ARTICLE

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Iron Production in Scandinavian Archaeology

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Trends in archaeological research in iron production during the 100 years that this topic has been studied in Scandinavia are highlighted in this article. In some periods there has been a relatively high level of activity among iron production researchers; in other periods the interest has tended to wane. Why should this be so and to what extent have theoretical trends in archaeology influenced this field? From a European perspective, Sweden and Norway are uniquely placed for studies of ancient iron technology because the remains of iron production in these countries are situated in remote areas. They are preserved because there has been no activity in the forests and mountain regions to disturb them since the production sites were vacated hundreds and thousands of years ago.

INTRODUCTION

The study of artefacts and the establishing of a chronology had dominated the discipline of archaeology in the 19th century in Scandinavia. The works of, for example, C. F. Thomsen in Denmark, O. Montelius in Sweden and O. Rygh in Norway opened the doors at the universities for archaeology. Grave mounds were systematically examined in the search for more material that could be used in building typological sequences, while other remains from prehistoric times were ignored in the initial phases. Dwelling sites from the Stone Age were, however, soon discovered and archaeologists began to excavate them using new methods based on stratigraphy. At the beginning of the 20th century there was a growing interest in the traces of iron production in the Scandinavian countries. This happened simultaneously in Sweden, Denmark and Norway.

HISTORICAL BACKGROUND

An interest in iron production took place a long time before archaeologists started to investigate iron production sites. In Norway and Sweden there was a direct iron production in recent times parallel with modern iron production in steelworks. This production was concentrated in remote parts of the upper valleys and forested areas, where peasants could produce their own iron and to some extent produce iron for trade. This production lasted until the beginning of 19th century in some places. Several researchers have documented the methods of production, especially in the 17th and 18th centuries (Schulze 1732, Swedenborg 1734, Evenstad (1790) 1960, and others).

In the time of enlightenment, scholars journeying through the Scandinavian countries took note of where they could find traces of old iron production. In Norway, Gerhard Schönning, one of the founders of The Royal

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Norwegian Society of Science and Letters, was in fact one of the earliest informants on iron production sites (Schöning 1979).

These descriptions did not lead to any scientific research on production sites probably because there were no methods that could be used in the investigations. With the introduction of archaeology as an academic discipline, a method became available that could reveal ancient production activity.

THE PIONEERS

The first archaeological excavation of an iron production site in Scandinavia was carried out in 1896 in Denmark in connection with the excavation of graves (Sarauw 1898:91ff.). Oscar Montelius excavated an iron production furnace in Sweden in 1907 and the results were published in 1919 (Montelius 1919, Englund 2002:55). In Norway the first excavation of a furnace took place in 1909 at Etne in Hordaland by Haakon Shetelig. He called the furnace a 'Blesterhola' and it is obvious that he did not know how this furnace had functioned or how old it might be (Shetelig 1910). At first hand, those discoveries did not lead to discussions between archaeologists, but they were recognized as important debris from the past. One effect of the discoveries was that other disciplines became interested and, above all, amateurs began to waken up.

In Denmark Rasmus Mortensen, who was a teacher, and Niels Nielsen, a geographer, initiated investigations of iron production sites in ca. 1920 and continued to carry out this research for 20 years. They also excavated some of them (Mortensen 1920, Nielsen 1922). Their activities were concentrated on technological aspects and an attempt to classify slags and furnaces. Nielsen divided the smelting technology into two groups: hearth-pit technology and bowl technology. Slags were classified as 'Small black slag solidified in thin fluid state' and 'big slag blocks with charcoal impressions'.

In Sweden Carl Sahlin, the director of a steel mill, played an important role in establishing interest in early iron production. He initiated interdisciplinary research, founded museums and secured old iron works. He started this activity in ca. 1900 and continued until the 1940s. Sweden had for a long time been one of the major producers of iron in the world and there was a strong metallurgical competence associated with this industry. There was a central interest office for iron production *Järnkontoret* that had initiated research and published results from this research in *Järnkontorets annaler*, established in 1817. Sahlin had re-established a historical guild for metallurgy in 1921 (Sancte Örjens Gille) which started a culture historical publication 'Med hammare och fackla' in 1928 and perhaps more importantly Sahlin founded a special branch in Järnkontoret publications: *Järnkontorets bergshistoriska skriftserie* in 1930. There is a permanent group in Järnkontoret dealing with historical questions, 'Bergshistoriska utskottet', that has been essential in supporting archaeological research on iron production (Englund 2002:55ff.).

In the 1920s, Sahlin established a cooperation with John Nihlen, who was an archaeologist, and this led to several important excavations of iron production sites in Dalarna, Uppland, Värmland, Halland, Gotland and Småland (Nihlen 1932). An important task was finding traces of ancient iron production and they used the local press in various regions where they announced their interest and asked the local population to report finds of slag and furnaces. This method led to hundreds of reports, which were fundamental for the research. This method was immediately copied in Norway where Rolf Falk Muus, a geologist, did the same between 1920 and 1940 and he ended up with some 4000 registrations!

As in Sweden, the pioneers in Norway were not archaeologists. Three persons must be mentioned: Ivar Kleiven, a farmer and local historian, Olaf Olsen, a priest, and Torje Nilsen Holme, a teacher. They were all active in surveying and, to some extent, excavating

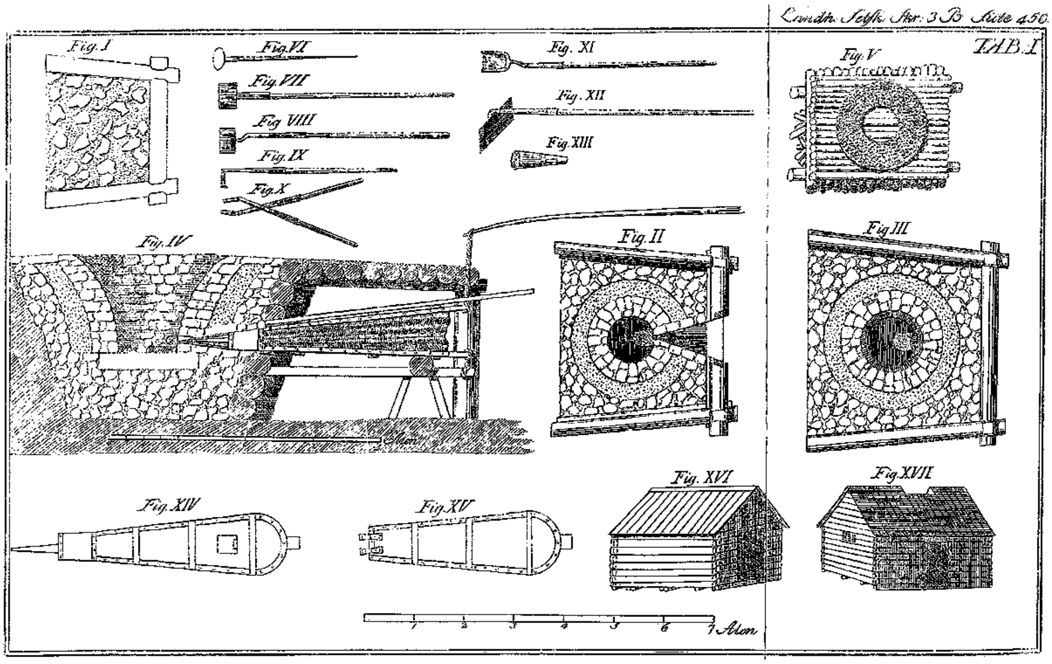

Fig. 1. *Ole Evenstad's drawings of an iron production furnace and recommended equipment from 1780.*

iron production sites. Olaf Olsen wrote an article in 1916 'Myrmalmsmelting i Norge i ældre tid' [Bog iron ore smelting in ancient Norway] which is considered as the first academic treatment of iron production in Norway. These pioneers were influenced by the 'Ole Evenstad tradition'. They had read his book and became interested in the old technology. They combined this knowledge with information from the sagas, placenames, old laws and old taxation lists (Narmo 1996:4ff., Rundberget 2002:5ff.). The work done by these people helped Haakon Shetelig to understand what he had found in Etne in 1909. He therefore published his excavation in 1913 and called the furnace a 'Blesterhola" [a blast hole] after an old description from 1756 (Rundberget 2002:6) (Fig. 1).

THE ARCHAEOLOGICAL ABSENCE

After the first period of interest in iron production, a similar development took place in all the Scandinavian countries. However, there was a lack of engagement by archaeologists. In Denmark there was almost no activity between 1940 and 1962. The difficulties archaeologists had encountered in dating the traces of iron production (Nørbach 2003a) could be one explanation for this situation. When the ^{14}C-method of dating became available, it opened up new possibilities and a new interest was kindled. Olfert Voss started a long-lasting study of iron production in Jutland. He was the first to interpret the slag blocks beneath the surface as slag pits under shaft furnaces. He was also motivated by the discovery of a well-preserved shaft furnace in Scharmbäck in Germany, which demanded a new explanation for earlier classifications (Voss 1962).

When John Nihlén retired from his position in Vitterhetsakademien in 1927, there was reduced interest in iron production in Sweden as well. After 1940 no one seemed to be engaged in this field (Englund 2002:60f.). In the beginning of the 1960s, amateurs had discovered a great many iron production sites in Skåne and Dalarna and they started experimental work. Conferences were held and this engaged the interest of the archaeologist Inga Serning. She became central in reestablishing Swedish research on ancient iron production. Inga Serning had led several excavations in Dalarna where modern archaeological methods had been used. In this research she could also include scientific analysis (Serning 1973).

In Norway, archaeologist had listed iron production as an important aspect in Norwegian archaeology. As resources were limited, the National Archaeologists' Meeting in 1927 decided not to give it priority. Instead, the initiative was handed over to technological investigations. This had been the main focus for the pioneers (Rundberget 2002:19f.). A special commission was appointed to take care of this project. This, of course, led to flagging interest among archaeologists, and technologists defined problems concerned with iron production. Although there was sporadic archaeological engagement between 1930 and 1960, it was not until the late 1960s that a new and profound interest in iron production was aroused. This interest was mainly due to the huge hydroelectric developments in southern Norway and Irmelin Martens was in charge of investigations before the construction work commenced (Martens 1972).

THE TECHNOLOGICAL PERSPECTIVE

Two directions seem to emerge in the study of iron production: a technological perspective and an archaeological perspective. Technological aspects were essential from the beginning, and people with a technological background engaged in this field in Norway. As a result of a national agreement, the first Norwegian Ph.D. thesis on iron production was written by an engineer in 1946 (Hauge 1946). The geologist Rolf Falk Muus had studied morphological aspects of iron production (Falk Muus 1927:358ff.). It is also likely that these people were influenced by contemporary research in Sweden and Denmark (Narmo 1996:6). The Swedish research connected to Järnkontoret was in this case important because metallurgical and geological competence had been employed (Englund 2002:57).

This technological line in the study of iron production can be followed in later periods. In Sweden, Inga Serning founded an archaeometallurgical institute in the 1970s that could assist archaeologists in their attempts to interpret material from their excavations. Järnkontoret was reorganized in the 1960s after an initiative by Inga Serning. *Jernkontorets Bergshistoriska Utskott* (The National Iron Office Mining History Committee) was established in 1968. Nils Björkenstam, a metallurgist, was director of this office, and continued research on metallurgical and technological issues (Englund 2002:61). Inga Serning saw the need for a common classification system of furnaces and established a system based on morphological elements (Serning 1976:48f.). This system was challenged by Irmelin Martens, who presented another classification system in 1978 (Martens 1978).

The study of technological aspects has been a strong discipline in Sweden in recent years. *Geoarkeologisk Laboratorium* (GAL) established in 1992 in Uppsala, has continued the work that was started in the archaeometallurgical laboratory founded by Inga Serning. GAL is today the main centre in Scandinavia for archaeometallurgical research.

As in the other Scandinavian countries, the technological aspect was dominant in the beginning. The first Ph.D. thesis was produced by the geographer Niels Nielsen 'Studier over Jærnproductionen i Jylland' [Studies of Iron Production in Jutland] in 1924 (Nørbach 2003b). In Denmark, Vagn Buchwald is a representative of the technological interest in iron production. Buchwald is a geologist and has for many years made quality tests of iron and slags and has sought to determine the provenience of iron products including blooms (Buchwald 1995, 1999). Arne Jouttijärvi has done provenience studies of iron in bog finds (Jouttijärvi 1994).

In Norway, Anna M. Rosenquist, a chemist, cooperated with Irmelin Martens when iron production sites at Møsvatn were investigated in the 1970s (Rosenquist 1988). The metallurgist Arne Espelund, Trondheim, has been a key person since the early 1980s. Espelund has participated in excavations in Mid-Norway and carried out metallurgical analyses of finds and interpreted the metallurgical process in furnaces (Espelund 1993, 1999). Espelund has also studied iron production in other regions and in other Scandinavian countries. Sigmund Jacobsen studied reducibility in ores found during excavations in southern and central Norway and conducted experimental work (1983).

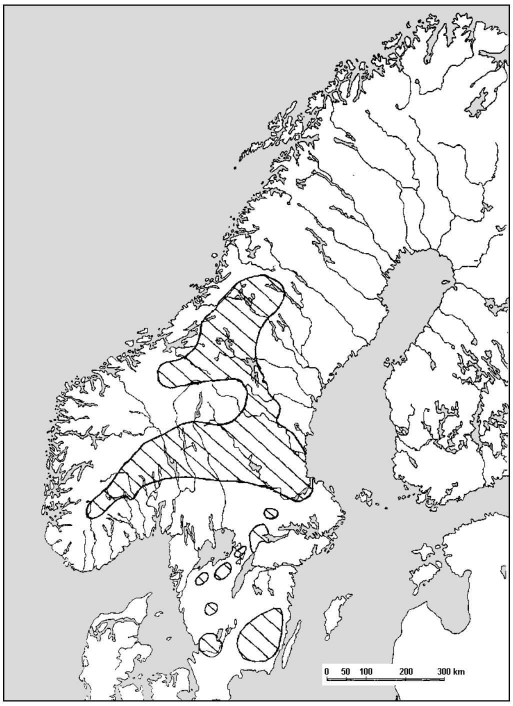

Fig. 2. *The main distribution of prehistoric and medieval iron production on the Scandinavian Peninsula. After L. E. Narmo.*

THE ARCHAEOLOGICAL PERSPECTIVE

In the beginning of the 1960s, interest in iron production began to increase. Archaeologists asked questions that had to be answered by archaeologists. It was, however, necessary to seek assistance from other professions to obtain a broader understanding of the problems. Chemists, metallurgists, botanists, geologists and historians have been involved in these questions. It is not possible to present a full picture of what has happened in the Scandinavian countries during the past 40 years but a few important investigations are mentioned in this article (Fig. 2).

Norway

When a reliable method of dating was introduced in the 1960s, it was possible to connect iron production sites to archaeological periods. It was not surprising when most of the sites could be dated to the Viking Age or Medieval Ages in southern Norway (Martens 1972). Viking Age graves in Scandinavia, particularly in Norway, contain many weapons and tools made of iron. It was exactly what had been expected when it seemed that the Viking period had marked a peak in iron production.

This situation was questioned when Arne B. Johansen found a production site at Sysendalen in Hordaland in Western Norway which was dated to the Roman Iron Age. This site was different from any other site in Southern Norway. The technology was different and the amount of slag was much larger than on production sites from later periods. Most surprising was the interpretation of the site, because it was explained as an activity of people living of hunting in the mountain area and not by farmers living in the fjord districts (Johansen 1973). This led to a discussion among Norwegian archaeologists and almost all of them rejected Johansen's theories (Løken 1979).

The early production site at Sysendalen

Fig. 3. *Slag pit belonging to a shaft furnace from Roman Iron Age, Fjergen, North Trøndelag. Photo L. F. Stenvik*.

remained an exception until a series of datings from Mid-Norway were made in the early 1980s. Suddenly there were hundreds of production sites that could be dated to the Early Iron Age. As a result of a randomized dating programme, it can be seen how production has changed over a period of more than 2000 years (Stenvik 1991). Production has started in the Pre-Roman Iron Age (300–400 BC) and a special production technology had been invented. This technology lasted until the Migration Period in ca. AD 600 and then disappeared completely. The production in this period must have been very large. Several furnaces had been operated at the same time on each production site and the output could have reached 100 tons on one site. The furnaces were much larger than furnaces recognized from later periods (Fig. 3).

Similarities with other smelting technologies in Scandinavia or Europe cannot readily be discerned, even if it is correct to say that the furnaces in Mid-Norway belong to a European shaft furnace tradition. Wood and not charcoal had been used. This explains the size, and the shaft could have been funnel shaped. Slag pits beneath the surface had openings that made emptying possible during production. Thus the production could continue for a long while.

Production exceeded local demand and Mid-Norway must have supplied other regions with iron for a long period. Production was very high in the Roman Iron Age, especially around AD 200.

Soon after the discoveries in Mid-Norway, another type of furnace was found in Central Norway. These were also huge shaft furnaces with slag pits and fired with wood. When the slag pits were full (slag blocks weighing more than 400 kg are known) the furnace had to be

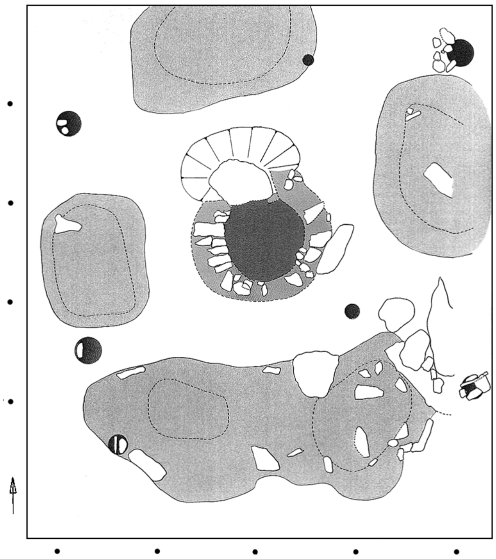

Fig. 4. *Layout of a typical production site from Early Iron Age at Fjergen in Mid Norway. In the middle a furnace surrounded by pits and post-holes. Drawing S. Bjerck.* (• = 1 m).

broken down and the slag removed. Then the shaft had to be rebuilt before the campaign could start (Larsen 1991). It is possible that this furnace and the furnaces from Mid-Norway did not need bellows. Experiments indicate that natural draught created the right temperatures. Furnaces of this type have been found in many places in parts of southeastern Norway (Fig. 4).

Finds of furnaces from the Roman Iron Age at Age near Kristiansand, the southernmost part of Norway, have revealed a type of furnace with some similarities to those in Denmark. Those areas have had close contact across the sea and it is not surprising to find that technologies had been exchanged.

Iron production in the Early Iron Age outside South and Mid-Norway is documented in Rogaland (Haavaldsen 1997), Western Norway (Bjørnstad) and North Norway (Roger Jørgensen, pers. comm.). The furnaces from the Early Iron Age in Norway belong to a European shaft furnace tradition, but there has been a local development of the technology.

It is interesting to see that there are boundaries between technologies in different regions in Norway during the Early Iron Age. This means that technology was dependent on various conditions such as local ore, fuel, organization, control over craftsmen, demand and perhaps religious factors (Stenvik 2003).

In later periods, technology seemed to be common to a greater part of the country. Iron was produced in many parts of Norway, even north of the Arctic Circle. In Mid-Norway production was concentrated in the southern areas. Three huge rescue projects in South Norway (Dokkfløy, Rødsmoen and Gråfjell) in advance of development projects revealed an astonishing intensity in iron production in areas with a scattered population (Larsen 1991, Narmo 1997, Risbøl 2001). The production is mainly dated to the Late Iron Age and Medieval Period and was not meant for local consumption. A special discovery on these sites was a shaft furnace with a slag pit, reminiscent of an earlier period, which could be the missing link to furnaces known from the Post-Medieval period in this part of Norway (Narmo 1997:112).

Sweden

In the 1970s archaeological surveys had located a dense iron production in Dalarna and in parts of Central Sweden. These investigations were seen in connection with settlement and organization (Hyenstrand 1974, 1979). In the same decade, Gert Magnusson started excavations of iron production sites in Jämtland, Central Sweden. This region lies next to Mid-Norway, and it is no secret that his investigations inspired researchers on the Norwegian side of the border (there has always been friendly national rivalry between Norway and Sweden. When the theme of the international conference in Budalen was named ‘Bloomery Iron-making during 2000 years’, a Swedish project was named ‘Bloomery Ironmaking during 3000 years’ soon after!) (Fig. 5).

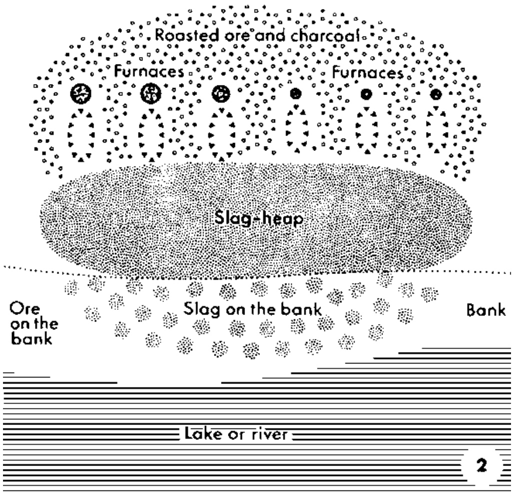

Fig. 5. *Model of an iron production site at the shore in Jämtland, Sweden. After G. Magnusson.*

Magnusson found furnaces from the Early Iron Age, Late Iron Age and Medieval Ages (Magnusson 1985). The production reached a peak during the Migration Period. In this period several furnaces on each site produced more iron than local consumers required. The technology in this phase was similar to contemporary technology on the Norwegian side. Magnusson discusses technological, social and economic factors.

Swedish archaeologists had located very early traces of iron production. Pre-Roman Iron Age furnaces were dated in the 1980s (Wedberg 1984). This raised questions about the introduction of Iron to Scandinavia and is a main issue in Ewa Hjärthner-Holdars Ph.D. thesis from 1993 (Hjärthner-Holdar 1993). She had found sound evidence of iron production in dwelling sites from the Bronze Age. The discovery of bowl furnaces indicated that they managed to produce iron for several purposes. Iron technology was introduced in Sweden before 1000 BC, and this is astonishing. Several theories on how this technology was spread are discussed:

1. Metallurgical knowledge is local, acquired only as a result of bronze-working.
2. Metallurgical knowledge is local, acquired as a result of bronze-working and new ideas from outside.
3. All knowledge is produced from outside via contacts with metal-producing societies.
4. All knowledge is imported by a foreign iron-producing community.

Option 2 is considered as possible in Sweden (Fig. 6).

The archaeological excavation of Lapphyttan in Sweden had revealed a blast furnace operated by waterpower that was dated to the 14th century. Remains of an earlier blast furnace were discovered underneath the last

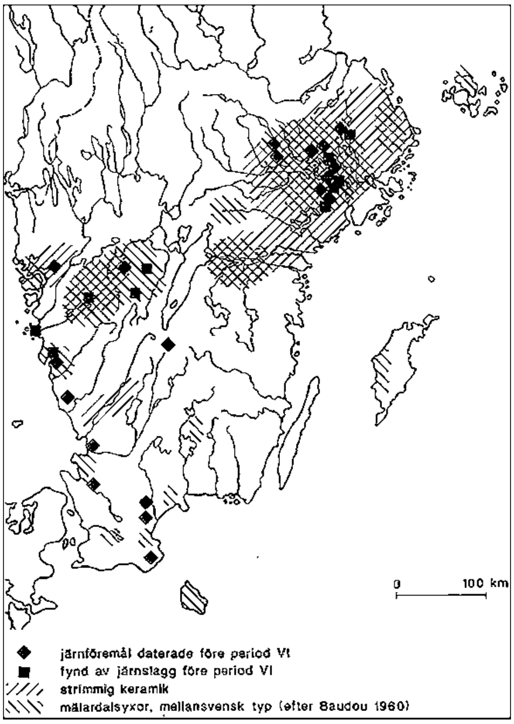

Fig. 6. *The distribution of striated ware, Mälardalens celts, iron objects from period III-IV and iron production before period VI of the Bronze Age. Drawing A. Grenberger. After E. Hjärthner-Holdar.*

furnace. This was dated to the 12th century (Björkenstam 1995). This technology was quite different from other technologies, in that it involved an indirect process where iron (pig iron) had to be treated two times to be malleable. It may look like a Swedish invention, and several blast furnaces have been located since the discovery at Lapphyttan, but there are similar furnaces in Germany from almost the same period. So far, none has been found in Norway. A special iron quality, 'Osmundjärn', may have been produced in these blast furnaces (Björkenstam 1993). In a multidisciplinary project on Järnmölle in Halland (Danish region in Medieval Times) a probable forge and a water-powered bloomery furnace have been investigated (Magnusson 1995).

Lars Erik Englund studied different aspects of bloomery iron-making such as changing techniques, chronology and organization on the basis of surveys, excavations and experiments in Västergötaland (Englund 2002). Considerable emphasis is laid on the interaction between observations during excavations and experiments. Englund has succeeded in producing malleable iron in reconstructed Iron Age furnaces. Studies of consumption of charcoal, ore, time and output are very informative.

Anders Ödman studied iron production in Skåne, in southernmost Sweden and has found traces of a well-organized production associated with ancient castles (Ödman 1992, 2000).

