the medicine man. But, in addition to this, he also takes on the role of blacksmith because the craft is held to be sacred and, since the chief has the monopoly of magical powers, only he is allowed to meddle with it. And, as mentioned earlier, in Zimbabwe the Bambala 'iron doctor' presides over any iron working and he is the only one who has knowledge of the medicine, without which iron ore cannot be transformed into iron.

This element of magic is also encountered in Greek mythology. In the Odyssey there is an account of how Athene transforms the appearance of Odysseus which uses a smith simile:

It was as when a man adds gold to a silver vessel,
a craftsman taught by Hephaestus and Athene to

master his art through all its range, so that everything he makes is beautiful; just so the goddess gave added beauty to the head and shoulders of Odysseus (Bk6:232).

The magic qualities of the smith are again stressed in the Odyssey when the bard Demodocus sings of the love of Ares and Aphrodite and how Hephaestus forged magic chains and wound them around the lovers' bed:

all around the bed-posts he dropped the chains,
whilst others in plenty hung from the roof-beam,
gossamer light and invisible to the blessed gods
themselves, so cunning had been the workmanship.
(Bk8:275).

The magic attribute of the smith is also evident in Hesiod. In Works and Days he makes Pandora out of earth and water:

He told Hephaestus quickly to mix earth
And water, and to put in it a voice
And human power to move, to make a face
Like an immortal goddess, and to shape
The lovely figure of a virgin girl (61ff).

According to Forbes, (1964:72) ancient Javanese literature also is full of tales alluding to the magical powers of the smith. And his identification with the spirit world is also evident in European legends where, for example, he may be assisted in his craft by dwarfs or he derives his power from the devil. It is, perhaps, understandable that the smith is identified as a magician and the craft is surrounded by magico-religious behaviour in technologically simpler cultures, which do not have such a wide body of empirical, scientific knowledge to draw on, in order to explain the metallurgical processes involved.

The idea that magic persists in conjunction with technical procedures because it serves cognitive ends has already been mentioned (see Chapter 3). It is a view that is endorsed by Gell who states: