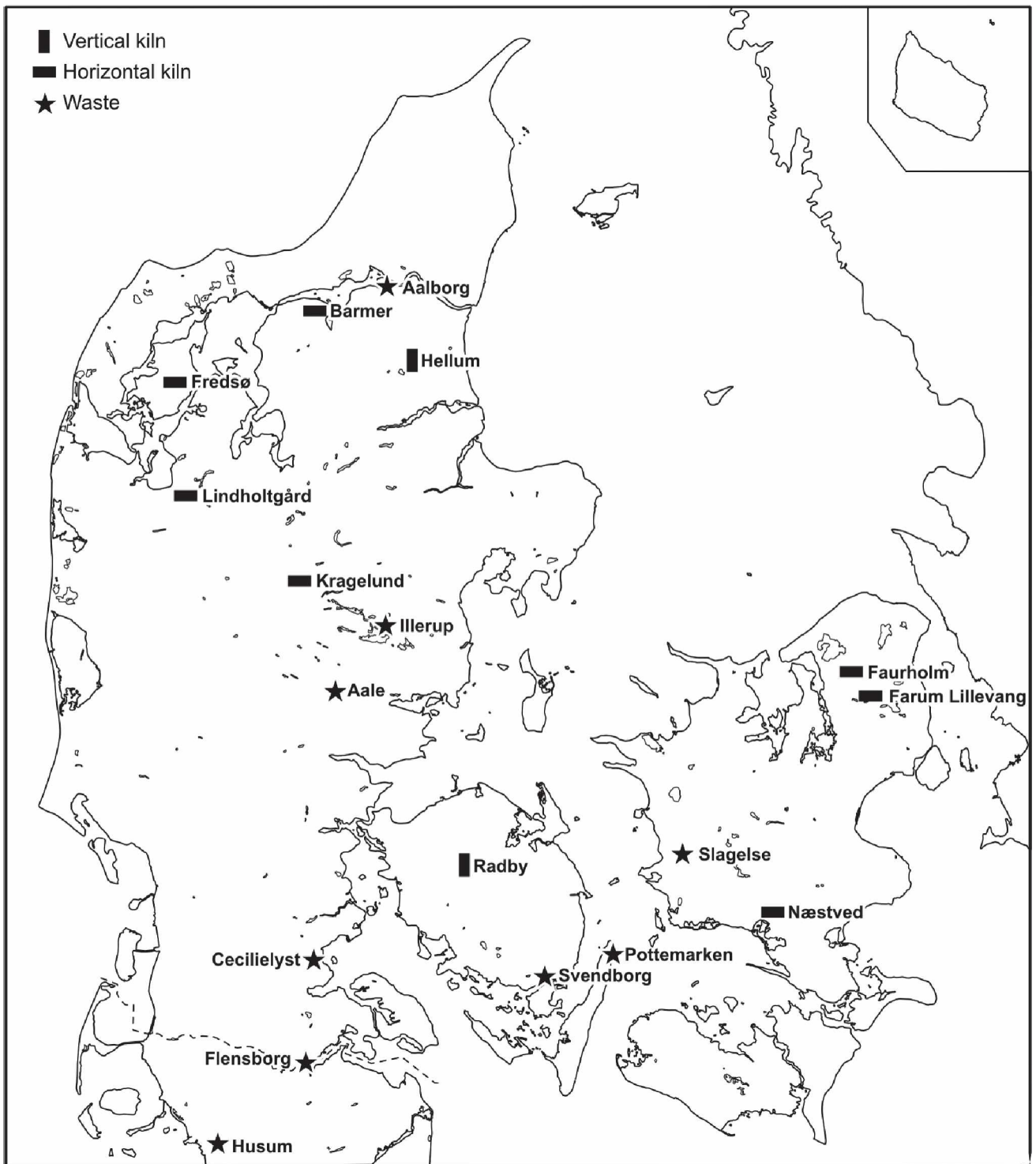


# medieval ceramics **Papers**



**Figure 1**

Archaeologically demonstrated pottery kilns and potteries from the Middle Ages and the Renaissance in Denmark by 2006.

Drawing by Sven Kaae

# Medieval pottery kilns in Denmark

## Excavation and reconstruction

Jan Kock

### Summary

*Until the beginning of the 1980s only two pottery kilns were known from the Middle Ages in the Danish area. Both kilns were found on Zealand at the localities of Farum Lillevang and Faurholm. Not until 1983 did new finds appear. In the course of several months three new pottery kilns were found with accompanying discarded and misfired pottery. The first of these kilns was found on the western edge of the village of Hellum in eastern Himmerland. Only a few months later the remains of another kiln appeared at the village of Kragelund about twenty kilometers north of Silkeborg, and almost at the*

*same time more pottery and kilns came to light near the village of Barmer in Himmerland. The three new kilns were not only widely different in construction but also different from those already known. This gave rise to the establishment of a research and publishing project that included an analysis of the kilns as well as the preserved pottery, the realization of a series of experimental archaeological experiments, and the collection of comparative archaeological material and selected parallel ethnological and ethnographic material.*

### The European context of the Danish kilns

It has long been apparent that during the 12th–13th century pottery underwent a period of rapid technological development in Denmark. There is evidence that little by little the fast-moving potter's wheel became more common, that potters learned to fire the pots at a higher temperature, that the potters were able to fire both oxidated and reduction-fired pots and in addition learned to lead glaze. A crucial precondition for several of these technological improvements was the use of kilns, which made it possible to control the firing process better and to obtain higher temperatures. Elements of both the central and northern Europe types of horizontal kilns and the vertical types of kilns dominating in the Mediterranean area, southwestern Europe and the British Isles are to be found in the pottery kilns now documented here in Denmark (Köpke 1985, Karte 4, Köpke 1991, 284; Köpke & Graf 1988, 111 & 118; Kresz 1991, 262; Segschneider 1980, 217 ff.; Vossen 1991, 30).

The oldest Danish kiln finds from Farum Lillevang and Faurholm can be characterized as variants of the horizontal type, though without an internal division. The kiln from Hellum, on the other hand, is of the vertical type, known from the British Isles and regions farther away. The kiln from Barmer is of the horizontal type, with entirely separated fire and kiln chambers, the two chambers being separated by a screen consisting of three pillars. This kind of kiln was widespread in the countries south and southwest of Denmark. Also the kiln of Kragelund is of the horizontal type, but with the fire and kiln chambers standing end to end and the flames being led up around the pots by way of a couple

of flues. Again this is one of the most common kiln types in northwestern Europe.

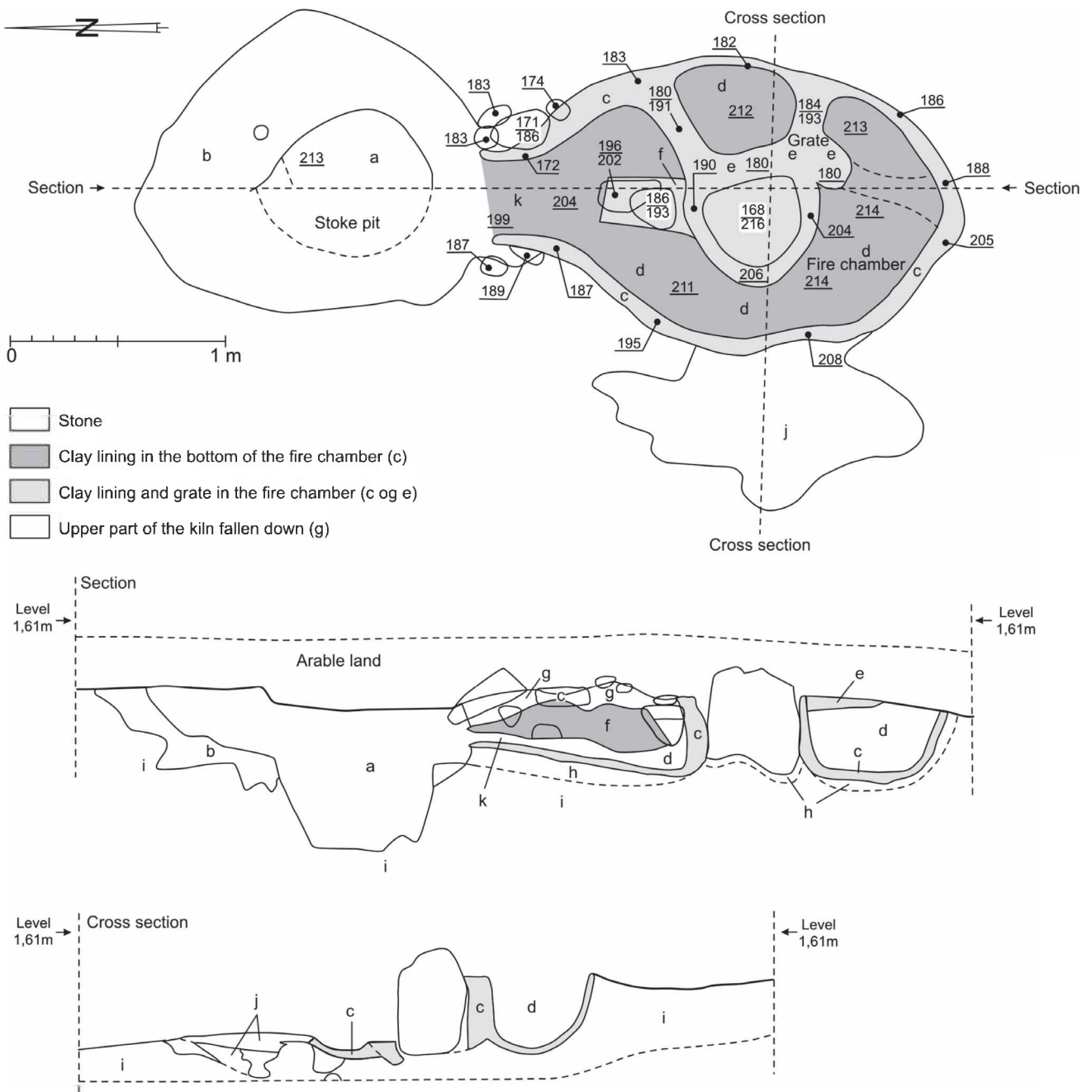
The kilns were of course part of a workshop, but there are almost never archaeological traces of these beyond wasters of more or less fused pottery from the potter's production. A number of wasters have also been discovered without any further traces of the production centre to which they belong.

### The Hellum kiln

The town of Hellum lies at the eastern edge of the Rold Forest, which is one of the largest forests in Denmark. In the district of Hellum, pottery was widely produced throughout the eighteenth and nineteenth centuries and up into the twentieth century. Written materials substantiate that the production can be traced back to the seventeenth century. (Christensen 1832, 136; Begtrup 1810, 228; Kock 1975, 23).

From contemporaneous descriptions it appears that the workshops were small and that pottery making was actually a source of extra income to supplement what the farming could yield on the relatively poor soil. Thus it was a kind of auxiliary industry, albeit important during certain periods.

With this in mind, it was therefore no real surprise that the museum in Aalborg was notified that the plowing of fields on the western outskirts of the town of Hellum had turned up a quantity of potsherds. These were expected to stem from a pottery workshop or wasters from production within the last few centuries. The subsequent inspection offered a pleasant surprise. The plow had without a doubt cut into one side of a



**Figure 2**

Plan and profiles of the pottery kiln of Hellum

**a** Stoke pit, greasy, ashy soil with charcoal and many potsherds

**b** Stoke pit, slipped soil, mixed with subsurface

**c** Lining of fire chamber, sand-tempered clay

**d** Fire chamber filled with an ashy layer of soot, charcoal, pottery and remains of the walls of the kiln chamber

**e** Clay bar made of sand-tempered clay

**f** Fallen clay bar made of sand-tempered clay

**g** Collapsed part of the dome, sand-tempered clay

**h** Subsurface, sand coloured red by heat

**i** Subsurface, yellowish red sand

**j** Hazard dig, mixed layer of subsoil sand, ashes, soot, charcoal and pieces of burnt clay lining

**k** Fire-neck

Working drawing by Sven Kaae

pottery kiln, and the many sherds of somewhat rough, hand-shaped (pressed and coil-built) grayish-black pottery suggested that the kiln had functioned sometime in the late Middle Ages. The actual examination was carried out the same year and the excavation report is located at the Aalborg Historical Museum under reference number 1399. The site lies just west of town on a sandy, almost flat moraine hill, which slopes slightly downward toward a small stream somewhat farther west. A large area surrounding the kiln was cleared without it being possible to detect traces of other installations in the form of postholes from a protective superstructure, other associated buildings or more kilns.

Since the kiln has not been repeatedly rebuilt, the main structure is very clear (Figure 2). It is a vertical kiln, the fire chamber of which is placed beneath the kiln chamber and separated from it by a wheel-shaped grate. The stoke hole is in the side, through a short neck on the fire chamber. In front of the stoke hole is a narrow and relatively deep stoke pit. The kiln is oriented north–south with its stoke hole facing north.

The construction of the kiln must have taken place somewhat as follows. Prior to constructing the kiln, an almost pear-shaped hole about 50 cm deep, 220 cm long and almost 140 cm wide was dug into the subsurface of the soil, clearly in order for the surrounding soil to stay warm during the firing process. Partially burying a kiln in the subsurface is a recurrent element in virtually all of the known parallels to this as well as other types of kilns.

To support and strengthen the grate separating the fire and kiln chambers, a heavy, almost cylindrical granite stone was placed in the middle of the dug-out area. The hole for the kiln was dug so precisely that the final covering of a thick and even layer of clay was all that lacked. The analyses clearly showed that the clay covering occurred in horizontal layers of a height of between 10 and 15 cm and a thickness of between 4 and 10 cm. The covering was very carefully made. The single layers were well compressed, and the impression of the kiln builder's fingers was quite distinct in many places. The finished surface of the clay covering was finely smoothed down, so that a smooth-walled fire chamber was formed around the middle stone, which was also covered with a thick layer of clay. The clay used for the covering felt quite thin, and an analysis of carried out by the Geological Survey of Denmark and Greenland also clearly showed that it had a high content of sand, which was necessary for it to withstand the heat.

The fire chamber and the fire-neck were built together and were also carefully lined with clay. The sides of the fire-neck were reinforced by an approx. 20-cm-wide lining of stone at its mouth. The wheel-shaped separation between the fire and kiln chamber were built from 10 to 15-cm-wide thick clay bars, the cross-sections of which were shaped like Ds, the plane side facing upward. Each bar rested on both the middle



**Figure 3**

The Hellum kiln uncovered and the north-southward profile completed. To the left the stoke pit partially excavated. In the middle the kiln with the fire-neck at the front. The left part of the kiln has not yet been excavated. Here the middle stone has been removed. To the right the hole dug to provide the kiln with air during the last firing. Seen from the northwest.

section and the outside of the fire chamber (Figure 3). The still workable clay bars were then modeled in soft and rounded forms along with the lining of the fire chamber, which was made of the same sort of clay. Cuts and gaps in the clay bars show that no bracing was used inside the bars; they could support themselves, perhaps with a little help during the actual construction of the kiln. Two of the clay bars were preserved intact; in addition, there were remains of a third one. There were probably a total of five, besides the covering on the fire-neck. The final ploughing must have removed the western bars.

The fire-neck was entirely covered and extended all the way into the middle stone by a triangularly shaped bar. This method of construction was possible to record since the covering or the beam collapsed at some point and now lay above the bottom of the fire-neck, separated from it by a thin layer of ash.

Virtually none of the actual kiln chamber remained. Only at the stoke hole was some collapsed, very thin clay and a little stone, which can hardly be anything but parts of the superstructure of the kiln. The weak traces can be interpreted as indicating that the walls of the kiln chamber were built of the same kind of clay as the bottom part, and that in any case the bottom part of the kiln chamber's dome at the fire-neck was also lined with stone. Based on the archaeological evidence, nothing can be said about the shape of the superstructure. The part of the kiln preserved reveals nothing about whether it was cubical, conical or cylindrical, whether it was closed, and how the pots were moved in and out.



In front of the stoke hole into the fire-neck an almost 80-cm-deep stoke pit had been dug. The stoke pit was filled with subsoil sand, charcoal and relatively many potsherds.

At the time of analysis, the fire chamber was filled with large pieces of charcoal, soot, ashes, collapsed pieces of the walls of the kiln chamber and beams, in addition to a large quantity of sherds from fire-blackened pots. The actual ceramic material is not presented here.

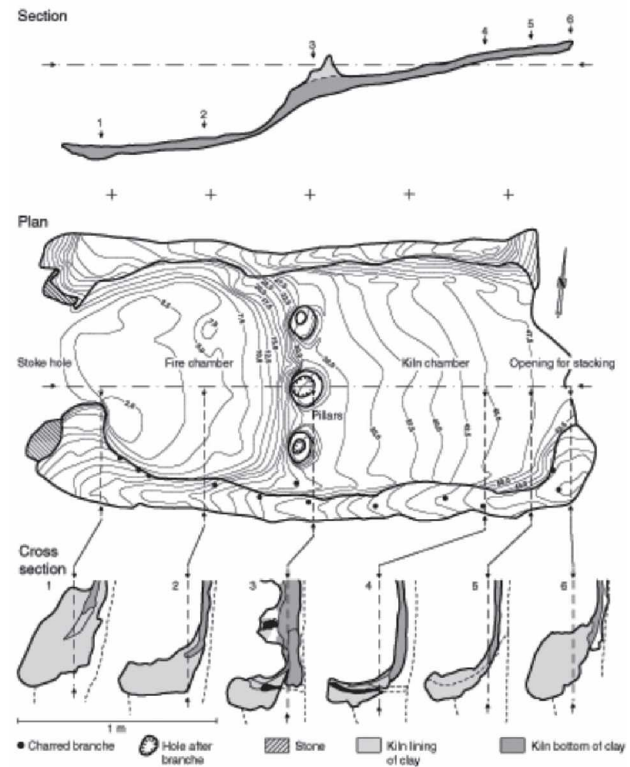
The big potsherds must primarily come from pots that broke during the last firing and that therefore fell down into the openings in the wheel-shaped grate. The potter did not take the trouble to empty the fire-neck of these potsherds, certainly because no subsequent firing took place.

The Hellum kiln must be characterized as the vertical type with a separation between the kiln and fire chambers constructed as a wheel-shaped grate with spokes. It is therefore distinct from the other Danish material from medieval pottery kilns. This type of kiln is found in northern Europe, primarily in the English area, where it goes back to prehistoric times and as a type was in use for a long time after the Middle Ages. According to the information available now, there are good reasons to suppose that the model for the Hellum kiln is to be found on the British Isles and probably in the eastern part of England, where several variants of the vertical type of kiln are found (Musty 1974). The pottery from Hellum dates the installation to sometime in the twelfth century. To achieve the best possible dating of the installation, tests for C-14 datings have been gathered and a few thermoluminescence datings have been done. Three C-14 datings have been made, all of which are partial tests taken from the same sample. The result of the C-14 is between 1020 and 1160 and less exact the thermoluminescence dating is 1250.<sup>1</sup>

Sherds from approximately 70 vessels were found in the fire chamber itself. With the exception of a couple of sherds, all were from round pots, with an opening-diameter of 4–20 cm. All the vessels are coil-built, the rim is out-bent, and not, or only slightly thickened on the outside. On the inside, the rim can have a more or less obvious ridge, and double ridges as well as completely smooth rims also occur. The rim is thrown both inside and out with a wet cloth. The material is mainly fired in reducing atmosphere. There are no feet, ears, or handles, which fits well with the C-14 dating showing that the workshop was in use sometime in the first half of the 12th century.

## The Barmer kilns

The village of Barmer lies in a hollow between two large moraine hills surrounding the town. In the northern part of the village, sand has been dug out for a local cement plant for many years. In 1984, at the edge of this sand pit, black layers and a considerable amount of



**Figure 4**

Barmer kiln I, plan, longitudinal section and six cross sections. To the west the stoke hole and the fire chamber, in the middle the three pillars which have separated the fire chamber from the kiln chamber, then the kiln chamber and finally to the east the opening for stacking the pottery. Next to this opening the southern wing is intact. The northern wing was preserved too, but it was removed before the kiln facility was recognized. A difference of level of 2.5 cm is shown.

Drawing by Jan Slot-Carlson. Working drawing by Sven Kaae

pottery appeared from more or less reduction-fired bowls, pots and pitchers. The first examination showed clear traces of a pottery kiln.

The report of this final examination is in the Aalborg Historical Museum under reference number 1623. The final examination of the area revealed two kilns located on a moraine hill of sand sloping steeply downward toward the west. Both kilns were roughly oriented east-west with their stokehole and workplace on the west side of the kilns, so that the pottery kilns made use of the sloping ground. In this way a sunken space, an ash pit, was achieved without necessarily having to dig one. The entire workplace was characterized by repeated firings in the shape of partially vitrified potsherds, ashes, charcoal and burned bits of clay from the domes of kilns situated there. It is possible that more kilns are located in the unexcavated areas.

It would not be unnatural for the kilns to have been covered to protect them against the weather and the wind. But in the area examined no traces were found of buried posts or other phenomena which merely suggest the presence of such a covering. Nor have

actual settle-ments been detected. The potter may have lived down in Barmer and had his kilns at the edge of town.

The bottom part of Kiln I was well preserved. Since there were no more phases or renovations, the way in which the installation was constructed is quite obvious (Figure 4). Before starting to build the actual kiln, an approx. 50-cm-deep hole was dug into the subsoil in order to provide the kiln with sufficient insulation; the kiln was then constructed here. The kiln was built with separate fire and kiln chambers, the fire chamber being located a little more than 25 cm lower than the kiln chamber. The total length of the kiln was 2.5 m, the fire chamber accounting for 1.2 m of it; it was not quite 2.5 m wide throughout its length. Hence: a rectangular floor plan with rounded corners (Figure 5).

The bottom of the fire chamber's somewhat trough-shaped hole was lined with a very thin clay mixture, which was spread out in a thickness of a little more than 5 cm. This clay mixture has been tested by the Geological Survey of Denmark and Greenland and seems to show that local moraine clay was probably used. The sides of the fire chamber, preserved up to height of approx. 35 cm, were roughly daubed with the same thin clay mixture. The highly exposed stoke hole opening was reinforced with a couple of large granite stones which had originally been covered entirely with clay.

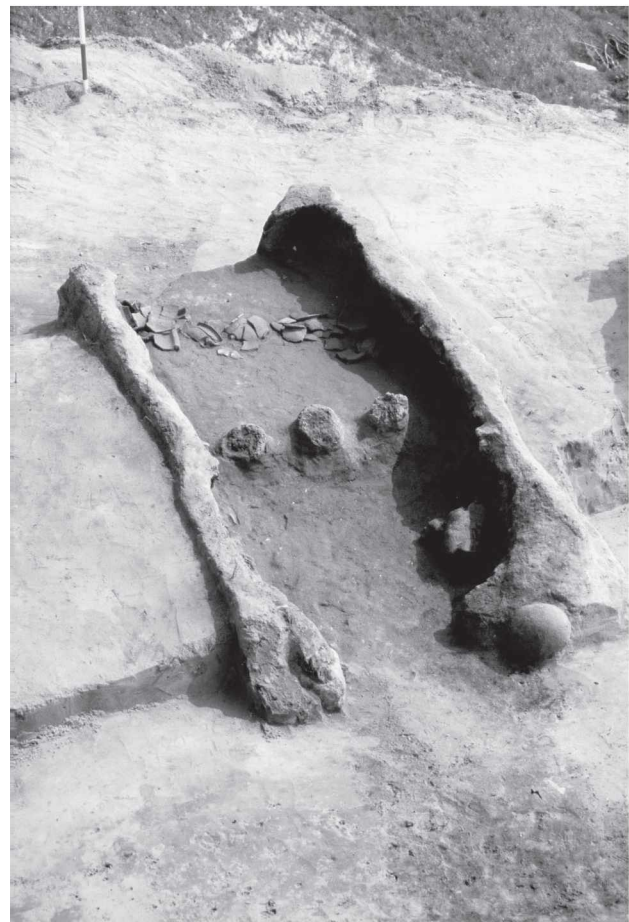
Toward the kiln chamber, the lining of the fire chamber was done more meticulously, and the clay was applied in thicker layers. It was quite clear that care had been taken to provide the quite sharp rise toward the kiln chamber with a smooth surface.

The bottom of the kiln chamber was meticulously covered with an even lining of thin clay, though only in a layer of between 2 and 5 cm. The bottom had a slight, even rise toward the east end of the kiln. Along each side, a little more than 5-cm-wide, quite flat furrow was formed in the clay while it was still soft; at the east end of the kiln it continued around the corners and did not end until the opening for stacking the pottery.

At the east end of the kiln was an opening for stacking the pottery. Care had been taken to make the jambs for the opening evenly round. This opening must have been about 60 cm wide. The height of the opening could not be determined.

After the bottom of the kiln was finished a skeleton of branches was constructed, mostly hazel, but also mountain ash was used. The walls and dome of the kiln chamber were made of the same very sandy clay which had been used to line the bottom. The thickness of the dome varied greatly but was generally about 12 cm.

In the passage between the fire and kiln chambers three columns had been placed at intervals of about 25 cm. Each column was daubed with clay around a stick which was stuck down through the clay at the bottom of the kiln. The columns had a diameter of between 18 and 20 cm. The best-preserved column was preserved to a height of 20 cm, but underneath in the fire chamber



**Figure 5**

Barmer kiln I uncovered. At the front, the stoke hole and the fire chamber. Three pillars have separated the fire chamber from the kiln chamber. Further behind the kiln chamber with a number of vessels still in place as they were found. At the very back the opening through which the pots were brought into the kiln. In front of the kiln a work area from which the potter stoked the kiln. Seen from northwest.

lay many pieces of fallen column. The best-preserved piece had a length of 22 cm. Consequently, it is fairly certain that the columns measured at least 42 cm in height.

During or more likely after the last firing the dome collapsed and the potter could not save all his pots. In any case, during the investigation many almost complete pots were recovered in the kiln chamber which was left shattered under the collapsed parts of the dome.

At any rate, the large quantity of wasters in the area next to the stoke hole, which contained charcoal, ashes, pottery as well as many badly burnt pieces of the dome, indicates that pots have been fired repeatedly in this place.

Kiln II lay a few metres south of kiln I. The state of preservation was worse than that of kiln I; but it was clearly identical to this one.

The kiln type itself does not give us any particularly precise dating seeing that this type is known from a large area in the north-western and central parts of

Europe and at the same time this type has been used back in prehistoric time as well as during a big part of the Middle Ages.

The analysis of the pottery from the two kilns and the work areas does not indicate a significant difference. Apparently, there are no major differences in the material, either typologically or technologically. The pottery is made of fine, sand-tempered clay. All the pottery is coil-built and pressed up. The main forms are bowls with rounded body and base and out-bent rims, bowls with strongly profiled rims and shoulders, bowls with in-bent openings, pots with rounded body and base, smaller pots, also with rounded body and base, and finally, a small number of jugs. All the pottery is greyish-brown-to-grey, sand-tempered ware and fired to varied degrees of hardness. Everything indicates that it was intended to produce fairly hard-fired, reduction-fired ware. It is not possible to estimate a minimum of the contents of the kilns because most of the pottery was found outside in the working-area.

The C-14 dating, and the occurrence of very similar vessels from a nearby castle mound whose construction can be dendrochronologically dated to the last quarter of the 14th century, allow for a clear dating of when the Barmer potter was active.

A quite precise dating can be given due to a fortunate constellation. In the medieval earthwork of Halkær or Hedegaard, which is situated just about 10 km from Barmer, a large number of bowls were found. With regard to the shape, these bowls look like the bowls found at the kilns of Barmer. An analysis of the clay used for the bowls shows that exactly the same clay was used, which supports the theory that the pots of the earthwork come from the potter of Barmer. In the earthwork a lot of timber has been found which shows unambiguously that the castle was built between 1370 and 1390 (AUD 1989 1990, 267–268). Consequently, the potter must have been working towards the end of the fourteenth century and during the first decades of the fifteenth century.

Furthermore, a number of C-14 datings have been made of the thin, fresh branches which were used when the branch skeleton of the dome was built. From kiln I three samples have been processed. The result is for kiln I 1280–1400 and for kiln II 1320–1440.<sup>2</sup>

In other words, these C-14 datings place the kilns in the fourteenth century. The find context indicates that we must assume that the four datings are contemporary. This dating corresponds very well with that of the entirely similarly shaped ceramic material from the nearby medieval earthwork of Hedegaard, which has been dated dendrochronologically to between 1370 and 1390.

## The Kragelund kiln

Gardening at 25 Kragelundsvej, Kragelund north of Silkeborg, had been bringing burnt lumps of clay,

potsherds and charcoal to light for a number of years. As a result of this, an investigation was initiated in 1984. The kiln found was very badly preserved. Only the bottom parts could be recognized. This means that the ground plan of the kiln is just partially known. However, there was enough to indicate the structure of the kiln fairly clearly. The rearmost part of the kiln chamber had barely been dug into the ground and therefore it had disappeared.

The kiln facility with a preserved length of approx. 2.3 m and a maximum width of approx. 2.0 m consisted of a fire chamber with a kiln chamber behind it which was positioned at least 45 cm higher (Figure 6). The front part of the fire chamber had been dug approximately 30 cm into the subsurface and it flattened somewhat towards the kiln chamber. All of it was meticulously lined with a 10 cm thick layer of sand-tempered clay. The kiln was stoked from a 30 cm deep stoke pit.

The kiln chamber was separated from the fire chamber by an elevated platform which has not been preserved at its full height and length. It was preserved at a height of 45 cm. The top side was probably plane and lined with clay. At the front, the platform was approximately 80 cm wide. A length of the platform – and consequently of the kiln chamber – of 1.5 m or longer is probable.

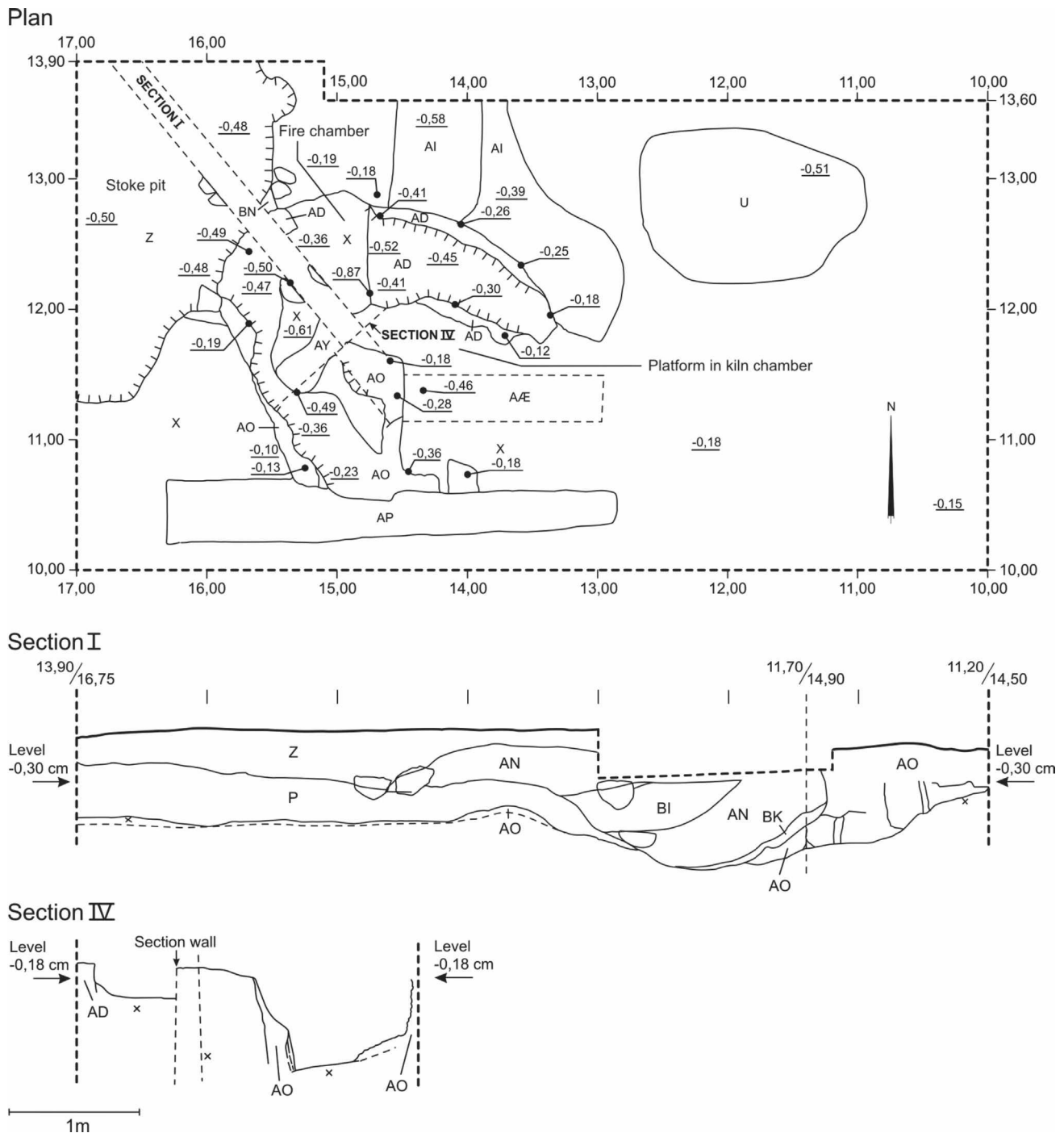
On each side of the platform there was a sloping flue which connected the fire chamber with the kiln chamber. Due to the sloping construction of the kiln, the rear-most part of the kiln was not preserved.

The kiln has been covered with a clay dome, remains of which were found in the form of large lumps of burnt clay. Untempered, local moraine clay was used for the dome. There are some spots of glaze on the lumps of clay from the dome, which shows that glazed pottery has been fired there. There have not been found any traces of a skeleton of branches in the dome and impressions of one on the intact part of the kiln have not been found either. This proves that the dome solely consisted of clay. The shape of the dome and its construction as well as the location of flue openings and the opening for stacking the pottery were not to be seen during the investigation.

At the bottom of the kiln chamber vitrified potsherds were found. The potsherds were often fused together. The glaze of the glazed potsherds was greyish, lustreless and bubbled.

In spite of the bad state of preservation of the Kragelund kiln there is no doubt which kiln type it is grouped with. The Kragelund kiln belongs to the group of horizontal, two-chambered kilns with a platform structure in the kiln chamber on which the pottery was stacked during firing. This kiln type is known in several variants from the western part of the continent of Europe (Stephan 1982). This type is spread over a large geographical area as well as a long period of time. Consequently, this leads to differences between the individual kilns. This makes it impossible to form a



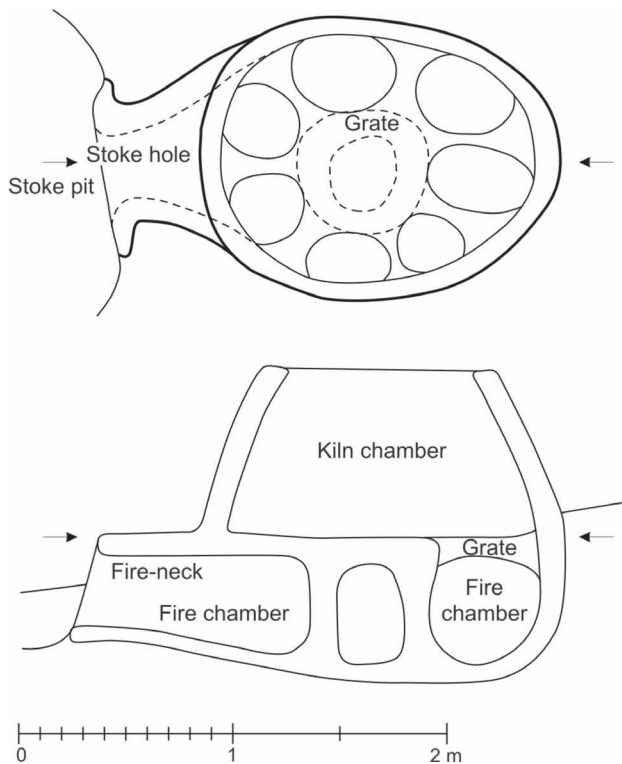


**Figure 6**  
 The Kragelund kiln. Horizontal plan and profiles I and IV.  
 Measuring by Helle Reinholdt. Working drawing by Sven Kaae

precise picture of the Kragelund kiln. All the kilns have some sort of platform in the kiln chamber; but the shape of the individual platform may vary quite a lot.