Denmark

Olfert Voss has been a central actor in Danish investigations since the 1960s. He excavated the iron production site at Drengsted (Voss 1986) and has published an overview of furnace types in Denmark (Voss 1985). Three types are known. From the Pre-Roman Iron Age there are traces of a sunken shaft furnace. The most common type, a shaft furnace with a slag pit, is dated from the Roman Iron Age to the 7th century. The last furnace type is a shaft furnace with slag tapping dated to Medieval Times (Voss 1995:132).

The smelting process in shaft furnaces with slag pits has been reconstructed. The slag pit was filled with straw that prevented ore and charcoal from falling into the pit but also to prevent the first slag from running straight into the pit.

> In the 'Bowl' just below the air inlets, directly below the hottest part of the furnace, the slag could be kept above its smelting point of 1150°. Gradually, as the pressure from the accumulating slag mounted, the straw filling would be compressed and slag would run, all at once, to the bottom. . . (Voss 1995:133f.).

When production is finished, slag blocks normally weigh about 200 kg. At Snorup, pairs of furnaces were found indicating a cooperation between at least two men. Voss has calculated the consumption and output of the process.

Lars Chr. Nørbach has tried to see the iron production sites in connection with natural resources and settlement pattern.

Iron production sites in Denmark are usually located in cultivated areas and have therefore been damaged but are also difficult to find because they are not visible on the surface. With the introduction of magnetometer surveys, more than 100 iron production sites are now known (Nørbach 2003) (Fig. 7).

EXPERIMENTAL WORK

When archaeologists had studied the remains from iron production and analytical results were combined with theories on operation, the time had then come for experimental work. There was, however, no manual to show how prehistoric furnaces were operated. In Denmark Olfert Voss had tried to produce iron in furnaces reconstructed on the basis of finds in Jutland (Voss 1973). In recent years a series of experiments has been carried out at the Historical-Archaeological Experimental Centre in Lejre. The Centre arranged a

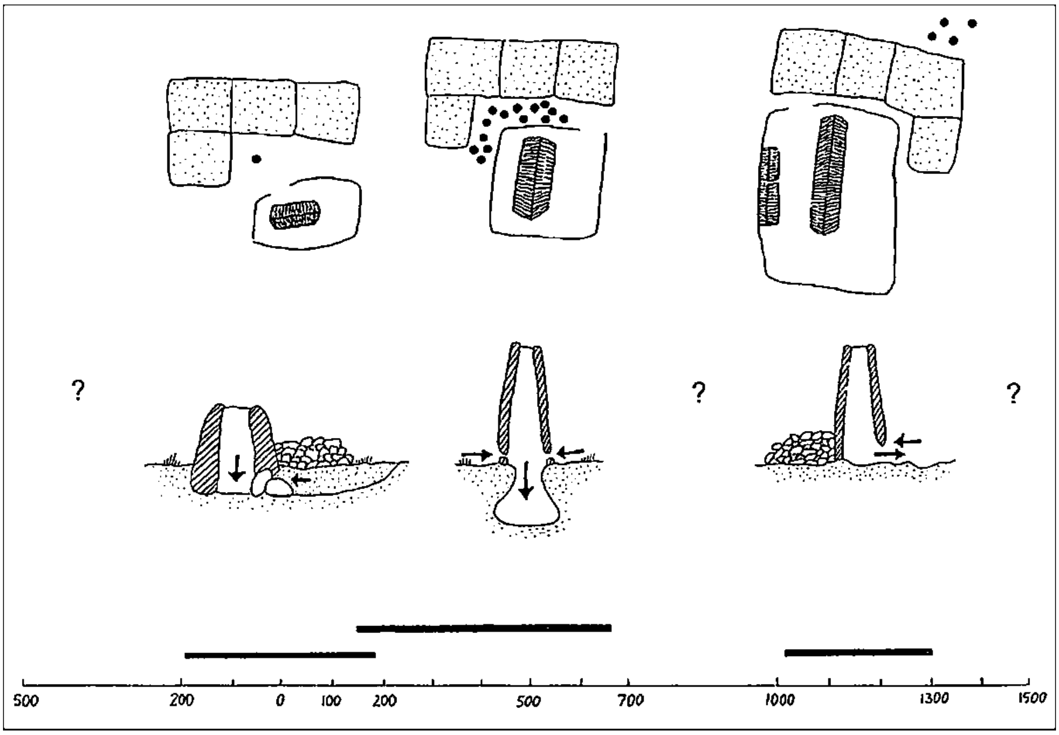

Fig. 7. *Furnace types and the relation between farms and furnaces during the Iron Age and Early Middle Ages. Drawing Maj Olika. After L. C. Nørbach.*

Conference on this topic in 1996 where the results of the experiments in Scandinavia were presented (Nørbach 1997).

In Mid-Norway several experiments were carried out following descriptions in Ole Evenstad's book from the 18th century. These experiments were a cooperation between archaeology and metallurgy as well as craftsmen (Berre 1998, Espelund 1997:47f.). When new results from excavated furnaces from the Early Iron Age were analysed, reconstructions were made and experimental smelting tried. Ivar Berre, Lars F. Stenvik and Arne Espelund have conducted several experiments.

After the excavations at Dokkfløy in southeastern Norway, experiments were carried out on the basis of observations made. At first hand, experiments using a technology known from the Late Iron Age/Medieval Times were undertaken (Jacobsen et al. 1988, Borup 1997:97f.).

In Sweden Lars Erik Englund was in charge of experimental iron production in Tranemo. He succeeded in producing iron in furnaces constructed on the basis of observations made in archaeological excavations. The aims of these experiments were: producing iron, producing malleable iron, producing steel and producing slag similar to that found on the production sites (Englund 2002:206f.). The GAL laboratory in Uppsala has performed several experiments in cooperation with Susan and Peter Crew in Wales. They have shown that it is possible to produce iron from magnetite in early Iron Age shaft furnaces known from archaeological excavations (Hjärthner-Holdar et al. 1997:15).

The aims of these experiments have mainly been technological or metallurgical. It has been important to find out how the process was managed. In this respect, chemical, physical, geological and metallurgical tests have been essential.

Other important aspects have been time-consuming studies and consumption of ore, wood, charcoal, clay and building materials. These aspects have been important for archaeologist in reconstructing organization. They have also been important in the education of students of archaeology as an example of craftsmanship and as a demonstration of how knowledge is transmitted through participation. This has been an annual event at the University of Science and Technology in Trondheim.

THEORETICAL INFLUENCE OR LACK OF THEORY?

It is difficult to point to any theoretical manifest for the pioneers in the study of iron production. At the beginning of the 20th century, archaeology was still in its infancy. It was important to establish chronologies and, above all, to establish national prehistories. At least it was important in Norway, which had just severed its union with Sweden. In this respect the growing interest could be perceived as a step in the nation-building process.

The period after World War I was, however, a time of depression, especially in the late 1920s when unemployment and bank crises were dominant. The establishment of trade unions and labour parties had led to a new political situation. Extensive and expensive archaeological projects could not be given priority. One can therefore understand why studies of ancient iron production could be dropped.

The main conception of material culture in this period was that finds could be related to different cultures. This is not discussed when archaeologists are dealing with iron production. It is, however, seen as an element of the Germanic cultures living in Scandinavia. In Sweden and Norway, remains of iron production are found in areas inhabited by people of different ethnic and cultural backgrounds, but it is not seen as a possibility that these peoples could have produced iron.

Marxism became an important issue in both political and academic discussions in the 1920s. Focus was set on economic and technological development. Functionalism is visible in the architecture and a functionalistic perspective on iron production would be feasible. Even if archaeologists did not express it, there are reasons to believe that there was a *discourse* between academics on what kinds of problems should be dealt with. In this light, it is interesting to see that technological aspects were given priority at the National Meeting of Archaeologists in 1927 in Norway.

Even if discussions among archaeologists on the problems of iron production were apparently absent in the initial phase, there are some exceptions. In the 1920s, Professor A. W. Brøgger, Oslo, one of the archaeological pioneers in Norway, discussed the influence of iron production on economy and settlement (Brøgger 1925).

In the period after World War II, economy and settlement played a dominant role in archaeological discussions of the role of iron production in Norway (Hougen 1947, Johansen 1973, Martens 1988, Larsen 1991, Stenvik 1991, Narmo 1996).). The ‘annales-school’ in the discipline of history had defined a goal for research where ‘the total history’ was the final objective. Iron production was soon considered as an important part of the totality in society.

In Swedish archaeology the same development can be seen. In the 1970s the economic aspect as well as the influence of iron in society is visible. Titles such as ‘Iron and Settlement’, ‘Iron and economy in Sweden’ are quite characteristic (Hyenstrand 1974, 1979).

In the 1960s and 70s new perspectives were introduced and the influence of New Archaeology is visible. It is illuminating to see the archaeological perspective reflected in the titles of congresses that were arranged in the Scandinavian countries in the past few decades.

These congresses mirror what Scandinavian archaeologists consider as important issues. Some of the congresses have been national. In 1979 there was a Norwegian National Meeting discussing iron production with special focus on iron production as a cultural factor (Løken 1979). In Sweden there have been similar meetings: *När järnet kom* [When iron arrived in Sweden], Göteborg 1976 (Cullberg 1977). Some international congresses have also been arranged: *Bloomery Ironmaking During 2000 Years*, Budalen, Norway 1991 (Espelund 1991, 1992, Espelund & Stenvik 1993); *The Importance of Iron Making. Technical Innovation and Social Change*, Norberg, Sweden 1995 (Magnusson 1995). In Denmark a Nordic congress was arranged in 1996 where the focus was on experimental smelting (Nørbach 1997). In 1999 an international conference was held in Sandbjerg where the conference title was: *Prehistoric and Medieval Direct Iron Smelting in Scandinavia and Europe. Aspects of Technology and Society* (Nørbach 2003a). A conference held in Uppsala, Sweden, in 2001 focused on *The Introduction of Iron in Eurasia*.

The aim of these conferences was primarily to present actual research in the Scandinavian countries and it is quite obvious that it is important to see iron production as an element in the society and there is a desire to combine technology and archaeology. This is not surprising for a period when processual thinking had made its way into archaeology.

Scandinavian archaeology has been strongly influenced by Anglo-American theoretical discussions in recent years. New trends have been adapted, but there have been very few attempts to include new theoretical perspectives in the study of iron production. The strong scientific tradition may be one reason for this situation. There has been limited space for humanistic thinking.