The pottery from the kiln and a waster pit represent at least 54 vessels, partly lead glazed and modestly decorated pitchers, unglazed pots and bowls. The pots have mainly been fired in an oxidized atmosphere. All the vessel types are mainly built up by coil building. The pitchers however is hand built up to the shoulder after

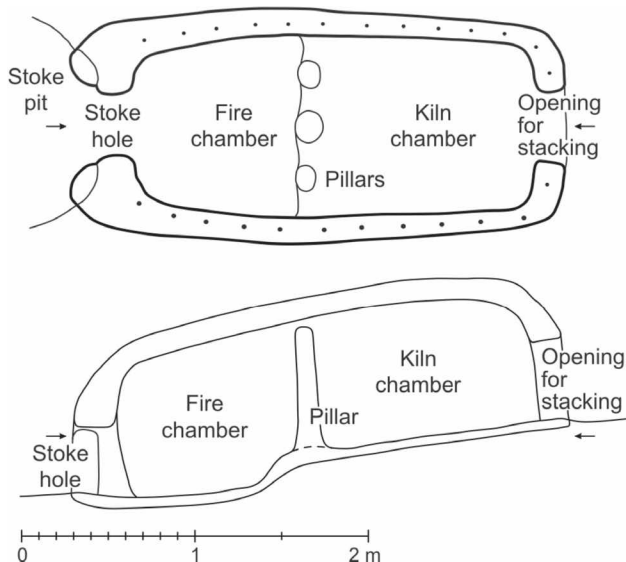
which the neck and the rim are thrown. The decoration is simple. On the pitchers occur horizontal grooves that accentuate changes in the shape. In addition to the horizontal grooves painted stripes of iron oxide and applied and raised motifs resembling raspberries occur. Pots and bowls are decorated with horizontal grooves right below the rim. The very common form and decoration types that characterize the pottery from Kragelund do not allow a narrow dating. The kiln



**Figure 7**

To the left, a reconstruction proposal of the Hellum Kiln.  
To the right, the pottery kiln from Torksey.

After Barley 1964



**Figure 8**

To the left, a reconstruction proposal of the Barmer kiln.  
To the right, the pottery kiln from Paffrath

After Lung 1955–56.

seems to have functioned for a short period of time in the 14th century.

A C-14 analysis of charcoal from the kiln dates it to some time in the 14th century. This dating agrees with the dating indicated by the glazed pitchers and other pottery from the kiln.

## Background for the reconstruction

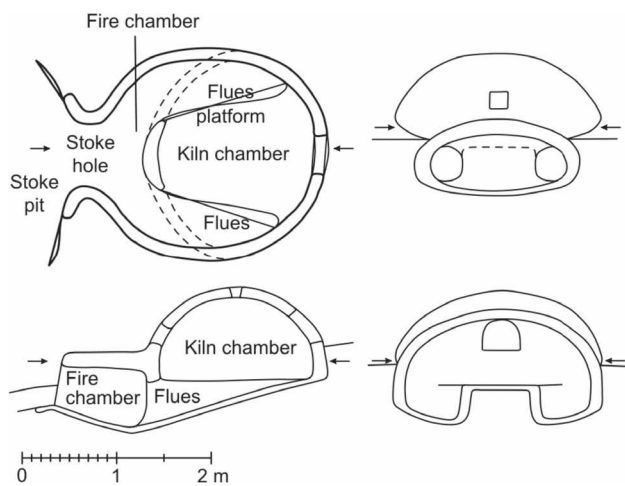
Archaeological parallels for better understanding of the three kilns presented here have been searched intensively. Because the number of excavated kilns in Europe is high there are a lot of supplementary evidences to use. But it is always uncertain whether one solution used and documented at one location may also have been used at the three actual kilns.

Ethnological and ethnographic parallels in traditional pottery-making can be very important for our understanding of the remains of medieval pottery kilns found in Denmark. A number of well documented examples from Denmark of traditional pottery works with downdraft kilns in recent time are taken in consideration, providing much supplementary knowledge of the furnishing of the workshops, the raw material for both pottery clay and lead glaze, production, the construction of the kilns, fuel, the actual firing, and marketing conditions (Kock 2003, 247 ff.). Sadly it is rare to find proper documentation on potter's workshop even from the latest centuries.

Adding to this is very informative, comprehensive regional investigation in south-western Europe, showing that the updraft type of kiln has been dominant in that area in recent times, while the downdraft kiln has been more common in northern and eastern Europe. (Köpke 1985, Karte 4, Köpke 1991, 284; Köpke & Graf 1988, 111 & 118; Kresz 1991, 262; Segschneider 1980, 217 ff.; Vossen 1991, 30).

The reconstruction of the kiln from Hellum afforded few problems. The preserved substructure indicated a simple round updraft (vertical) kiln, the floor of which was supported by a central pillar with radiating clay bars. What was really uncertain was the opening of kiln chamber. This kiln type is well known all over Europe from ancient times to the present day and in our case is very similar to a kiln from Torksey in Lincolnshire (Figure 7).

The kiln from Barmer was constructed differently. What was left under ground level looked like a hip bath, with stoke hole and fire chamber in the lower part and a slightly sloping floor for the pots in the upper part, where an opening at the rear was presumably used for stacking the pottery and during the firing as a vent for the exhaust. The two chambers were separated by a fire screen in the shape of three solid pillars – very much like kilns found in France and Germany, among others the kiln from Paffrath (Figure 8). No traces of the upper parts of the kiln remained in Barmer, but a row of small holes with charred wood in



**Figure 9**

To the left, a reconstruction proposal of the Kragelund kiln. To the right, the pottery kiln from Brunssum.

After Renaud 1959

the sidewalls indicated a barrow vault moulded on a wooden structure.

In Kragelund, only the front part of the kiln was preserved. The stoke hole and the fire chamber, with a flue on either side of a raised platform, indicated a type of kiln found in the Netherlands, France and Germany. None of these kilns offered much information about the structure above ground level, except possibly one of a series of kilns from Brunssum (Figure 9), where the foremost part of a domed roof seemed to have rested on the front part of the platform. A reconstruction along these lines seemed a permissible experiment.

## The reconstruction of the kilns and the firing

In order to get some clay of the right composition to reconstruct the kilns the clay from the kiln facilities was analysed at the Geological Survey of Denmark and Greenland. The analyses showed that local moraine clay with fine sand added to it was probably used in all three places. The ratio of clay to sand varied in the three kilns. However, the difference was not so big and when the kilns were reconstructed the same mixture could be applied, i.e. two parts clay and three parts fine sand. Plenty of firewood had been felled the year before; but the wet spring of 1987 resulted in the firewood not being as dry as desired. This turned out to cause problems in connection with the Kragelund kiln. In order to measure and record the temperatures reached during the experiment a large number of temperature probes were installed in each reconstruction readings of which were taken continuously via a data system. These measurements form the basis of the temperature curves that have been prepared for each kiln.

The Hellum kiln consists of an underground fire chamber with a narrow stoking-channel and a kiln chamber above ground. To build the floor of the kiln chamber a large stone was placed in the middle of the fire chamber with thick clay bars spreading out to the outer walls. To reconstruct the kiln the building-site was dug and the floor and outer walls of the fire chamber were moulded in clay. The large stone was placed in the middle and covered with clay. Then the difficult task of building the floor of the firing chamber began. Thick bars of clay were arched between the stone and the outer walls. The finished floor looked like a wheel with thick spokes. Finally, the walls of the kiln chamber were moulded, narrowing upward and leaving an outlet for smoke.

Potters have made close replicas in shape and size of the pots found. The clay from the original pots was analysed and seriously copied and used. But without success, the clay did not work. Instead the potter took raw clay from a pit nearby and added tempering material.