Some exceptions can be mentioned from Norwegian research, although the examples may not be representative since I have been involved as a supervisor. Kristin Prestvold has seen the iron production in Mid-Norway within a societal context where the change in quantity of the iron production was related to, and conditioned by social stability and social change, conflicts and contradictions. She has used graves and hill forts in her study of the society contemporary with iron production. Her conclusion is that the social conflict in the actual regions reaches a climax at about the same time as the iron production is reaching its peak. Her way towards understanding the dynamics of iron production is through the contradiction and conflict as demonstrated in structural Marxist theory (Prestvold 1996).

On the basis of grave finds and the occurrence of hill forts, Prestvold claims that Inntrøndelag during the Roman Iron Age is '. . . a society that is about to change character and where the old social structures are being replaced by new ones.' The peak in iron production coincided with the peak in the struggle for power. Production decreased when the social conflict lessened and the social structures were consolidated (Prestvold 1996:58f.).

The concept of technology is essential in Bernt Håkon Rundberget's study of an iron production site in Meråker, North Trøndelag. He discusses the way technology can be spread. A central point is that technological knowledge is transmitted through action and participation. He has adapted a 'chaîne opératoire' method and analysed remains left in furnaces. Special attention is given to flagstones carefully laid on top of slag pits. It is obviously an intentional act and interpreted as an attempt to hide knowledge. This interpretation is clearly influenced by post-processual thinking. It was important to keep the knowledge within a social unit where religious, political and economic factors as well as power and personal prestige are decisive (Rundberget 2002).

Another subject of discussion is whether there are ethnic differences in iron production. One possibility is that iron technology was introduced in North Norway at a very early stage. Finds of iron objects in Finmark have raised this question (Olsen 1991). Slag finds inside ceramic vessels found in Northern Scandinavia were interpreted as remains of iron production (Hulthén 1991). Arne Espelund has, however, seen these remains as carburization of iron objects (Espelund 1992). In any case, this has opened the debate to other possibilities regarding the introduction of iron to Scandinavia than through a southern route, and other ethnic groups than Germanics are conceivable.

THREE DIRECTIONS IN NORWAY

The study of iron production has been an essential part of the research at three universities in Norway. There is, however, a different emphasis on this topic at the various universities. This is mainly due to tradition and specialization at the involved institutes. The University of Oslo is the oldest academic institution and has played the main role in the initial phase. Here there has been a tradition of technological studies, and researchers were pioneers in combining technological and cultural perspectives. Irmelin Martens, Jan Henning Larsen and Lars Erik Narmo are exponents of a tradition where the iron production is seen in combination with economy and settlement.

At the University in Bergen a multidisciplinary research programme was established in the 1970s where the aim was to study how man had harvested nature in prehistoric times. One of the projects focused on the iron production adjacent to Hardangervidda, a mountain plateau between Eastern and Western Norway (Johansen 1973). This triggered interest in iron production in other parts of the world. African iron production soon became an important subject at the Institute of Archaeology in Bergen with Professor Randi Haaland and Dr Randi Barndon as central persons (Haaland 1985, Barndon 2001). They have focused on the anthropological aspects of iron production.

The study of iron production at the Norwegian University of Science and Technology in Trondheim began in the late 1970s but it was episodic. It was not until a joint expedition on Heglesvollen in North Trøndelag had been organized in 1982 that things started to happen. This expedition was a close cooperation between archaeology and metallurgy where an iron production site from Roman Iron Age was excavated and interpreted (Farbregd et al. 1985, Espelund 1991). A later project at Fjergen, which was initiated because of a hydroelectric development, has strengthened this cooperation (Stenvik 1996). Since the beginning there has been a strong metallurgical profile on the research with special emphasis on understanding metallurgical processes. The metallurgist, Professor Arne Espelund, has been in charge of this research, while I have been leader of archaeological excavations in Mid-Norway and seen iron production in a social and economic perspective (Stenvik 1997, Espelund 1999).

FINAL REMARKS

The study of iron production in Scandinavia has been closely linked with international research. It is easy to see that researchers have seen influences in technology from other regions in Europe. Discussions have been initiated between Scandinavian researchers and European colleagues exemplified in the *Norwegian Archaeological Review, vol. 11(2)* (1978). A great many researchers have presented their work at conferences arranged by the *Comité pour la sidérurgie ancienne,* a European group of researchers dealing with archaeometallurgy. Several meetings of this group have been held in Scandinavia, during which Scandinavian research has been presented to a European audience.

It is not always easy to link traditional archaeological research with other disciplines. Metallurgists and chemists have their own methods and without sufficient knowledge of their respective ways of thinking, dialogue may be difficult. Mistakes can be made by all disciplines involved in iron research and this has obviously led to the wrong conclusions being drawn.

It is stated that there are many well-preserved iron production sites, especially in Sweden and Norway, but new technology in forestry constitutes a threat to these remains. New roads must be constructed because new and heavy machines are being introduced. These machines cause damage to the ground and destroy the iron production sites. During the past ten years there has been an alarming increase in damaged iron production sites (Stenvik 1992). It is time for action from both archaeologists and national heritage authorities to save this unique material.

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