Stacking posed a problem because some of the pots had to hang, firmly wedged by those standing on the bars, over the holes down to the fire chamber. By taking great care in placing the pots, the rest of the stacking was easily done. The number of pots in one kiln-firing depends very much of the way we have chosen to reconstruct the kiln and how tight the pots are stacked. So the actual amount of pots is not so interesting. Important is to be a skilled potter that know something about stacking, and most important is that a kiln have to be stacked fully to burn correct.

The firing started very slowly with a small fire in the stoke hole. After two hours with moderate feeding, the fire was allowed to burn more freely and wood fuel and embers were pushed into the fire chamber. A problem with steam in the outlet smoke from very wet fuel forced us to keep the outlet open for longer than planned, but after five hours of firing it was narrowed to 10 by 10 cm.

The best and most effective way of firing was a steady firing only in the fire hole. The wood-gas has to burn around the pots and not in the firing chamber. Too heavy firing results in charcoal, and then you have to pull this out to get a sufficient fire. The wood for firing preserved in the excavated kilns was mostly hardwood and with a diameter of 6–8 centimetres. This quality also worked very well in the experiments.

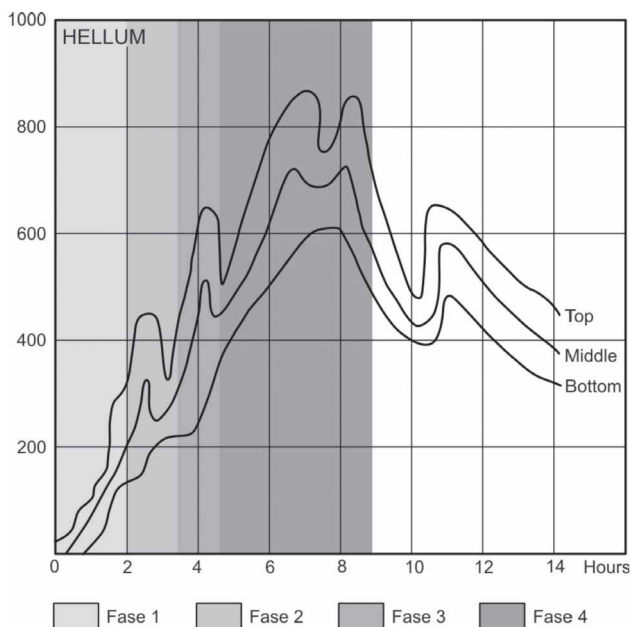
After a further five hours of firing the temperature had reached 820 degrees Celsius, and a glance down into the kiln showed the pots glowing a translucent red. The wanted temperature was reached so the firing chamber was filled with firewood and the kiln closed (Figures 10 and 11). After cooling the kiln was opened and the pots removed and inspected. A minor part was broken. The temperature had clearly been most intensive in the rear. The reduction of the pots was not successful; they have a brown colour instead of a black. The kiln has clearly not been tight enough.



**Figure 10**

The Hellum kiln is reconstructed.

The floor of the kiln chamber is finished and the building of the dome itself has just begun.



**Figure 11**

Analysis of the firing process in the Hellum kiln, based on calibrated temperature curves.

Drawing by Morten Aamann Sørensen

Later we have made more firings in this kiln with great success and due to covering the kiln with earth the reduction was perfect. In the first firing the firewood was really wet, but still it was possible to do a firing. By later firings there were used dry wood with even a better result.

The Barmer kiln was reconstructed over a skeleton of branches which had been demonstrated by the archaeological investigations. It had been considered whether the dome should consist of two parts that rested on the pillars or if it would be better with a cylindrical dome which did not rest on any of the pillars. A cylindrical dome where the pillars reached the dome was chosen (Figure 12). This later proved to be unfortunate partly when the kiln dried and shrunk considerably and partly during the firing itself when unfortunate settling occurred too. So the solution chosen was not the best working one. Since then a new reconstruction has been built where the pillars do not touch the cylindrical dome. The pots used were again replicas of the excavated pots. The needed amount of pots to fill the kiln was higher than we had estimated, so we had to fill the rear part with replica originally dedicated to the Kragelund kiln. The stacking did not give any problems. It was possible for a potter more than 1.80 meter high to climb into the chamber of the kiln in the version of it that we have chosen to





**Figure 12**

The Barmer kiln with its partly covered skeleton of branches. The pillars which separate the fire chamber from the kiln chamber are in place. The stoke hole is supported by rods until the clay is dry enough.

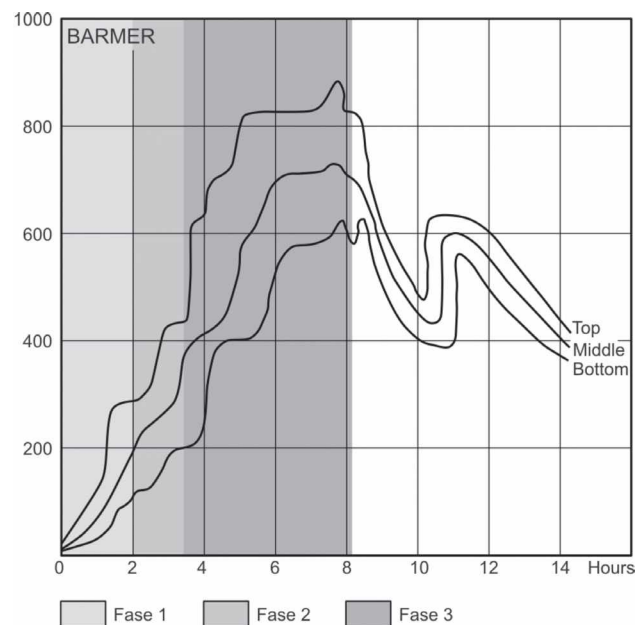
reconstruct. It works perfectly. As the temperature measurements show the firing of it was unproblematic (Figure 13). The way of firing was clearly the same as used at Hellum. A sharp sound from the kiln of a broken pot was a clear warning that we were firing to hastily, so we had to slow down a bit.

A later firing turned to be nearly disaster like. The firing was so intensive that the pillars more or less were molten and partly broken down. Exactly this was the situation we found when we excavated the kiln.

The compromises in this reconstruction are really minor. What is uncertain is the high of the high of the dome, the stokehole and the opening for stacking the pots.

The kiln from Kragelund was the largest and most complicated of the three kilns in the experiment. The lower part, with stoke hole, flues, and the front part of an elevated platform, could safely be copied from the plan of the excavation, whereas the domed roof, its shape and the number of openings and vents partly had to be decided on the basis of experience with previous experiments in kiln building (Figure 14).

There were no traces of a wooden structure, and the dome had to be hand-moulded from several layers of clay. A regular hemispherical form was attempted, with moderate success. A small hole was left open in the top of the dome, to let steam out in the early phases of the



**Figure 13**

Analysis of the firing process in the Barmer kiln, based on calibrated temperature curves.

Drawing by Morten Aamann Sørensen





**Figure 14**

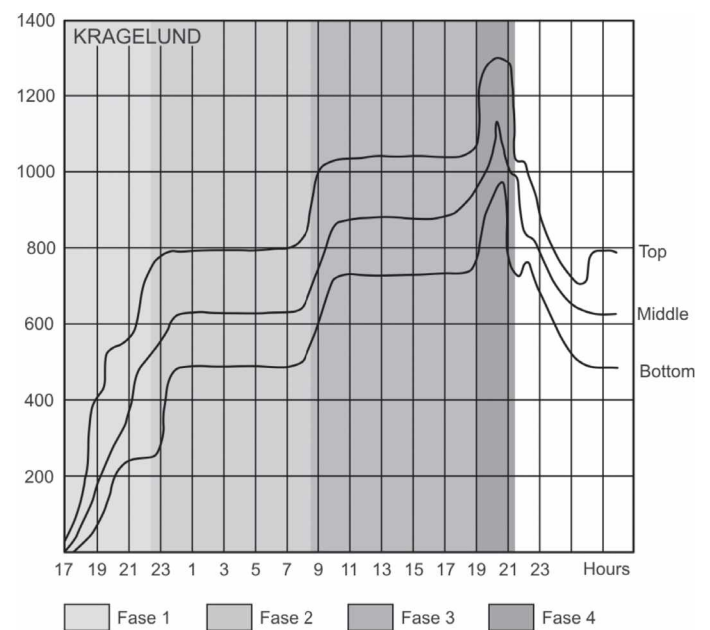
The Kragelund kiln is being built. The covering of the stoke hole has begun. The dome rests on the outermost part of the platform.

firing. An opening was made at the rear for stacking the pottery and later used in a diminished form as a vent to let out exhaust gases. Another vent in the front of the dome was to allow for regulating the draught during firing.

After a couple of firings to dry out the kiln, copies of the original pottery, consisting of glazed jars and pots, were stacked on the platform, and the firing could begin.

The next 28 hours gave every opportunity to experiment with adjusting the draught and changing the methods of firing. For a 20-hour period, it seemed impossible to force the temperature up to the desired 900° C. As fire-wood was used the same wet material as in the Hellum and Barmer kilns. Ultimately, it was decided to try an intensive firing now with dry wood, regardless of the amount of wood consumed. Within a few hours the temperature reached 900°–1000°, and the firing was stopped (Figure 15). The stoke hole and other openings were blocked up, and to intensify a reduced atmosphere in the kiln, a small mountain of previously removed charcoal was put back into the fire chamber.

The experiment could hardly be called a success. The kiln was difficult to manage and consumed far too much wood compared with the amount used in repeated firings with the two other kilns. But it is clear



**Figure 15**

Analysis of the firing process in the Kragelund kiln, based on calibrated temperature curves.

Drawing by Morten Aamann Sørensen

that dry wood was the solution for solving the problems. We have never managed to do a new firing in this kiln, partly because it was severely wounded by the last intensive firing and partly because it contained a huge amount of pottery, so it was a job to do so many replicas as needed.

The pottery was well fired; the glaze was due to reduced firing grey and lustreless, with small particles of metallic lead. The glazed pottery was clearly over fired so the lead glaze reconverted to metallic form. The sudden rise in temperature in the final phase indicated that intensifying the firing with dry wood at an early stage could have saved time and wood, and the lustreless glaze might be caused by the large amount of charcoal, producing an atmosphere excessively deficient in oxygen.

By comparing the archaeological and experimental archaeological observations made here with selected ethnological and ethnographical parallel materials from Denmark as well as other countries it has been possible to obtain a more profound knowledge and understanding of medieval pottery. The potter's working tradition is changing through the centuries but at the same time keep tradition living. The three pottery kilns from Denmark presented here are typical in that respect.

## Acknowledgements

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Translation Stacy M Cozart and Eva Raagaard Nielsen

## Endnotes

- 1 The result of K 4220 was 950 $\pm$ 50 C-14 years before 1950, calibrated to  $\pm$ 1 std. dev. (Stuiver et al. 98): 1020–1160 AD Kal.  
The result of K 4221 was 930 $\pm$ 50 C-14 years before 1950, calibrated to  $\pm$ 1 std. dev. (Stuiver et al. 98): 1030–1160 AD Kal.  
The result of K 4222 was 960 $\pm$ 50 C-14 years before 1950, calibrated to  $\pm$ 1 std. dev. (Stuiver et al. 98): 1020–1160 AD Kal.  
The average of the three datings is 947 $\pm$ 29 C-14 years before 1950, calibrated to  $\pm$ 1 std. dev. (Stuiver et al. 98): 1020–1160 AD Kal.  
In addition, two pottery tests were done to give a thermoluminescence dating.  
Risø TL no. 832901, TL dating 1270 AD  $\pm$ 50 years.  
Risø TL no. 832902, TL dating 1250 AD  $\pm$ 50 years.  
The middle value of these two tests gives the following result: 1260 + 50 years.
- 2 The result of K 4647 was 680  $\pm$ 50 C 14 years before 1950, calibrated to  $\pm$ 1 std. dev. (Stuiver et al. 98): 1280–1390 AD Kal.  
The result of K 4648 was 600  $\pm$ 50 C-14 years before 1950, calibrated to  $\pm$ 1 std. dev. (Stuiver et al. 98): 1300–1400 AD Kal.  
The result of K 4649 was 610  $\pm$ 50 C-14 years before 1950, calibrated to  $\pm$ 1 std. dev. (Stuiver et al. 98): 1300–1400 AD Kal.  
From kiln II one sample of charred wood has been processed.  
The result of K 4650 was 550  $\pm$ 50 C-14 years before 1950, calibrated to  $\pm$ 1 std. dev. (Stuiver et al. 98): 1320–1440 AD Kal.

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## Résumé

Avant le début des années 80, en tout et pour tout deux fours de poterie étaient connus pour le Moyen Age au Danemark. Ces deux fours ont été trouvés dans le Zealand aux lieux-dits Farum Lillevang et Faurholm. Ce n'est qu'en 1983 que de nouvelles découvertes ont été mises à jour. Au cours de plusieurs mois, trois nouveaux fours à poterie accompagnés de céramiques de rebut et de ratés de cuisson ont été découverts. Le premier de ces fours a été trouvé du côté ouest du village de Hellum dans l'Himmerland de l'est. Seulement quelques mois plus tard, les restes d'un autre four apparurent dans le village de Kragelund à environ 20km au nord de Silkeborg; à peu près au même moment d'autres fours et de la poterie ont été découverts à côté du village de Barmer en Himmerland. Ces trois nouveaux fours sont, non seulement différents dans leur construction mais aussi différents des exemples connus précédemment. Ces découvertes ont donné naissance à un projet de recherche et de publication qui inclut une analyse des fours et des céramiques trouvées, la réalisation d'une série d'expérimentations archéologiques, la collection de matériel archéologique pour comparaison et de parallèles ethnologiques.

## Zusammenfassung

Bis zum Beginn der 80er Jahre kannten wir nur zwei mittelalterliche Brennöfen in Dänemark. Beide Öfen befanden sich auf Sjælland, in Farum Lillevang und Faurholm. Erst 1983 kamen neue Funde dazu. Im Laufe weniger Monate wurden drei neue Brennöfen nebst Abfallscherben und Fehlbränden zutage gebracht. Der erste dieser Öfen wurde am westlichen Rand des Dorfes Hellum im östlichen Himmerland gefunden. Nur wenige Monate später kamen die Überreste eines anderen Ofens im Dorf Kragelund, ungefähr 20km nördlich von Silkeborg zutage und fast gleichzeitig entdeckte man mehr Töpferware und Öfen nahe dem Dorf Barmer in Himmerland. Die drei Öfen waren nicht nur völlig unterschiedlich in ihrer Bauart, sondern auch andersartig als die bereits bekannten. Dieses gab den Anlaß zu einem Untersuchungs- und Veröffentlichungsprojekt, das die Öfen und die erhaltene Töpferware analysierte, eine Reihe archäologischer Versuche durchführte, und vergleichbares archäologisches und parallel ausgesuchtes ethnologisches und ethnographisches Material zusammenfaßte.